Indigenous goat production on Kikuyu in South Africa

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Abstract

This study investigated indigenous goat production on kikuyu at Cedara Research Station, KwaZulu-Natal, South Africa. Three stocking rates were used (30, 45 and 60 goats/ha) to evaluate goat production on kikuyu. Does with kids grazed kikuyu for a total of seven months under a four camp rotational grazing system. Kid and doe mass were monitored. The results show that does lost weight to weaning at all stocking rates, with significant differences between the years. Does were able to regain some of the weight lost during lactation once the kids were weaned. Stocking rate affected kid growth rates, with higher weight gains at the lower stocking rates. Evaluation of doe performance showed that the light stocking rate had higher production per animal but lower production per hectare. Therefore, to maximise production per hectare a heavy stocking rate should be used, but to maximise weight gain per animal, a low stocking rate should be implemented.

Keywords: grazing, performance, production, stocking rate, weight
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Introduction

Kikuyu, *Pennisetum clandestinum* Hochst. ex. Chiov. (Mears, 1970; Skerman & Riveros, 1990) is one of the most important dryland summer pasture species in South Africa (de Villiers, 1998; Miles *et al*., 1995), with high yield potential, resilience under poor management and a good response to nitrogen fertilization (Miles *et al.*, 1995). Kikuyu is the predominant dryland summer pasture grown in the Midlands of KwaZulu-Natal (de Villiers, 1998) and widely used as winter foggage (deferred grazing or standing hay) during the winter months.

Goats are regarded as an important livestock species in developing countries in Asia and Africa (Nozawa, 1991). Small-scale farming in African countries plays a major role in the livelihood of rural people and contributes approximately 30% to the national economy, but would appear to not be sustainable due to low productivity (Lehloenya *et al.*, 2007). Goats can excel because they are adapted to a wide range of environmental conditions (Gall, 1991) which is assisted by their highly selective grazing behavior - this enables goats to survive in difficult areas and cope with toxic plants (Morand-Fehr, 2005). They are used as a means of investment or may be sold for cash flow. They provide employment opportunities, especially the effective utilization of unpaid family labour (Devendra, 1992; Morand-Fehr *et al*., 1993). Goats in the tropics are primarily used for meat production (Devendra, 1991). They are kept traditionally by a large part of the population in the rural areas of South Africa (Braker *et al.*, 2002) and are used to maintain social bonds with the community e.g. as lobola (dowry) (Braker *et al.*, 2002). Goats are also used for ceremonial and religious purposes and provide an income as well as meat and milk for the household (Braker *et al.*, 2002; Lehloenya *et al.*, 2007). Goat production is considered a resource which can be utilised to improve the income and nutrition of rural communities and to incorporate these communities into commercial markets (Braker *et al*., 2002). In South Africa the primary use was for meat, fibre and milk (Ramsay & Donkin, 2000) with approximately 7 830 644 goats (STATS SA, 2016). Goats are an important but under-utilized indigenous resource and provide an alternative income due to their versatility (Smuts, 1997). Local cultural demand for the use of goats in South Africa is currently driving (and exceeding) the supply of live goats. Goats for meat are mainly marketed in the informal sector, in the Eastern Cape and KwaZulu-Natal, which is driving the goat industry.

The informal live market pays higher prices than the formal mutton and goat abattoirs can offer (e.g. R1 200 vs R700 for the same size/age animal - Nov 2018). The informal goat meat market in South Africa is mostly supplied by live indigenous goats as well as some older Angora goats (Louw, 2018).

Stocking rate has a considerable effect on live weight production with production per hectare affected by grazing method, stock type and stocking rate, of which stocking rate has the largest impact (Kirkman & Carvalho, 2003).

The purpose of this study was to determine the potential for improving goat production by improving their nutrition and to determine the nature of the relationship between stocking rate and animal production and the relationship between stocking rate and herbage availability when grazing.

Materials and methods

The research was carried out on the Cedara Research Station (29°32'S, 30°17'E) of the KwaZulu-Natal Department of Agriculture and Rural Development in the midlands of KwaZulu-Natal province in South Africa. The trial was conducted on the same site for two consecutive years (the summers of 2001/2002 and 2002/2003). The research station lies at an altitude of 1076 m above sea level, with long-term annual means of 885 mm, 1577 mm, 22.3°C, 9.4°C and 16.2°C for rainfall, mean annual evaporation and maximum, minimum and average daily temperatures respectively (Agromet, Institute of Soil, Climate and Water, Private Bag X79, Pretoria, 0001, South Africa). Severe frosts occur during June and July. Established dryland kikuyu pastures were utilized for the trial and the site was burnt (after more than 15 mm rain in 24 hours) before the experiment commenced in the first year only. The dominant soil type was a Hutton soil form, which is an orthic A horizon over a red apedal B horizon (Soil Classification Working Group, 1991). This is a well-drained soil. The soil phosphorus (P) and potassium (K) levels were raised to the recommended levels in accordance with soil analyses (Fertrec Laboratory, KwaZulu-Natal Department of Agriculture and Rural Development, Private Bag X9059, Pietermaritzburg) which are 120 mg/L for K and 8 mg/L for P (AMBIC). The acid saturation was 21% and the pH (KCl) was 4.12. Nitrogen was applied in the form of Limestone Ammonium Nitrate (LAN (28% N)) at a rate of 50 kg N/ha after each grazing cycle, in accordance with recommendations (Miles, 1998). A total of 300 kg N/ha was applied to the treatment area over the trial duration.

The experiment evaluated three stocking rates in a randomized block design with two replications. The stocking rates were 30, 45 and 60 goats/ha. Animal numbers per treatment were kept constant, with areas varying in size to simulate the various stocking rates. There were ten does per treatment, with camp sizes being 0.33ha, 0.22ha and 0.17ha for the stocking rates 30, 45 and 60 goats/ha respectively. Each treatment was divided into four equally sized camps that were grazed on a rotational basis. The grazing period per camp was seven days and the period of absence was 21 days per camp. Samples of grazed herbage were collected monthly (before grazing) using the hand-plucking method (Cissé *et al.*, 2002) to determine forage quality. All goats were weighed at two weekly intervals. The study continued for the does after weaning the kids for the entire 7 month grazing season.

Herbage production was measured using a falling plate disc meter. Disc meter measurements were done prior to and after each grazing (50 readings per camp) for all camps and all grazing cycles, to give an indication of herbage production (Figure 2). Kearl (1982) determined dry matter intake of goats in relation to body mass as 76.7, 76.3 and 119.6 g DM/kg $W^{0.75}$ daily for growth, late pregnancy and lactation respectively. These relationships were used to determine apparent dry matter intake. The prediction of residual pasture yield (y) (kg DM/ha) from disc meter height (d) (cm) as determined by Bartholomew (1985) was used, where $y=749.5 + 242.79d$. Doe mean mass at the end of the trial was used to determine apparent consumption for lactating goats.

Sixty mature unimproved indigenous Zulu goat does, with an average weight of *c*. 43 kg, were allocated to the 3 treatments in a randomized block design. The does, with kids at foot, were evenly allocated to each stocking rate treatment, after blocking for doe weight and twinning. All male goats were castrated soon after birth. Weaning occurred at an average age of 150 days. All goats were initially vaccinated with Multivax-P© vaccine (which includes Tetanus and Pulpy-Kidney vaccines) in accordance with veterinary recommendations. Goats were dewormed three times during the trial period (alternating the active ingredient at each deworming) and footbathing (for footrot) was done when deemed necessary. All goats were given two Vitamin B-Co© injections during the trial period since vitamin B_1 was identified during the early stages of the trial (by autopsy) as being deficient in goats. The goats had access to a sodium (salt), calcium and phosphorus mineral lick *ad libitum*. Institutional and national guidelines for the care and use of animals were followed.

All statistical analyses were conducted using Genstat 6.1 (Copyright 2002, Lawes Agricultural Trust, Rothamsted Experimental Station). Fisher's protected LSD and regression analyses were used to determine the effect of stocking rate on animal weight, where the ANOVA identified a treatment effect ($P<0.05$).

Due to the logistics of grazing research, there were limited degrees of freedom for treatment differences, with groups of animals being the experimental units. The assumptions that were made were that the animals would display correlated responses to treatment variables and that the pastures were uniform. The mean weight of the group was used in an analysis of variance. Differences between treatments were determined for both ADGs to weaning for both does and kids and for the whole grazing period for the does. Linear regressions were used to show the nature of any change over time and gain per hectare was determined for the combined years.

Rainfall and temperature data for the trial periods were obtained from the Cedara AgroMet Station (Agromet, ARC – Institute of Soil, Climate and Water, Private Bag X79, Pretoria, 0001, South Africa).

Results and Discussion

Analysis of weather data showed that the 2001 year experienced late spring rain, high midseason rainfall (Figure 1) and cooler spring minimum temperatures. The 2002 year experienced early spring rain, low midseason rainfall (Figure 1) and warmer spring minimum temperatures. The rainfall during the trial period was considerably higher in 2001 than 2002 with the 2002 year experiencing more late-season rainfall than the 2001 year (Figure 1), with negligible differences in temperature.

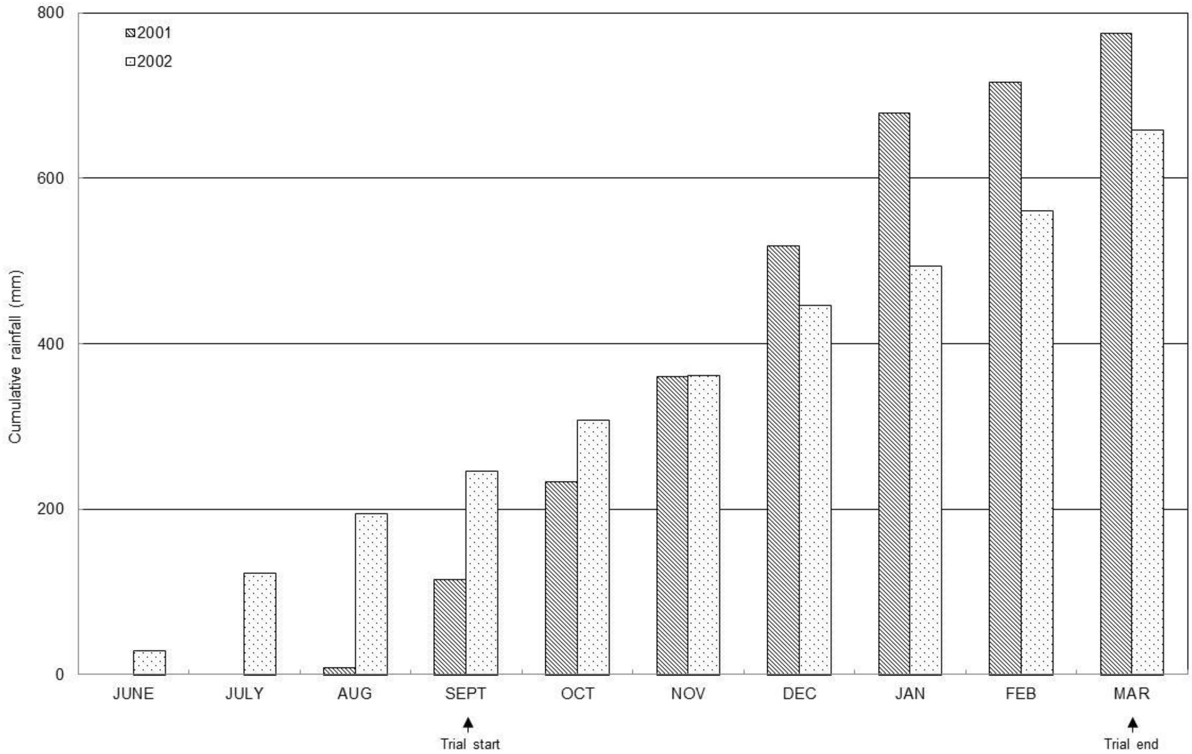

Figure 1 Cumulative rainfall experienced during 2001 and 2002 preceding and during the trial period

Apparent intake was added to residual dry matter and an average of the two treatments was calculated to obtain total yield per treatment per year (Figure 2).

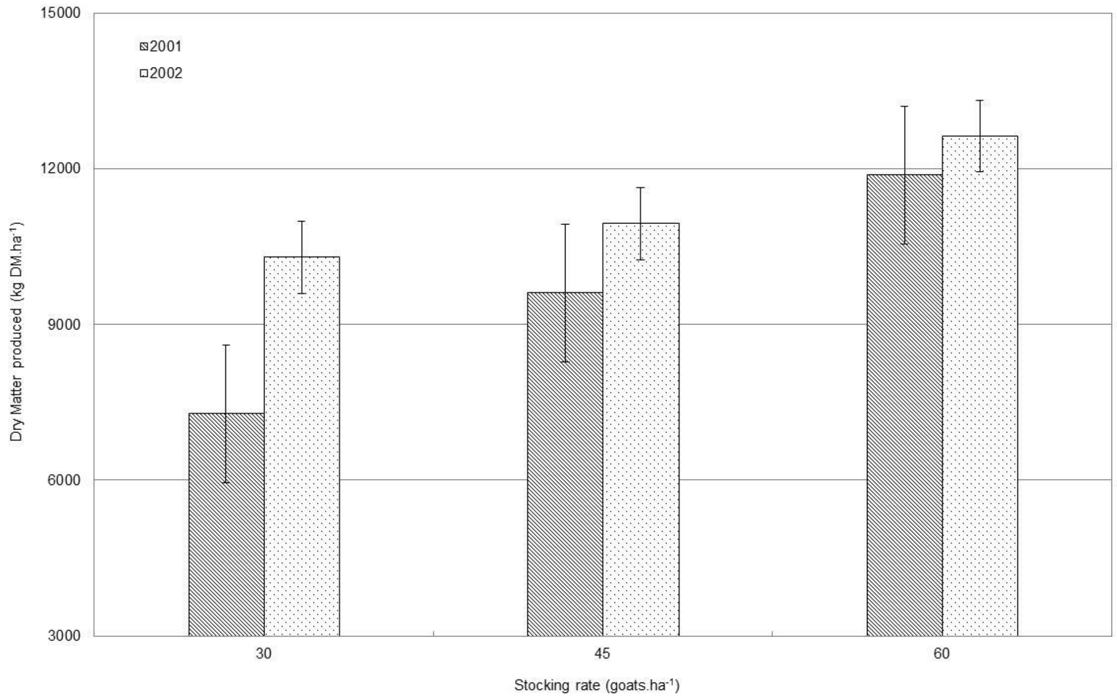

Figure 2 Apparent herbage production (kg DM/ha) of kikuyu for 2001 and 2002. Bars represent the SE

Table 1 Mean weights (kg) of the does and kids at the start and finish at weaning of the grazing trial comprising 105 days

Stocking rate (does/ha)	30		40		65	
Replication	1	2	1	2	1	2
2001						
Start weight – does	43.2	43.4	41.2	41.9	43.3	42.0
Final weight – does	40.8	40.3	39.1	38.7	38.5	35.9
Weight loss - does	2.4	3.1	2.1	3.2	4.8	6.1
Start weight - kids	7.91	8.11	7.18	7.09	7.49	8.68
Final weight - kids	13.56	12.65	12.36	12.55	12.77	11.54
Weight gain - kids	5.65	4.54	5.18	5.46	5.26	2.86
2002						
Start weight – does	43.0	43.1	43.1	43.2	43.1	43.1
Final weight – does	40.1	39.9	39.0	36.9	36.7	36.0
Weight loss - does	2.9	32.2	4.1	6.3	6.4	7.1
Start weight - kids	7.4	6.7	7.7	7.5	6.3	7.2
Final weight - kids	14.3	13.8	15.1	12.1	14.6	13.0
Weight gain – kids	6.9	7.1	7.6	4.6	8.3	5.8

The livestock weights are presented in Table 1. Since the animal weights had been evenly distributed between the treatments and the replications, there were no significant differences in doe start weights. Average daily gains were calculated from the doe start weights to weaning and also to the end of the trial period. The data for both years were combined and analysed using ANOVA, which showed a treatment effect on ADG to weaning for both year (P<001) and stocking rate (P<0.001) but no interaction, so the stocking rate/year stratum was dropped from the ANOVA to increase the degrees of freedom (Ndiwa *et al*., 2003).

The investigation showed that the does lost weight until weaning in both years and in all stocking rate treatments. The mean loss was 0.0061 and 0.0472 kg/animal/day for the 2001/2002 and 2002/2003 years respectively (Figure 3). Fisher's protected LSD showed a statistical difference between the AGDs of the two years (P<0.001) (Figure 3). When comparing doe ADGs (the means of both years) there was also a difference between stocking rates, with the mean ADGs being -0.0157, -0.026 and -0.0384 kg/animal/day for 30, 45 and 60 goats/ha respectively (P<0.01; $lsd_{0.05}$=0.00855; CV=19.6%).

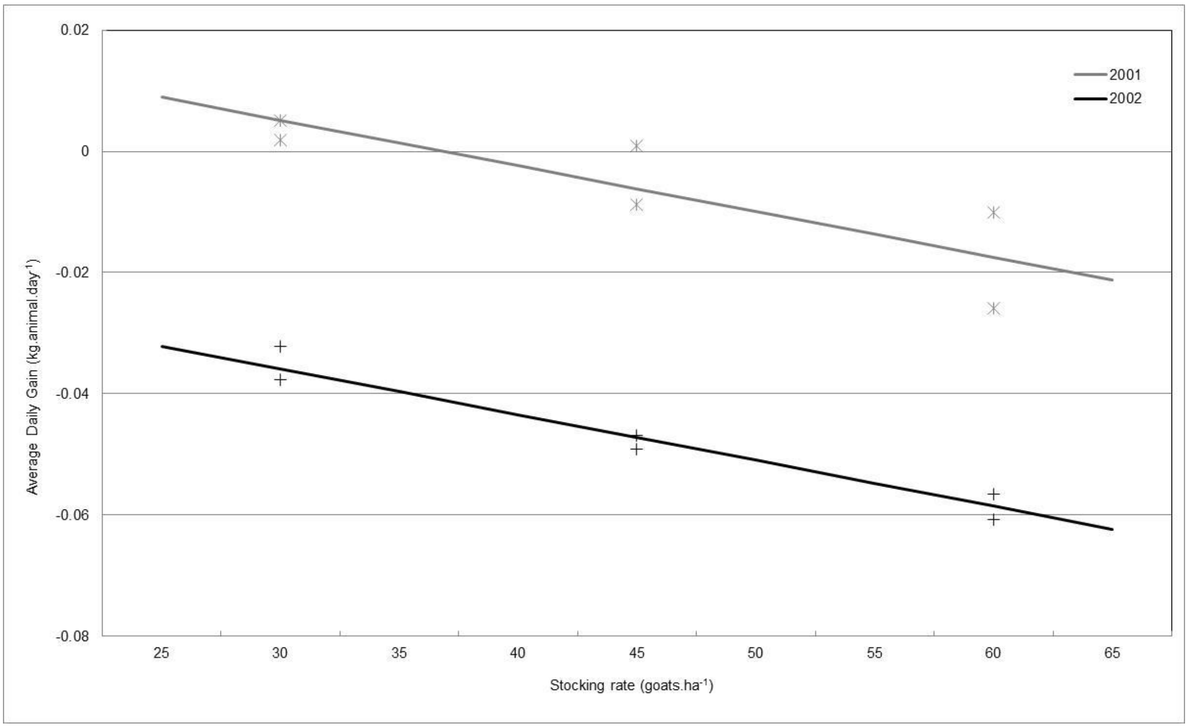

Figure 3 Regression analysis of mean doe ADGs to weaning (y) on stocking rate (x) for goats grazing kikuyu until weaning for 2001 and 2002 combined.

For both the 2001 and 2002 years, the does lost weight to weaning. The rate at which does lost weight while stocking rate increased was the same for both the 2001 and 2002 years (R^2=95.7%; P<0.001) (Figure 4). The weight loss in the 2002 year was more pronounced than that experienced in the 2001 year (Figure 4). Analysis of the data for the entire grazing season showed a similar trend, with years being different (P=0.03) although there were no significant differences between stocking rates.

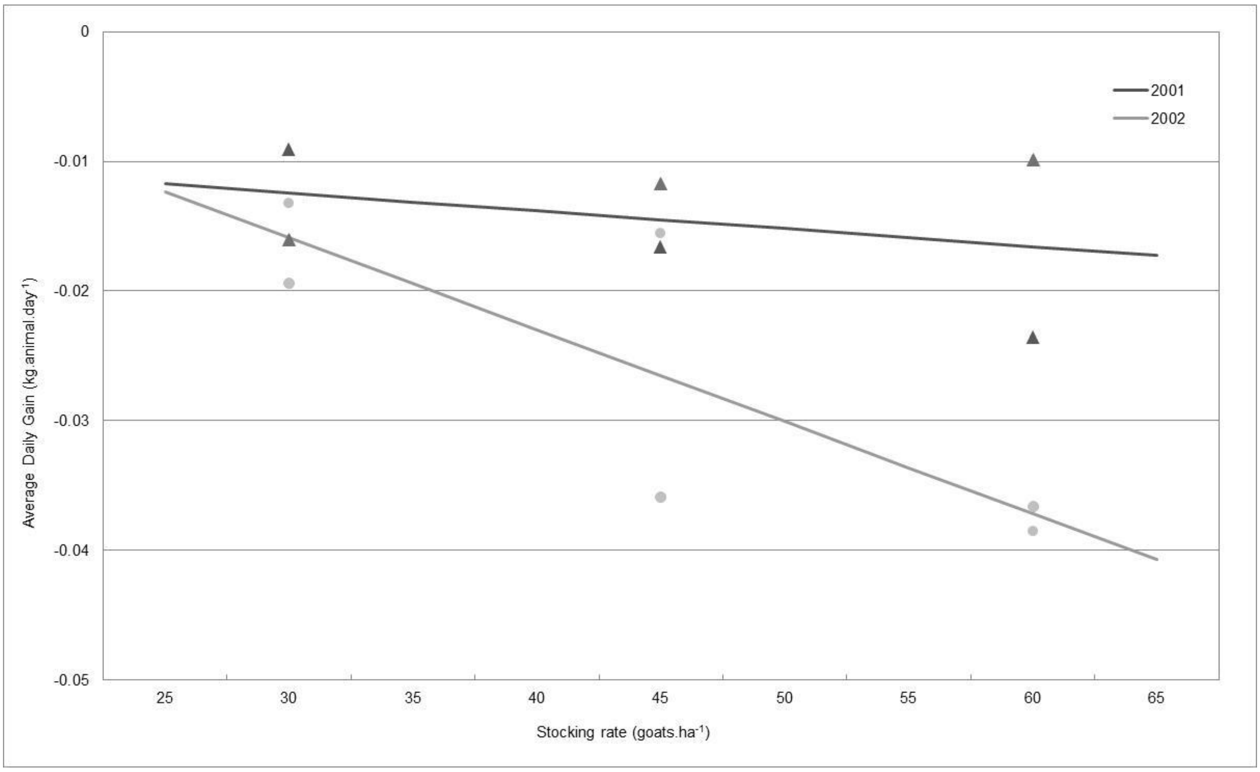

Figure 4 Regression analysis of doe ADG (y) on stocking rate (x) for goats grazing kikuyu for the full grazing season of 7 months for 2001 and 2002 combined.

Using an unbalanced regression analyses of kid performance, year showed an influence on weaning weights (P<0.001; R^2=21.8%). However, kid ADG was not a simple relationship, other factors had an influence, namely doe start weight (P<0.001) and whether the kid was a single or multiple (P=0.015). Kid ADG at the high stocking rate was different to the low and medium stocking rates (P=0.007) while sex had no contributing effect to ADG (P=0.446). Doe and kid masses at weaning were combined per treatment and per year, converted to a per hectare basis and differences between these figures were analyzed (Figure 5). Since there were no significant differences between the years, the stocking rate/year interaction was removed from the ANOVA to increase the degrees of freedom (Ndiwa *et al*., 2003).

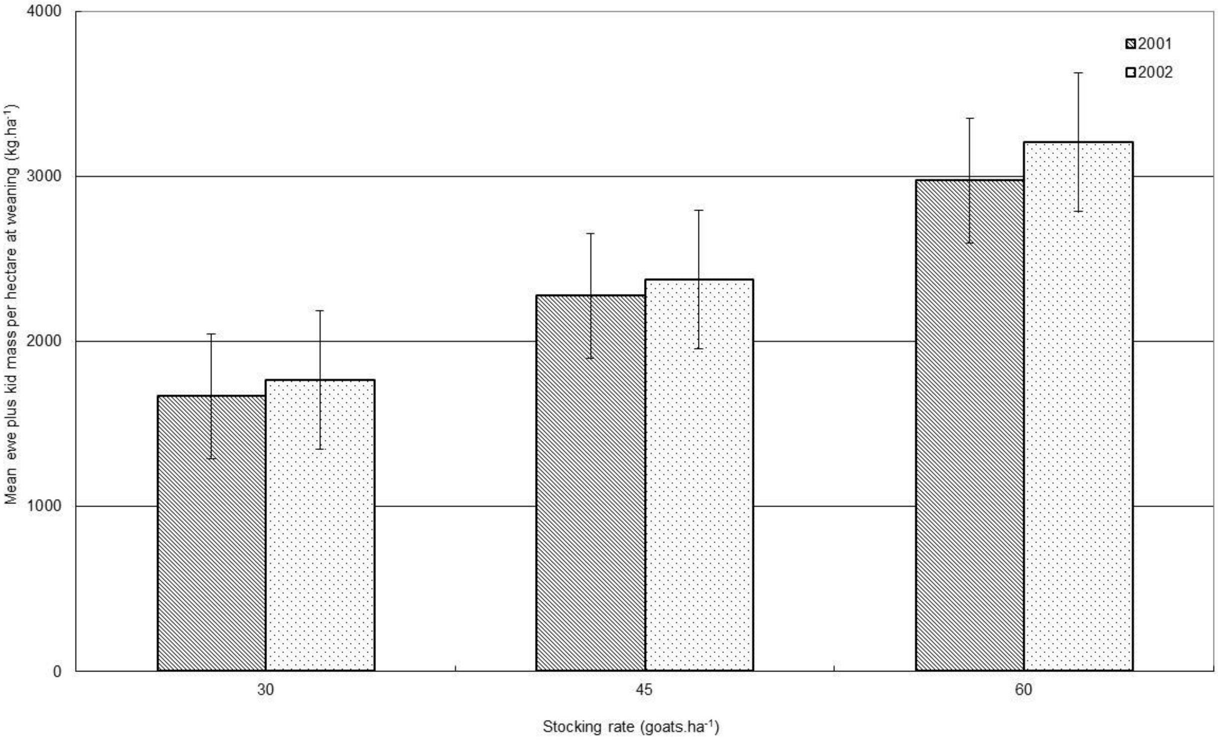

Figure 5 Mean total doe weight plus total kid weight per hectare at weaning for goats with kids grazing kikuyu at three stocking rates for 2001 and 2002. Bars represent the SE.

There was a difference between stocking rates on a per hectare basis (P<0.001; CV=4.7%) when both years were combined with the heavy stocking rate producing the highest total live weight and the light stocking rate producing the lowest total live weight per hectare (Figure 5), with a grand mean of 2377 kg/ha. There were no differences between the years (P=0.060) when comparing total live weight of does plus kids per hectare.

Pasture height (both "in" and "out" readings) and "pasture loss" (apparent intake) of does ("in" minus "out" readings) were regressed on doe ADG and kid ADG.

On assessment of the height of the pasture on offer (actual data points), there was a difference between the height of the pasture on offer between the two years, with the 2001 year having taller pasture on offer (P=0.048; R^2=4.8%). There were also differences between the rate of change of doe weight between the two years (P=0.053; R^2=7.7%). Doe ADGs in 2001 decreased as pasture on offer increased, and doe ADGs in 2002 increased as pasture on offer increased. Doe ADG during the 2002 year was correlated to pasture on offer (P=0.002; R^2=14.3%) while the response of doe ADG to pasture on offer was the same for all treatments.

There were no significant correlations between pasture loss (apparent intake) and doe ADGs for the combined years. Regression of doe ADG on pasture loss during 2001 showed no significant relationship. Doe ADG during the 2002 year was correlated to pasture loss (P=0.033; R^2=6.0%), although explaining very little of the variation in doe ADG's. The response of doe ADG to pasture loss was the same for the three stocking rates. The higher the intake of the does, the better the individual performance was.

Kid ADG was correlated to pasture loss (apparent intake), with the medium and high stocking rates having higher ADGs than the low stocking rate treatment (P=0.041; R^2=10.1%) during the 2001 year, although explaining very little of the variation in kid ADG's. The rate of change of kid ADG was significantly different between stocking rate treatments. Kid ADG was not significantly correlated to pasture on offer or residual pasture during the 2001 year. The 2002 year showed no significant relationships between kid ADGs and pasture on offer, residual pasture or pasture loss. There were no significant correlations between pasture loss and kid ADGs for the combined years.

Kid ADG was correlated to doe ADG (P=0.013; R^2=5.8%) (Figure 6) while stocking rate had no effect on kid performance.

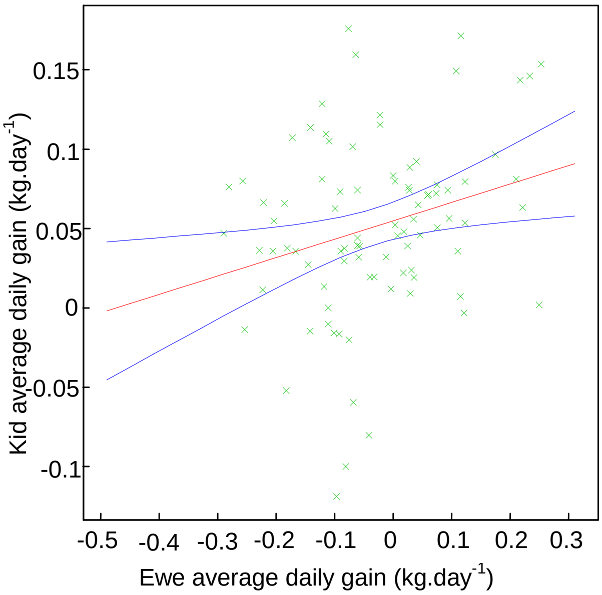

Figure 6 Regression of kid ADG (x) on doe ADG (y) showing 95% confidence levels for goat does with kids grazing kikuyu pastures during 2001 and 2002 combined.

During the study period, it was determined that the first year experienced later spring rains and had higher rainfall overall than the second year of the trial period, with negligible differences in temperature. As a result, the second year produced more dry matter than the first year since growth could commence earlier due to moisture availability. Temperature differences were negligible and did not appear to affect pasture and animal production. Since stocking rates for the second year were based on the results of the first year, those stocking rates evaluated in the second year were too light for the high dry matter that was produced. As a result, the stocking rate at which animal production is maximized was not reached and therefore not determined. Since there was a difference between stocking rates to weaning ($P<0.001$) but no difference between stocking rates at the end of the grazing period ($P=0.137$), it would appear that the does had managed to regain some of the weight that had been lost during the period of lactation and had a similar weight loss to the high stocking rate treatment by the end of the grazing period. This investigation showed that for does, the more pasture on offer, the better the performance of the individual animals.

Stocking rate influenced the rate of weight loss of the does to weaning (Figure 3) in both years. The level of weight loss was different ($P<0.001$) (Figure 3) between the years. The does during the 2001 year lost less weight than the does during the 2002 year even though the 2002 year appeared to produce more fodder (Figure 2), possibly due to the higher early rains (Figure 1). Kearl's (1982) estimation of goat forage intake uses the assumption that animals are at least able to maintain body weight. However, in this experiment the animals lost weight. As a result, herbage production may be over-estimated, especially at the higher stocking rate.

When evaluating the full grazing period, stocking rate had an effect on doe performance and the rate of weight loss was slower for both years (Figure 4), indicating that the does were able to slow down the rate of weight loss once the kids had been weaned and were able to regain some of the weight lost during lactation once the kids were weaned. This can be contributed to the removal of the milk production demand after weaning. The does were able to allocate energy to maintenance and weight gain instead of milk production.

There was a difference between kid performance during the two years ($P<0.001$; $R^2=21.8\%$) with doe start weight (P<0.001) and whether kids were singles or multiples ($P=0.015$) having an effect. The kids at the heavy stocking rate treatment had lower ADGs than the medium and low stocking rate treatments ($P=0.007$; $R^2=21.8\%$). The kids gained weight during both 2001 and 2002. Since 2001 appeared to have higher total rainfall than 2002 (Figure 1), one would have presumed that forage availability would have been a limiting factor in 2002 and therefore differences between treatments would be more pronounced.

Marais (2001) stated that milk yield and dam kidding weight were positively correlated. Therefore, the expected trend would be that the more milk a doe produces, the higher the kids ADGs. However, South African

Indigenous goats produce low volumes of milk and the quantity produced is often difficult to measure, with short lactations that barely supply enough milk to feed their kids (Cissé *et al.,* 2002). Apart from a limited number of kid mortalities no short lactations were encountered on this trial.

A heavy stocking rate treatment has high competition for available forage and therefore restricted intake. Broadbent (1964) found that lambs' rate of live-weight gain was related negatively to stocking rate and the total live-weight of lamb produced per hectare was related positively to stocking rate, and that the does' live weights were similarly affected, there being the highest losses of live weight under the heavy stocking rate. Improving milk yield of dams by providing adequate nutrition can lessen pre-weaning kid mortality and improve growth of offspring (Akinbamijo *et al*., 1994).

When the total change in live weight per treatment (does plus kids) was converted to a per hectare basis, the heavy stocking rate had the highest production per hectare (Figure 5) during both years. This is consistent with the theory that the heavy stocking rate has lower production per animal but higher production per hectare (up to a maximum stocking rate) (O'Reagain & Turner, 1992). The Jones Sandland model (Jones & Sandland, 1974) shows that the peak gain per animal (i.e. ADG) occurs at stocking rate that is lower than that at which maximum gain per hectare occurs. In this experiment, the light stocking rate had higher production per animal (Figures 3 and 4), but lower production per hectare (Figure 5). The loss of weight of the does is a factor for concern, but when the total mass of the does plus the kids is assessed, there is a large difference between the low and high stocking rates, which should compensate financially for any loss of body mass of the does (Figure 5). This loss of weight could also be detrimental to re-conception rates and needs to be explored further.

Jones & Sandland (1974) state that due to the linear relationship between production per animal and stocking rate, two stocking rates are sufficient to predict gain at the optimum stocking rate. However, since the does were losing weight on the kikuyu and not increasing in weight (as per the animal performance model), the data did not produce an acceptable model.

Snyman (2007) conducted an investigation into reproductive performance and kid mortality in South African angora goats and found that kids that were kept on pasture until weaning were 5.7 kg heavier than kids that were kept on veld and 4.6 kg heavier than kids that were kept on pasture for a few weeks and then moved onto veld. The mean average daily gain for both angora doe kids and angora ram kids from birth to weaning was 97.8 ± 2.3 g/day under varying management systems, while those on pastures exclusively achieved 132.3 ± 3.4 g/day.

Thiruvenkadan *et al.* (2009) collected data from 566 Tellicherry goats grazing natural vegetation in Tamil Nadu, India, over a period of 20 years. The mean pre-weaning ADGs obtained over this 20-year period was 72.41 ± 1.68 g/day. Payne *et al.* (2006) performed a study at the Texas Agricultural Experiment Station in Texas, USA, evaluating the effect of supplementation on intake and animal performance in three-month old meat goats. They reported that there were significant increases in ADGs when comparing non-supplemented goats fed only forage (sorghum-sudan hay) to supplemented goats fed a complete ration, however there is substitution effect of forage with supplement. The forage-based feeding system achieved a weight gain of 21.8 g/day which was insufficient to allow goats to reach 30 to 50 kg by one year of age.

The maximum ADG achieved during this study on kikuyu pastures was 80 g/day at the stocking rate of 30 goats/ha during 2002. This compares favourably with the performance levels achieved by Snyman (2007) and exceeds that achieved by Thiruvenkadan *et al.* (2009) and Payne *et al.* (2006).

Animut *et al.* (2005) evaluated four to five month old goats' performance at three stocking rates on a *Cynodon dactylon* and *Sorghum halepense* mixed pasture in Oklahoma, USA. Their findings were that ADG decreased linearly (P<0.10) on all stocking rates as stocking rate increased. The explanation for this decrease was decreasing forage mass and nutritive value since as availability declines, biting rate and grazing time increases. This is in agreement with the findings of this study, where stocking rate had an effect on ADG on kikuyu pastures (P<0.001). In a similar experiment conducted by Animut *et al.* (2006) using goat wethers on *Cynodon dactylon* and *Sorghum halepense* mixed pasture, their findings were that initial and final body weight were not influenced by stocking rate and mean ADG was not affected by stocking rate (P>0.05). This contradicts the findings of this study.

Yiakoulaki *et al.* (2007) evaluated the effect of stocking rate on performance of doe goats with kids rotationally grazing mixed pastures (*Cynodon dactylon* and *Sorghum halepense*) in Oklahoma, USA. Their findings were that final doe weight decreased linearly (*P*<0.10) as stocking rate increased, as did kid body weight (*P*<0.06), with the change in kid weight being less than the change in doe weight. Their findings were similar to that found in this study, with ADG decreasing as stocking rate increased. Lefrileux *et al.* (2008) stated that it is essential to stimulate high intake capacities in grazing goats, since there is a high correlation (r>0.80) between dry matter intake and milk production. In this study, the higher stocking rate would have resulted in less dry matter per animal and correspondingly lower milk production, which lowered kid weight gains (P=0.007; R^2=21.8%) in comparison to the medium and low stocking rate treatments. Lefrileux *et al.* (2008) also stated that in young female goats grazing pastures, weight gains can be more than 100 g/day and that would allow the females to reach a weight suitable for mating at seven to eight months of age.

There were no noticeable differences in temperature during the trial period between the two years. Disc meter regressions for the combined years showed no significant differences between pasture loss and no significant differences between pasture remaining between treatments.

Conclusions

Due to the high cost of establishing and maintaining a pasture, it is important that the value added to the product is more than the cost of establishing and maintaining the pasture. To maximise gain per hectare, one needs to stock at a stocking rate of at least 60 goats/ha (does with kids at foot). Since the stocking rates tested were not heavy enough for the good years experienced, the stocking rate at which maximum gain per hectare occurs was not reached and therefore can't be stipulated, only extrapolated. The choice of an optimum stocking rate must be a compromise between production per hectare, stability of pasture, stress to livestock, soil conservation and body condition score (de Villiers *et al.,* 1994).

Acknowledgements

The KwaZulu-Natal Department of Agriculture and Rural Development is gratefully acknowledged for funding this project, and Margie Whitwell for the statistical analyses.

Author contributions

Conception and design: SDH; data collection and analysis: SDH; drafting of paper: SDH; critical revision and final approval of version to be published: KPK.

Conflict of interest declaration

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

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