Reproductive performance of South African indigenous goats inoculated with DHP-degrading rumen bacteria and maintained on *Leucaena leucocephala*/grass mixture and natural pasture

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Abstract

This study examined the reproductive performance of dihydroxy pyridone (DHP)-inoculated South African indigenous (SAIG) female goats maintained on two dietary treatments: (i) *Leucaena leucocephala*/grass mixture and (ii) natural pasture prior to conception, and during gestation. *Leucaena leucocephala*/grass mixture was nutritionally superior (crude protein and mineral elements) than the natural pasture. The average daily gain, products of pregnancy and foetal development in gravid goats raised on leucaena/grass mixture were significantly ($P < 0.03$, $P < 0.009$ and $P < 0.005$, respectively) higher than those raised on natural pasture. Conception rate of goats fed natural pasture was higher than the band fed *Leucaena leucocephala*/grass mixture. Leucaena/grass mixture fed goats had kids that were heavier at birth than their counterparts on natural pasture. Pre-weaning kid mortality over the period of study was significantly ($P < 0.01$) higher in the *Leucaena leucocephala*/grass mixture treatment. Colostrum from kidded goats fed leucaena was viscous and difficult to sample. The absence of mimosine toxicity symptoms suggests a possibility of safe use of leucaena as a feed resource to DHP-inoculated SAIG. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Leucaena; Natural pasture; South African indigenous goats (SAIG); DHP-degrading rumen bacteria; Reproductive performance

1. Introduction

In subsistence agriculture common in developing countries, farmers keep small ruminants for sale, consumption and personal use. Gross income is determined by the number of offspring produced by the females in the band (Steinbach, 1988) which implies that high fertility and prolificacy are desirable and pre-requisites towards increased productivity (Bradford and Berger, 1988). However, one of the greatest constraints to high productivity is nutrition and protein rather than energy is the most limiting nutrient in ruminant diets (Preston and Leng, 1987). Productivity from tropical native pastures is limited by poor soil fertility (Cocks and Thomson, 1988). Fertilization or incorporation of some leguminous forage such as leucaena species can partly alleviate this problem. Leucaena flourishes well in the absence of

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expensive nitrogenous fertilizer (Cocks and Thomson, 1988) and rejuvenates soil fertility through nitrogen fixation. Leucaena species improve nitrogen status of the soil and are useful animal fodder with considerable potential towards meeting the protein need of ruminants especially in developing countries where the use of protein concentrates is becoming increasingly expensive. Substantial benefits on intake, digestibility and growth of ruminants has been reported from short term studies on leucaena under zero grazing conditions (Bonsi et al., 1996; Kaitho et al., 1998).

Plants generally evolve thorns, fibrous foliage, secondary compounds and peculiar growth habits as protective mechanisms from defoliation and continuous existence (Rozenthal and Janzen, 1979). Common secondary compounds in leucaena species comprise mimosine and tannins which vary in proportions depending on the species, accession and climate (Yeh, 1983; Kewalramani et al., 1987; Nsahlai et al., 1995). In ruminant feeding, tannins bound to proteins are beneficial at moderate levels and detrimental at high levels (Kaitho, 1997). The extensive use of leucaena is hindered by the presence of mimosine (Jones, 1981). In cattle, mimosine adversely affects reproduction by lowering calving percentage (Holmes, 1980; Jones et al., 1989), increasing still birth (Jones et al., 1976) and death (Pratchett et al., 1991; Hammond, 1995).

Since the Republic of South Africa does not fall within the leucaena naturalised areas, native ruminants cannot consume excessive leucaena species with impunity because they lack DHP-degrading rumen bacteria. The introduction of mimosine detoxifying microbes to the rumens of South African Boer goats eliminates the need to restrict the levels of leucaena species in their diets to avoid mimosine toxicity (Morris and du Toit, 1998). South African indigenous goats (SAIG) inoculated with DHP-degrading rumen bacteria were raised at the Ukulinga Research Farm of the University of Natal with the sole aim of building a goat band for the institution. The inoculated female goats were exposed to leucaena and their reproductive performance (poor conception and high pre-weaning kid mortality) declined persistently. Inoculation of unadapted ruminants with DHP-degrading rumen bacteria contained in the rumen digesta of stock from leucaena naturalised or native land was reported to overcome leucaena toxicity associated with the extensive use (>30% of basal diet) of the forage (Jones, 1985; Jones and Megarrity, 1986).

The potency of inoculating SAIG with DHP-degrading rumen bacteria has not been properly documented. Though inoculated goats at Ukulinga Research Farm exposed to leucaena did not exhibit alopecia or incoordination; poor reproductive performance in the form of poor conception and high pre-weaning kid mortality continued to occur. This study aimed at evaluating the reproductive performance of inoculated indigenous stock fed Leucaena leucocephala/grass mixture and natural pasture prior to conception and during gestation.

2. Materials and methods

2.1. Site

The study was carried out during the 1997/1998 and 1998/1999 seasons at the Ukulinga Research Farm of the University of Natal, Pietermaritzburg (29°40'S; 30°24'E). The average annual precipitation during the periods of study was 748.5 mm, and the average temperatures in winter and summer were 10 and 30°C, respectively.

2.2. Animals

Thirty and twenty four South African indigenous goats popularly referred to as ‘Nguni goats’, purchased locally were used in years 1 and 2 of the study, respectively. The Nguni goats are one of the South African un-improved indigenous goat breeds. They are smaller in size than the Boer goats and have a short-haired coat. The coat colours vary, ranging from black, brown and white and combination of the three colours. Nguni goats are kept primarily for meat and cultural practices. The females were introduced into a band in which goats were previously inoculated with DHP-degrading rumen bacteria (Synergistes jonesii strain) from Australia and were treated against endo- and ecto-parasites. The animals were randomly divided into two equal groups and assigned to their respective treatments. The live weights at bucks introduction were 36.12 (s.d. = 12.00 kg) and 38.62 (s.d. = 8.52 kg) on the leucaena and veld treatments, respectively.
2.3. Experimental treatments

The two experimental treatments comprised, *Leucaena leucocephala*/grass mixture and natural pasture. Grasses on leucaena plots were *Eragrostis curvula* and *Panicum maximum*. Browses on the natural pasture include: *Acacia karoo, Acacia nilotica, Acacia sieberana, Coddia rudis, Dalbergia obovata, Ehretia rigida, Peristrophe natalense, Rhus dentata, Rhus pentheri, Maytenus senegalensis, Hippobromus pauciflorus* and *Ziziphus mucronata*. Predominant grasses comprised: *Cynodon dactylon; Chloris gayana; Eragrostis plana; Panicum maximum; Setaria sphacelata; Setaria nigrinostoris; Sporobolus africanus; Themeda triandra; Heteropogon contortus; Tristachya leucothrix* and falling leaves from Bamboo stands. The animals were allowed to acclimatize for a period of 3 months in order to accustom to their respective dietary treatments. To avoid unplanned breeding, males were not allowed to interact with the females. During and post-acclimatization period the animals had access to their respective treatment diets between 08:00 h and 15:00 h daily. They were moved to separate night camps between 15:00 h and 15:30 h where they were allowed unlimited grazing access to Kikuyu grass (*Pennisetum clandestinum*) and clean water and remained there till 07:30 h the following morning before being moved to their respective day camps.

2.4. Reproductive management

At the end of the acclimatization period, the females on both treatments were allowed to naturally come on heat in Year 1 while in Year 2, their oestrous cycles were synchronized using progesterone releasing invaginal drug (PRID). A sponge containing PRID was inserted and retained in each goat vulva for 14d and then removed. The two bucks were assigned a treatment each 48 h after the removal of PRID to detect and service females on heat using the mating ratio 1:15 (male:female). The bucks were retained permanently in their respective female band for subsequent heat detection and servicing of females that failed to conceive during natural oestrus or synchronized oestrus. No mineral supplements were given during gestation in both years of the study.

2.5. Sampling treatment diets

Samples of treatment diets were first obtained by setting out 2 days each week (a day for each treatment) during the Year 2 study. Two does from each treatment were randomly selected and observed at close range between 08:00 h and 15:00 h and samples of all forage species grazed or browsed taken by hand and pooled. The samples were air-dried and stored pending laboratory analysis.

2.6. Measurements

During Year 1, records kept were parturition date, birth type, kids birth weight (recorded within 24 h of birth) and pre-weaning kid mortality. Year 2 measurements comprised:

(a) **Live weight changes of does during gestation:** The does were weighed immediately at bucks introduction and subsequently at 3, 5, 9, 11, 14, 16, 18, 19, 20 and 21 weeks post-bucks introduction using RUUDWEIGH, KM-2E electronic weighing system (RUUDSCALE, P.O. Box 298, Durbanville, South Africa).

(b) **Conception:** Conception and birth type (single, twins and multiples (>2)) in both treatments were first determined 50 days after bucks were introduced in Year 2 and foetal development was monitored by measuring the foetal external brain case diameter on the 76th, 91st and 105th day post-bucks’ introduction using Scanner 200 VET (Pie Medical Philipsweg 16227 AJ MASTRICHT, The Netherlands.) fitted with linear array probe which enhanced coverage and view.

(c) **Pregnancy variables:** Pregnancy variables (products of pregnancy, foetal growth rate, average daily weight gain of does) were derived from the live weight changes of gravid does during Year 2 based on the assumptions that live weight of pregnant goats during gestation often indicate foetal prenatal development (Amoah et al., 1996) and secondly, pregnant goats grew at a constant rate during gestation. Based on these assumptions, the cumulative weight of the products of pregnancy were derived.

\[
\text{PGADG} = \frac{\text{PGLWP} - \text{PGLWB}}{\text{GL}}
\]

\[
\text{PGLWt} = \text{PGLWB} + \text{PGADG}_t
\]
(iii) FGRG is the mean weekly changes in products of pregnancy during gestation and was estimated weekly by regressing the difference between the pregnant goats live weight during gestation (products of pregnancy inclusive) and pregnant goats live weight during gestation (excluding products of pregnancy) on gestation length (in days). Gestation length was calculated retrospectively based on the kidding date and gestation length of 151 days (Amoah et al., 1996).

PGADG is the pregnant goats average daily gain, PGLWP the pregnant goats live weight at parturition, PGLWB the pregnant goats live weight at bucks introduction, PGLWt the pregnant goats live weight at time \( t \), PGADGt the pregnant goats average daily gain at time \( t \) and FGRG the foetal growth rate during gestation.

(d) Does and kids live weight at kidding: The does and kids were weighed within 24 h of kidding.

(e) Colostrum sampling: Hand milking of colostrum was carried out only in Year 2 of the study (within the first 12 h of kidding).

(f) Reproductive traits: The following expressions were used in determining fertility

(i) Pre-weaning kid mortality = (Pre-weaning kid mortality/No. of live kids at birth) \( \times \) 100.

(ii) Prolificacy = No. of live kids at birth/No. of kidded goats.

(iii) Fertility rate = (No. of kidded goats/No. of female goats joined to buck) \( \times \) 100.

(iv) Kidding rate = (No. of kids born/No. of female goats joined to buck) \( \times \) 100.

2.7. Laboratory analyses

Treatment diets were analysed for dry matter (DM), crude protein (CP) (Dumas combustion using Leco Model No. 602-600 and for nitrogen determination and crude protein automatically calculated as N \( \times \) 6.25), ether extract (EE) and ash (AOAC, 1984). Acid detergent fibre (ADF) and neutral detergent fibre (NDF) were determined according to the procedures of Van Soest et al. (1991).

2.8. Data derivation and statistical analysis

Scanner accuracy was calculated for goats considered pregnant and non-pregnant based on numbers that actually kidded. Statistical analysis of kids birth weight entailed analysis of variance using the general linear model (GLM) of MINITAB software statistical package (Minitab, 1998) in which the weights of does at bucks introduction were used as covariate. The live weights of the pregnant goats at bucks introduction, their gross live weights increases 21 weeks post-bucks’ introduction, pregnancy variables, foetal external brain case diameter and kids weights at birth during Year 2 were appropriately paired and subjected to regression analysis according to Snedecor and Cochran (1971). Foetal growth rate, pregnant goats average daily gains and products of pregnancy were subjected to analysis of variance (ANOVA) with the live weights of goats at bucks introduction and birth type as covariates using the GLM available in SAS (SAS, 1987). Years 1 and 2 breeding records were used to determine the does reproductive performance: conception and fertility rates; prolificacy; kidding rate; birth type and pre-weaning kid mortality in both treatments using the appropriate mathematical expression and where possible \( \chi^2 \)-test as described by Steel and Torrie (1960) was employed.

3. Results

3.1. Health of animals

One of the pregnant does on the leucaena treatment died due to acidosis (as contained in Pathological results: Allerton Provincial Veterinary Laboratory, Private Bag X2, Cascades, South Africa) from accidental consumption of excessive amount of corn-based concentrate intended for steers in nearby pens. The records did not include data from this doe. Another doe died 72 h post-kidding from intestinal verminosis and fatty hepatosis as revealed in the post-mortem result; two of her three kids died a few hours later, but post-mortem results revealed no obvious pathological cause. However, the health of other animals in both treatments was good. Pregnancy lasted for 22 weeks and kidding in both treatments took place in the same season (month of May) in years 1 and 2, but was more widely spread in Year 1. All pregnant does in both treatments kidded within 1 week and there was no sign of dystocia. However, one still birth occurred in each of the groups and data from these
animals were not included in the records. The pathological examination results revealed no specific pathological cause. The most common symptoms associated with mimosine toxicity were not observed during the experimental period.

3.2. Chemical composition of the forage on experimental plots

The chemical composition of the forage on the experimental plots is contained in Table 1 and no statistical analysis were carried out. Crude protein content of the forage on leucaena-grass plots was about 150% more than that of the natural pasture. The poor quality of the natural pasture was reflected in its low crude protein, high neutral detergent fibre (NDF) and acid detergent fibre (ADF) values. With the exception of iron, leucaena plots had superior concentration in all the minerals analysed.

3.3. Scanner accuracy and foetal development

The scanner was 79.2% accurate when used 50 days post-introduction of bucks to determine pregnancy, but the accuracy was poor (31.2%) when employed to determine birth type. In both treatments, no goats were diagnosed as carrying multiples (>2). There were inconsistencies when foetal external brain case diameter and kids birth weights were compared in goats that were diagnosed correctly as carrying singles and twins (Table 2). Between 76 and 105 day post-bucks introduction the average increases of the external brain case diameter of singleton and twins were 1.6 and 2.0 cm, respectively (Table 2). The pattern of foetal growth during gestation (Fig. 1) shows a linear trend from the 3rd to 20th week of gestation, but unlike the first two trimesters of gestation, the products of pregnancy of goats on the leucaena treatment were consistently heavier than those on the natural pasture. A positive and low correlation coefficient (r) was obtained between the foetal external brain case diameter and kid birth weight in both treatments, but the coefficient was higher for animals in the natural pasture treatment (Table 3). However, the correlation coefficients (r) of other regressed reproductive parameters were higher for goats on the leucaena treatment than on the natural pasture treatment (Table 3).

3.4. Growth during gestation

All pregnancy variables in the leucaena treatment were significantly higher than in the natural pasture treatment (Table 4). At bucks introduction, females assigned to the natural pasture treatment were marginally heavier than their leucaena counterparts.
However, the leucaena-reared pregnant goats recorded a higher growth rate and were significantly heavier \((P < 0.05)\) than the pregnant goats on the natural pasture by the 21st week of gestation. The goats on leucaena treatment gained weight \((P < 0.03)\) while their counterparts on natural pasture lost weight. Does on leucaena treatment had significantly \((P < 0.009)\) superior products of pregnancy and foetal growth rates by 9.8 and 14\%, respectively. The growth response of the goats to the imposed treatments during gestation is depicted in Fig. 2.

3.5. Reproductive performance

Natural pasture treatment with more pregnant goats tended to have more live kids than goats raised on the leucaena treatment (Table 5). Over the 2 year period, leucaena kidded goats successfully weaned 70\% of their kids while their counterparts on the natural pasture treatment scored 95\%. Pre-weaning kid mortality recorded for goats on the leucaena treatment over the 2 year period was significantly \((P < 0.05)\) higher than in the natural pasture treatment. Prolificacy, fertility and conception rates over the 2 year period were higher in the natural pasture treatment than in the leucaena treatment. Mean birth weight of multiple kids in the leucaena treatment was significantly higher \((P < 0.05)\) than those in the natural pasture treatment (Year 2). Birth weight of kids in years 1 and 2 for the different birth types showed that kids from does on the leucaena treatment were heavier than kids from natural pasture-reared goats. Over the 2 year period, the birth weight of all kids was inversely related to the litter size. In Year 1, pregnant goats on the natural pasture treatment recorded a higher significant proportion \((P < 0.001)\) of twins at kidding but over the 2 year period, singles and multiple birth proportions were more in the leucaena treatment.

Fig. 1. Foetal growth rate in gravid indigenous goats.

![Fig. 1. Foetal growth rate in gravid indigenous goats.](image1)

Fig. 2. Changes in mean liveweight of gravid indigenous goats.

![Fig. 2. Changes in mean liveweight of gravid indigenous goats.](image2)
Table 3
Regression analysis of certain reproductive parameters in does fed leucaena/grass mixture and natural pasture

<table>
<thead>
<tr>
<th>Parameters compared</th>
<th>Leucaena/grass mixture</th>
<th>Natural pasture</th>
<th>Significant level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foetal external brain case diameter (BCD) vs. kids birth wt. (KBW)</td>
<td>KBW = -0.14 + 0.52BCD, $r = 0.30$</td>
<td>KBW = -23.7 + 5.39BCD, $r = 0.87$</td>
<td>NS$^a$</td>
</tr>
<tr>
<td>Products of pregnancy (PP) at week 21 of gestation vs. kids birth wt. (KBW)</td>
<td>KBW = 1.95 + 0.262PP, $r = 0.92$</td>
<td>KBW = 3.11 + 0.122PP, $r = 0.67$</td>
<td>$P &lt; 0.001$ and 0.02</td>
</tr>
<tr>
<td>Pregnant goats average daily gains (PGDG) vs. products of pregnancy (PP)</td>
<td>PP = 13.4 - 0.03035PGDG, $r = 0.85$</td>
<td>PP = 9.76 - 0.0186PGDG, $r = 0.71$</td>
<td>$P &lt; 0.007$ and 0.01</td>
</tr>
<tr>
<td>Pregnant goats average daily (PGDG) gains vs. foetal growth rate (FGR)</td>
<td>FGR = 112 - 0.235PGDG, $r = 0.73$</td>
<td>FGR = 80.6 - 0.119PGDG, $r = 0.60$</td>
<td>$P &lt; 0.04$ and 0.04</td>
</tr>
</tbody>
</table>

$^a$ NS implies $P > 0.05$. 

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Table 6. Doe and buck kids constitute 60 and 40%, respectively, of the total live kids at birth in the leucaena treatment, while 43 and 57% of doe and buck kids were kidded by dams raised on natural pasture, respectively (Table 6). Over the period of study, singleton and multiple (>2) birth types kidded by goats fed leucaena were 35 and 116% more than their counterparts from natural pasture. However,

Table 4
Live weight changes of pregnant goats during gestation and derived pregnancy variables a

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Leucaena/grasss mixture</th>
<th>Natural pasture</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of pregnant goats</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Wt. (kg) of female goats at:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bucks introduction</td>
<td>36.12</td>
<td>38.62</td>
<td>4.57</td>
</tr>
<tr>
<td>21 weeks of gestation</td>
<td>48.69</td>
<td>48.33</td>
<td>5.69</td>
</tr>
<tr>
<td>24 h post-kidding</td>
<td>39.06</td>
<td>38.12</td>
<td>4.28</td>
</tr>
<tr>
<td>Gross gain in weight as at week 21 of gestation</td>
<td>12.57</td>
<td>9.71</td>
<td>1.51</td>
</tr>
<tr>
<td>Net gain change during gestation</td>
<td>2.94</td>
<td>−0.50</td>
<td>1.82</td>
</tr>
</tbody>
</table>

Pregnancy variables

| Pregnant goats average daily gain (g)          | 86.19                   | −19.78          | 74.26 |
| Products of pregnancy at 21 weeks of gestation (kg) | 10.96                   | 9.98            | 1.57 |
| Foetal growth rate during gestation (kg per day) | 93.21                   | 81.50           | 16.04 |

a Treatment means were not adjusted for the effects of covariates.

Table 5
Summary of reproductive record (fertility rate, prolificacy and pre-weaning kid mortality) of female goats fed on leucaena and natural pasture plots during years 1 and 2 a

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Leucaena/grass mixture</td>
<td>Natural pasture</td>
<td></td>
<td>Leucaena/grass mixture</td>
<td>Natural pasture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of female goats</td>
<td>15</td>
<td>15</td>
<td>12</td>
<td>12</td>
<td>3.57 b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of kidded goats</td>
<td>9</td>
<td>11</td>
<td>8</td>
<td>12</td>
<td>3.57 b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of non-pregnant goats</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0.77 b</td>
<td></td>
<td></td>
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<tr>
<td>No. of live kids at birth</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of still birth</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of kids weaned</td>
<td>8</td>
<td>19</td>
<td>13</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-weaning kid mortality</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>8.88 c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproductive traits (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-weaning kid mortality</td>
<td>46.67</td>
<td>5.00</td>
<td>13.33</td>
<td>4.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prolificacy</td>
<td>167</td>
<td>182</td>
<td>188</td>
<td>192</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fertility rate</td>
<td>60</td>
<td>73.33</td>
<td>66.67</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kidding rate</td>
<td>106.67</td>
<td>133.30</td>
<td>125</td>
<td>191.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth weight (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singles</td>
<td>2.50</td>
<td>2.20</td>
<td>(0.57) d</td>
<td>2.85</td>
<td>2.88</td>
<td>(0.57) d</td>
<td></td>
</tr>
<tr>
<td>Twins</td>
<td>3.00</td>
<td>2.60</td>
<td>(0.28) d</td>
<td>2.24</td>
<td>2.34</td>
<td>(0.21) d</td>
<td></td>
</tr>
<tr>
<td>Multiples</td>
<td>1.63</td>
<td>–</td>
<td>–</td>
<td>2.50</td>
<td>1.92</td>
<td>(0.17)</td>
<td></td>
</tr>
</tbody>
</table>

a Treatment means were not adjusted for the effects of covariates.

b \( P > 0.05. \)

c \( P < 0.05. \)

d Standard error.
goats raised on natural pasture treatment recorded 33% more twins than goats offered leucaena diets (Table 6).

The hand milked colostrum obtained from kidded goats fed leucaena/grass mixture was less in quantity and more viscous in appearance than samples obtained from kidded goats from natural pasture treatment. The thick or viscous nature of the colostrum made sampling difficult and thus warranted the application of intense pressure during hand milking.

4. Discussion

4.1. Gestation diets

Engels (1972) reported that there was marked difference in nutritive quality (crude protein and fibre content) between the forage obtained using hand-clipped technique and the extrusa from oesophageal fistulates and recent studies of Coates (1999) went further to show that the chemical compositions of the extrusa and the whole intake were different. However, the use of hand clipped technique reported in this study was to assist in comparing the chemical composition of the forage on the treatments plots and does not represent actual intake. The goats on both treatments were expected to select forage better in nutritive quality than the hand clipped samples bearing in mind that goats are very selective.

4.2. Effects of gestation diet on animal health, foetal development and growth during gestation

The absence of any detectable adverse effects on the health of animals assigned leucaena treatment and non-incidence of symptoms of mimosine toxicity throughout the trials suggest that the goats were effectively transferred the rumen DHP-degrading bacteria capable of detoxifying (degrading) mimosine and its toxic metabolites (2,3-DHP and 3,4-DHP) to non-toxic compounds (Alinson et al., 1990). This agrees with the report of Jones and Megarrity (1986) that DHP-degrading rumen bacteria inoculation in ruminants enhances high tolerance of leucaena intake with no deleterious consequences (Hutton, 1983; Kudo et al., 1990). The absence of dystocia during kidding in both studies could be ascribed to low birth weights (McSporran et al., 1977; Knight et al., 1988) recorded. Holmes (1980) and Holmes et al. (1981) attributed the embryonic death in cows fed high levels of leucaena to abortion and resorption of embryos, while Jones et al. (1989) attributed the poor reproductive performance to a transient effect on embryonic death. The inconsistent and inaccuracy of the scanner technique impose a great limitation in the use of its data. It is thus difficult to ascribe the 25% reduction in fertility of goats fed leucaena in this trial during Year 2, to either the transient effect on embryonic death postulated by Jones et al. (1989) or abortion and resorption as described by Holmes (1980) and Holmes et al.

Table 6
Distribution of kids by birth type and gendera

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th></th>
<th>Year 2</th>
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<th>Year 1</th>
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<th>Year 2</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Leucaena/grass mixture</td>
<td>Natural pasture</td>
<td></td>
<td>Leucaena/grass mixture</td>
<td>Natural pasture</td>
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<td>Leucaena/grass mixture</td>
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<tr>
<td>Birth type (%)</td>
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</tr>
<tr>
<td>Singles</td>
<td>33.30</td>
<td>18.20</td>
<td>–</td>
<td>25</td>
<td>25</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Twins</td>
<td>55.60</td>
<td>81.80</td>
<td>20.17c</td>
<td>50</td>
<td>58.30</td>
<td>2.30b</td>
<td>–</td>
<td></td>
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<tr>
<td>Multiples</td>
<td>11.10</td>
<td>0</td>
<td>–</td>
<td>25</td>
<td>16.70</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Kid’s gender</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>6</td>
<td>13</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>9</td>
<td>10</td>
<td>1.00b</td>
<td>–</td>
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</table>

a Treatment means were not adjusted for the effects of covariates.
b P > 0.05.
c P < 0.05.
The poor results from the scanner can be ascribed to varying presentations of the foetus during scanning. Ruminants used by Jones et al. (1989), Holmes (1980) and Holmes et al. (1981) were not DHP inoculated, which possibly accounted for the poor reproductive performance observed and reported in their studies. The usual changes in the live weight during gestation are often assumed to be indicative of prenatal development of foetus(es) (Amoah et al., 1996). Isaacs et al. (1991) likewise acknowledged that the live weight of pregnant goats during gestation affects the amount of available energy for foetal growth. Therefore, changes in the weight of pregnant goats can be used to monitor foetal development which could be a better alternative in overcoming the scanner inconsistencies and inaccuracies.

Leucaena species possess a high nutritive value as animal feed, with crude protein content ranging between 19 and 30% and high total digestible nutrient (54–70%), phosphorus, calcium and carotene (Machado et al., 1978). The improved average daily gain (ADG) associated with the use of leucaena/grass mixture during gestation could be attributed to the higher crude protein, less crude fibre content and high mineral element contents over the natural pasture and thus confirms the nutritive potential of leucaena as regards growth (Hernandez et al., 1986; Wildin, 1986; Bonsi et al., 1994, 1995; Adejumo, 1995). The higher nitrogen content of leucaena could have provided digestible protein at levels above the requirement for maintenance (Akyeampong and Dzwowa, 1996) and also accords with the reports of Akbar and Gupta (1985), Gupta and Atreja (1999) and Srivastava and Sharma (1998) that goats fed leucaena were in positive balance for nitrogen, calcium and phosphorus. Muir and Massaete (1997) studies showed that goats supplemented with leucaena gained 168% of the body weight (BW) compared to non-supplemented ones, and Morris and du Toit (1998) recently reported weight gain benefit of leucaena in DHP-inoculated Boer goats.

4.3. Effects of gestation diet on reproductive performance

The prolificacy of goats on leucaena treatment in both years of study were within the range of litter size observed under experimental conditions (Henniawati and Fletcher, 1986) and exceeded values reported by Wilson (1976) and Manjeli et al. (1996) for West African dwarf goats. The higher birth weight of kids whose dams were on leucaena/grass mixture treatment could be linked to adequate nourishment (high crude protein and mineral elements and low crude fibre contents) obtained from leucaena. This agrees with the report by Peart (1967) that dam weight during gestation influenced kid weight at birth. Bindon and Lammond (1966), in contrast, reported low kid birth weights in pregnant ewes fed leucaena 30–90 days post-rams introduction. The denial of leucaena to ewes within 30 days of rams introduction, coupled with the absence of DHP-degrading bacteria in the ewes’ rumen capable of breaking down mimosine and its toxic metabolites (2,3-DHP and 3,4-DHP), might have accounted for the low birth weights in their study. In un-inoculated ruminants, blood circulating DHP's impair thyroid gland function (Megarrity and Jones, 1983; Quirk et al., 1988) by reducing circulating thyroid hormone (Elliott et al., 1985; Hammond, 1995) and voluntary intake. Previous studies (Jones and Hegarty, 1984) have shown that supplementation of ruminants fed leucaena with thyroxine had little effect on alleviating depression in voluntary intake and that DHP has a greater depressive influence on voluntary intake. The positive net growth of the gravid goats and the higher kid birth weights on the leucaena/grass mixture could suggest that the treatment diet enhanced placenta development. Also, the high incidence of multiple births by goats on the leucaena treatment can be ascribed to the diet in line with previous reports (Gunn, 1983; Rhind, 1992) that nutrition influenced ovulation rate. Within treatment, buck kids were heavier ($P > 0.05$) than their female counterparts and overall kids weights at birth for the 2 year period within treatment decreased as the litter size increased. These observations agree with the reports of Husain et al. (1997) and Mia and Bhuiyan (1997). Pre-weaning kid mortality in the leucaena treatment during Year 1 was mainly from the twin litter. Though twins from leucaena-fed dams in Year 1 were heavier at birth than their counterparts on the same treatment in Year 2, the latter still had low pre-weaning kid mortality. The high pre-weaning kid mortality in leucaena treatment in Year 1 with higher kids birth weight seems to suggest that pre-weaning kid mortality was not due to kids’ weights at birth and agrees
with the reports of Knight et al. (1988) that birth weight difference does not account for all pre-weaning kid mortality. Previous studies (Alexander, 1964; Dalton et al., 1980) attributed pre-weaning kid mortality to season, diet, dam parity, maternal nourishment and management.

Kidding occurred during the same season in both years, but was more spread in Year 1 due to lack of oestrus synchronisation. The high significant \((P < 0.01)\) pre-weaning kid mortality may not be ascribed to seasonal variation, but probably due to problems associated with multiple births (Wilson, 1976; Manjeli et al., 1996). Twins and multiple birth types are more prone to death from mismothering (Wilson et al., 1985; Ademosun, 1992), poor maternal milk supply (Adu et al., 1979) and physiological starvation (Smith, 1977) or inappropriate management (Husain et al., 1997). Sufficient quantities of colostrum intake by the kids positively influenced their survival (Altmann and Mukkur, 1983; Mellor and Murray, 1986). Colostrum production was reported (Barnicoat et al., 1949) to be influenced by diet fed during gestation, however, the availability of large quantities of standing leucaena at the end of each study suggests that the poor colostrum supplies of the leucaena-reared goats was not due to nutritional constraint but probably due to poor rate of colostrum secretion. The intense pressure applied during hand milking of kidded goats fed leucaena in Year 2 might have positively affected subsequent milk let down (secretion rates) and offers some explanation for the reduction in pre-weaning kid mortality in Year 2. The high pre-weaning kid mortality in leucaena raised goats during Year 1, when natural suckling was not disturbed, probably was due to the kids’ inability to obtain enough colostrum which may have predisposed the kids to opportunistic infection. Calavas et al. (1995) and Goyena et al. (1997) revealed that access to colostrum effectively prevents infection.

5. Conclusions

The *Leucaena leucocephala* grass mixture favoured growth performance of pregnant goats during gestation and high kids’ birth weight. The absence of deleterious effects associated with leucaena during the study showed that leucaena can be safely fed without restriction once the indigenous goats have been transferred the DHP-degrading rumen bacteria. To further authenticate the conclusion that the high pre-weaning kid mortality obtained in Year 1 of this study was due to inadequate maternal nourishment, future studies should focus on the yield and chemical analysis of the first milk (colostrum) and subsequent milk yield during lactation.

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References


