

The performance of Boer goats browsing *Leucaena leucocephala* in KwaZulu-Natal, South Africa

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Abstract

The introduction of mimosine detoxifying microbes to the rumens of African livestock eliminates the need to restrict the levels of *Leucaena leucocephala* in their diet to avoid mimosine toxicity. The performance of weaned Boer goats, which were inoculated with mimosine-detoxifying microbes, browsing stands of both *L. leucocephala* cv. Cunningham and var. Spectra was studied over 2 seasons. Goats were stocked at 8.6, 15 and 20 goats/ha for 120 days in 1994–95, and 11.5, 15, and 20 goats/ha for 140 days in 1995–96. No obvious signs of mimosine toxicity were visible during the trial. Weight gains were positive, except during the period immediately after the goats were introduced to the trial in 1994 and after short periods off the trial in the mid-summer of both seasons, necessitated by drought- and hail-induced defoliation of the leucaena trees. The mean individual animal performance over both years and leucaena types was 87 ± 6.4 g/d, with gains approaching 200 g/d at times. There were no differences ($P > 0.05$) in gain per animal between leucaena types or stocking rates. Therefore, gain per hectare increased with increasing stocking rate, resulting in a significantly ($P < 0.05$) greater gain per hectare at the high stocking rate than at the lowest rate in both seasons, for both leucaena types. In total, over the whole experimental period, the high stocking rate treatment produced 82 kg/ha more live mass than the low stocking rate treatment in 1994–95 (over 98 days) and 85 kg/ha more live

mass in 1995–96 (over 126 days). The productivity of Boer goats browsing leucaena could possibly be improved by providing a mineral supplement and a high energy base fodder (e.g. grass), as leucaena foliage is inherently low in phosphorus, sodium and digestible energy.

Introduction

Recent land reform initiatives in South Africa (Anon. 1996), which aim to secure land for previously disadvantaged farmers, will most likely result in increased subdivision of grazing land. Intensification of forage production may be required on the resultant smallholdings if commercially viable livestock enterprises are to be achieved. Forage tree legumes can play an important role in intensive livestock production systems where the existing natural forage resources may be of limited quality and quantity (Reynolds *et al.* 1988).

Leucaena (*Leucaena leucocephala*), a highly productive and palatable pantropical legume, is one of the most widely used forage trees in agropastoral enterprises as it provides a number of other resources (e.g. fuelwood, green manure, shade etc.) apart from its protein-rich forage (Brewbaker *et al.* 1985). Increased levels of leucaena in the diet of both large and small ruminants have, in numerous studies, been shown to have a positive impact on forage intake and live-weight gain (e.g. Yates and Panggabean 1988; Quirk *et al.* 1990). One problem with leucaena, however, is that the ingestion of large quantities of the non-protein amino acid mimosine, present in its foliage, can lead to acute and chronic toxicosis, resulting in weight loss and even death (Hammond 1995). Mimosine toxicity can be eliminated by infusing ruminants with rumen microbes (*Synergistes jonesii*) capable of degrading mimosine and its toxic degradation products, 3,4 and 2,3-dihydropyridine (DHP) (Jones and Lowry 1984). The introduction of

DHP-degrading microbes into ruminants in Africa (ILCA 1986) potentiates increased use of leucaena for animal production. The performance of such treated ruminants on a diet high in leucaena needs further study (Balogun and Otchere 1995), particularly in South Africa, where there is a dearth of knowledge on the animal production potential of leucaena.

The objective of our study was to measure the performance of Boer goats, infused with DHP-degrading rumen microbes and browsing *L. leucocephala*, as a first step towards developing management prescriptions for its use in subtropical southern Africa. Goats are an important component of subsistence agro-pastoral farms in KwaZulu-Natal and elsewhere in southern Africa and there is a growing demand from urban areas for live animals for ceremonial use and for meat for consumption (Casey and Van Niekerk 1988). The Boer goat, an extremely fecund meat-producer, was chosen for the study as it has the potential to exhibit high weight gains on a good quality diet (Skinner 1972).

Materials and methods

Site

The study was undertaken at the Ukulinga Research Farm outside Pietermaritzburg (30°24'S, 29°24'E; 700 m altitude), in the subtropical hinterland of KwaZulu-Natal, South Africa. The mean annual rainfall is 735 mm, falling mostly in summer between October–April. Mean annual maximum and minimum temperatures are 25.7 and 8.9°C, respectively. Light to moderate frosts occur occasionally in winter. The study site (2.8 ha) was located on a silt-loam soil, 0.5–0.75 m deep. Although, with a pH (KCl) of 4.56, the soils were ostensibly somewhat marginal for the optimum growth of leucaena (Shelton 1994), the proportion of exchangeable acidic cations (H^+ and Al^{3+}) was only 1%.

Plants

In October 1993, two types of *Leucaena leucocephala* (hereafter leucaena) were planted, after inoculation of the seed with an appropriate rhizobium strain (Pauw 1994), in hedgerows (1 x 0.30 m), resulting in a plant density of c. 10 000–14 000 plants/ha. The two leucaena types were:

(1) the widely used cv. Cunningham (Brewbaker *et al.* 1985); and (2) var. Spectra — a high-yielding, multi-branched variety currently under study in South Africa (Pauw 1994). A basal dressing of 180 kg/ha KCl and 175 kg/ha superphosphate (11.3% P) was applied at planting, with a further 175 kg/ha superphosphate a year later. Intensive weed control was undertaken to promote seedling establishment and growth. Two camps (paddocks) had to be re-planted in 1995 because of poor establishment. The leucaena plants were browsed first in October 1995 when they were taller than one metre. During the trial, browsing by the goats prevented the trees from growing beyond their reach (<1.75 m). Although some bark-stripping by the goats was observed in late summer in both years, this did not kill any of the leucaena trees. The plants were free of leucaena psyllid (*Heteropsylla cubana*), although the arrival of the psyllid in southern Africa is imminent (B Mappedoram, personal communication; Range and Forage Institute, Pretoria).

Animals

Five-month-old weaned Boer goat castrates were used in the trial. The average initial mass of the 30 animals used during 1994–95 and the 40 animals used during 1995–96 was 16.0 ± 0.37 kg and 16.5 ± 0.40 kg, respectively. During the trial, the goats were housed nightly together with goats previously infused with DHP-degrading rumen bacteria. In 1995, a qualitative colorimetric test for the presence of DHP in the urine (Jones and Megarrity 1986) indicated that DHP-degrading microbes had colonised the new trial animals within a period of approximately 3 weeks. The goats were fed leucaena for a week before the start of the trial in 1994. This preconditioning period was lengthened to 3 weeks in 1995.

Treatments

Goats were stocked at 3 rates, calculated to provide a range of herbage availabilities based on the expected leucaena production (*viz.* Maclaurin *et al.* 1982) and intake of Boer goats (Hofmeyer and Lategan 1964). Animals were blocked according to weight and 3 animals were allocated to each of 2 replicate camps for each leucaena type, with camps varying in size (0.15, 0.2 and 0.35 ha) to provide the range of stocking rates. During the

first year of the trial (1994–95) the stocking rates were 8.6, 15 and 20 goats/ha. In the second season, the light stocking rate was increased to 11.5 goats/ha (*i.e.* 4 animals/camp) to exploit the expected increased forage production from maturing trees. Liveweight gains were measured weekly following overnight fasting.

Camps were divided into 4 cells to facilitate a flexible rotational browsing schedule where animals were moved once most of the forage available in a particular cell was depleted. Complete utilisation was, however, not always possible, especially at the low stocking rate. The rate of rotation through the cells varied widely over the seasons and among stocking rates, with animals in the low stocking rate treatment taking, on average, 5–7 days longer to complete a cycle (about 5–7 weeks) than those in the medium and high stocking rate treatments.

A severe summer drought (rainfall 60% of normal), which resulted in complete leaf drop, necessitated interrupting the trial for 22 days in December 1994 and terminating treatments prematurely in mid-February 1995. In January 1996, animals were removed from the trial for 2 weeks because of extensive defoliation of the leucaena trees by hail. During these periods off the trial, the goats had unlimited access to a *Cynodon* hybrid (Coastcross 2; Theron and Arnott 1977) pasture.

Plant measures

A comparative yield procedure (Haydock and Shaw 1975) was used to estimate edible dry matter (EDM) available in each camp at the start of each experimental period. The EDM (leaves and stems of diameter <4 mm) available on 100 trees per camp was rated on a 5-point scale (to the nearest half-point) relative to a reference set of trees ($n = 5$) with a known amount of edible dry matter. A cut-off browsing diameter of 4 mm for EDM was determined by measuring the terminal diameter of browsed stems and twigs on a sample of trees ($n = 2000$) from a heavily browsed stand of leucaena prior to the start of the trial. Standing grass biomass was estimated from 50 pasture disc meter readings per camp in January 1996 (Bransby and Tainton 1977).

Statistical analysis

The average daily gain (ADG) of groups of animals on each treatment and the total gain per

hectare over the experimental period were subject to 2-way analysis of variance (ANOVA) to test the effects of stocking rate, leucaena type, and their interaction, with tree density as a covariate. Means were compared with a Tukey's HSD test. ANOVA was also used to test for differences among treatments in EDM available at the start of the early and late summer grazing periods, and standing grass biomass in January 1996.

Results

In both seasons, the goats browsing leucaena displayed no obvious external signs of mimosine toxicity (*e.g.* loss of appetite and hair, excessive salivation). However, due to the abnormally high rainfall received during the 1995–96 season (200% of normal), levels of internal parasites (*i.e.* wireworm and roundworm) were high, particularly in late summer. These infestations resulted in the death of one experimental animal, despite a regular dosing program, and may also have been responsible for the poor animal productivity during the late summer period (Figure 1).

Weight gains were initially low, and even negative in some cases, when animals were introduced to the trial in October 1994 (Figure 1). A similar decline in weight, following the re-introduction of animals to the trial after the enforced mid-summer break, was observed in all treatments in 1994–95 and in most treatments in 1995–96. In contrast, animals gained weight rapidly from the start of the second year of the trial in October 1995 (Figure 1). Such responses suggest the need for an adequate period of adjustment to a diet high in leucaena.

In both seasons, animal performance (ADG) did not differ significantly between the 2 leucaena types and was not influenced by stocking rate ($P > 0.05$). Variability in performance among replications of some treatments was high and inconsistent across years (*e.g.* *cv.* Cunningham at 15 animals/ha) (Tables 1 and 2). Such variability was not related to variation in tree density. The highest ADGs during the experimental period were achieved during the late summer period of 1994–95 and during early summer in 1995. After the initial period of weight loss in the late summer of 1994–95, the mean ADG until the end of the experimental period was 200 ± 8.8 g/d.

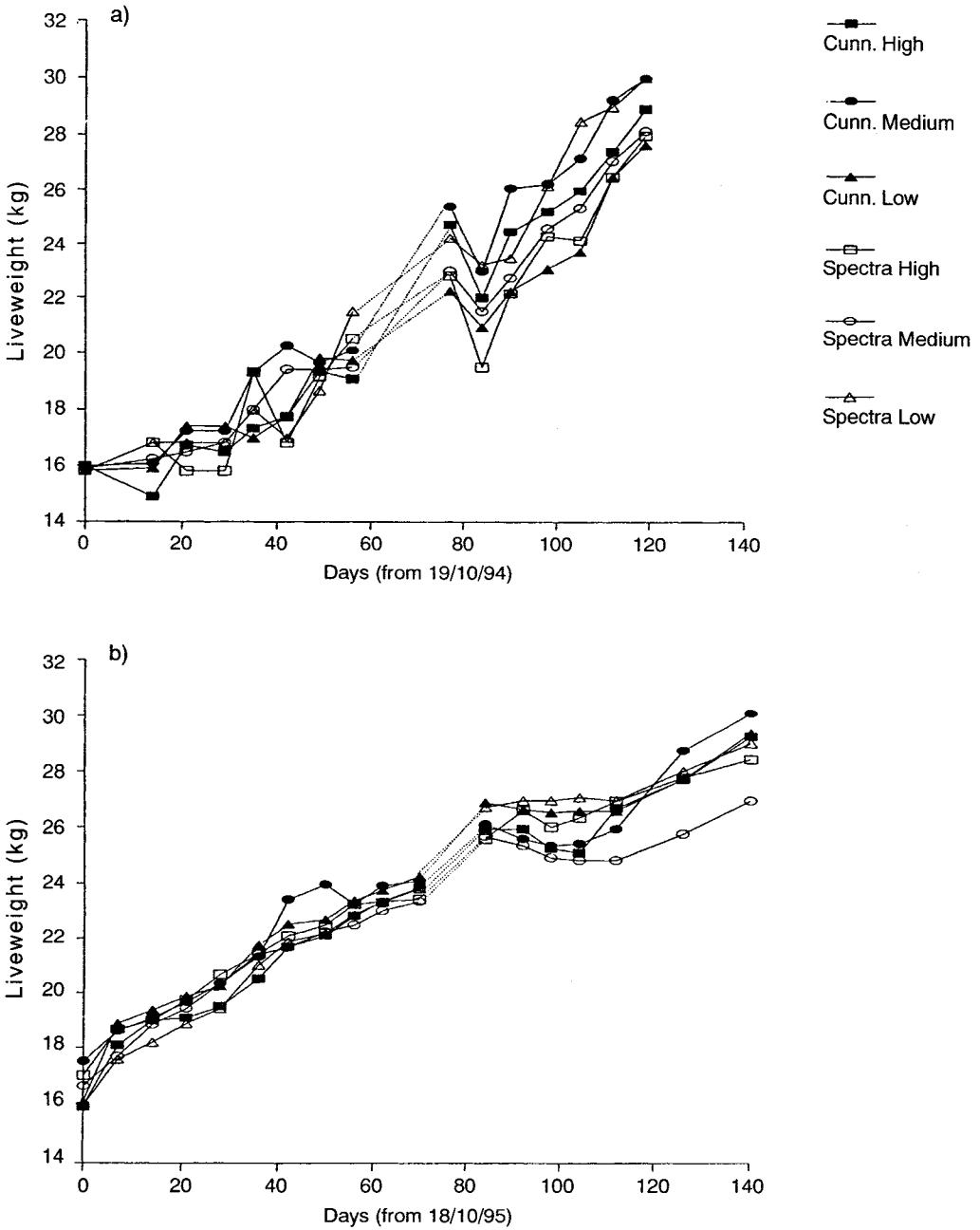


Figure 1. Liveweight changes of Boer goats browsing two lines of *Leucaena leucocephala*: cv. Cunningham (Cunn.), and var. Spectra, at three stocking rates in: (a) 1994-95; and (b) 1995-96. Dotted lines indicate periods when animals were off the trial.

Table 1. Mean (\pm s.e.) average daily gain (ADG) and gain per hectare of Boer goats at three stocking rates on two lines of *Leucaena leucocephala* during early and late summer in 1994–95.

<i>L. leucocephala</i> type	Stocking rate (animals/ha)	ADG (g/d)		Total gain (kg/ha)	
		early summer	late summer	early summer	late summer
cv. Cunningham	8.6	70 \pm 8.0	129 \pm 2.0	33.7 \pm 3.85	46.6 \pm 0.72
	15.0	73 \pm 25.0	109 \pm 10.0	61.3 \pm 21.00	68.7 \pm 6.30
	20.0	56 \pm 7.5	99 \pm 8.0	62.2 \pm 8.40	83.2 \pm 6.72
var. Spectra	8.6 ¹	101	137	48.6	49.5
	15.0	64 \pm 7.0	123 \pm 4.0	53.8 \pm 5.88	77.5 \pm 2.52
	20.0 ¹	83	123	93.0	103.3
Mean		75 \pm 6.5	120 \pm 5.6	58.8 \pm 8.06	71.5 \pm 8.74

¹One replication was excluded from the trial because of poor seedling establishment.

Table 2. Mean (\pm s.e.) average daily gain (ADG) and gain per hectare of Boer goats at three stocking rates on two lines of *Leucaena leucocephala* during early and late summer in 1995–96.

<i>L. leucocephala</i> type	Stocking rate (animals/ha)	ADG (g/d)		Total gain (kg/ha)	
		early summer	late summer	early summer	late summer
cv. Cunningham	11.5	117 \pm 16.9	45 \pm 15.6	94.1 \pm 13.63	28.8 \pm 10.06
	15.0	94 \pm 8.3	71 \pm 29.7	98.7 \pm 8.70	59.9 \pm 24.97
	20.0	113 \pm 3.5	60 \pm 2.9	158.5 \pm 5.00	66.7 \pm 3.30
var. Spectra	11.5	113 \pm 3.6	41 \pm 10.0	90.6 \pm 2.93	26.7 \pm 6.44
	15.0	96 \pm 23.1	22 \pm 4.5	100.7 \pm 24.22	18.8 \pm 3.75
	20.0	92 \pm 8.3	51 \pm 26.8	128.4 \pm 11.60	56.6 \pm 30.00
Mean		104 \pm 4.6	48 \pm 6.9	111.8 \pm 10.82	42.9 \pm 8.33

Individual livemass gains during the 2 periods when animals had to be removed from the trial, during which time they grazed *Cynodon* grass, were generally higher than gains immediately before and after these periods (Figure 1). ADG of all animals was 186 \pm 22.5 and 168 \pm 15.7 g/d during the periods off the trial in 1994–95 and 1995–96, respectively.

Since individual animal performance was not adversely affected by increased stocking rate, mass gains per unit area increased with increasing stocking rate (Tables 1 and 2). However, the only significant differences in production per hectare occurred during late summer of the 1994–95 season and early summer of the 1995–96 season when the gain per hectare was significantly ($P<0.05$) larger under the high stocking than at the low stocking rate for both leucaena types. The average difference in gain per hectare between the high and the low

stocking rate treatments was 29.3 \pm 7.78 kg/ha and 51.1 \pm 19.92 kg/ha during the late summer period of the first, and the early summer period of the second seasons, respectively. Over the whole experimental period, the high stocking rate treatment produced 81.7 kg/ha more live mass than the low stocking rate treatment in 1994–95 (over 98 days) and 85 kg/ha more live mass in 1995–96 (over 126 days).

The amount of EDM available in the camps at the start of the early and late summer periods in both years did not vary significantly among stocking rates and leucaena types ($P>0.05$), resulting in large differences among stocking rates in the amount of EDM available per animal. Although it was expected that forage production would increase as the leucaena plants matured with age, less EDM was available, on average, during the second year of the trial than at comparable times during the first year. The respective

mean EDM in the 12 camps in October 1994 and October 1995 was 1444 ± 143 kg/ha and 181 ± 18 kg/ha. In January 1995 and 1996, the mean EDM was 836 ± 147 kg/ha and 253 ± 35 kg/ha, respectively. The productivity of leucaena may have been depressed during the second year of the trial (despite favourable rainfall) by relatively unpalatable grasses (*Eragrostis* and *Sporobolus* spp.) which invaded the trial site during the late summer–autumn period of the 1994–95 season. In January 1996, the grass sward was equally dense in all camps ($P > 0.05$) with an overall mean standing biomass of 2305 ± 48 kg/ha.

Discussion

The ADGs achieved by Boer goats browsing leucaena during this study are, at times, comparable with those of similar aged Boer goats on intensive feeding regimes. With *ad libitum* access to a high-quality diet, post-weaning (*i.e.* >150 days old) liveweight gains of Boer goats have ranged from 139 g/d (Dreyer 1975) to over 200 g/d (Van Niekerk and Casey 1988), depending on feed type. In more extensive farming systems in sub-humid savanna, where goats are usually stocked at c. 0.5 animals/ha, gains of only 60–80 g/d can be expected from weaned Boer goats (Raats 1982; Unpublished data, Döhne Agricultural Research Station, Eastern Cape). Therefore, the results of our study suggest that the inclusion of leucaena in such production systems could increase individual animal performance and allow for higher stocking rates. However, the long-term effect on plant vigour and tree mortality of the relatively high stocking rates that were used in our trial still needs to be quantified.

The lack of effect of stocking rate on ADG, despite large differences between stocking rates in the amount of leucaena available per animal at the start of each grazing period, suggests that some factor other than forage quantity could have limited animal productivity to levels below that of the potential maximum (*viz.* Van Niekerk and Casey 1988). Although no detailed internal examinations of the animals were conducted (*e.g.* thyroid weights), the lack of external manifestations of mimosine toxicity suggests that production was most likely not limited by mimosine-associated toxicosis. Internal parasite infestations

appeared to have restricted productivity during the wetter periods, despite a monthly dosing program.

The quality of the leucaena leaf material ingested by the animals in the different stocking rate treatments may have varied as a consequence of different rates of rotation through the paddocks. Periods of occupation and absence were longer at the low than at the medium and high stocking rates. Therefore, goats at the low stocking rate could have consumed a higher proportion of older, lower quality leaves (Jones 1979; Child *et al.* 1982) than those in the higher stocking rate treatments. It is, however, unlikely that such differences in forage quality would have compensated for the large variation among stocking rates in the amount of leucaena available for consumption.

The digestible energy, phosphorus and sodium concentrations in leucaena foliage are low compared with those for other tree legumes (Jones 1979; Garcia *et al.* 1996). Mineral and energy deficiencies could, therefore, have limited the productivity of all goats on the trial as their diet was presumably high in leucaena during the trial period. This could also explain why the gains of goats were relatively high during periods off the trial when they had access to a high energy feed (*i.e.* grass pasture) with no known mineral deficiencies (Bransby 1984). Therefore, mineral supplementation of goats will most likely be needed to avoid nutrient deficiencies and imbalances if leucaena dominates their diet (Fariamarmol *et al.* 1996).

In agro-pastoral systems it is unlikely that a protein-rich forage such as leucaena will be the sole feed of livestock (*e.g.* Kumar *et al.* 1987). Forage legumes are usually used to supplement whatever forage is available to livestock from local vegetation or from crop stover (Jones 1979). The level of supplementation required depends on the quality of the basal diet, but the best animal performance is generally achieved when leucaena constitutes 40–60% (DM) of the diet (Norton 1994). Supplementation may be particularly important to prevent weight loss during the dry season when the quality of the available fodder is at its poorest (Zacharias *et al.* 1991).

In areas (such as the present study site) which receive frost and are subject to periodic drought, careful management of *L. leucocephala* stands will be required to allow for some forage consumption during the growing season while conserving a portion of the crop as hay for winter

use. Alternatively, other, more cold-tolerant leucaena species (e.g. *L. diversifolia*), or more drought-hardy local or exotic evergreen forage trees could be used together with leucaena to provide a constant flow of protein-rich fodder and energy, and a supply of other products such as fuelwood and green manure. Diversity in forage production would insure against drought and devastating disease infestations, such as that caused by the leucaena psyllid (Van den Beldt and Napompeth 1992).

Acknowledgements

The assistance of N. Shandu and S. Shoba in the field is gratefully acknowledged. Prof. N.M. Tainton, Dr T.M. Everson, and an anonymous referee provided useful comment on an earlier draft.

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(Received for publication March 5, 1997; accepted May 15, 1998)