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Influence of Nutritional Flushing Prior to Mating on the Performance of West African Dwarf Goats Mated in the Rainy Season

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Abstract: The effect of nutritional flushing for a period of six weeks prior to mating on the physical condition, serum metabolic and hormonal status at mating and litter size at birth of 32 pluriparous West African Dwarf (WAD) goats was studied using a 2 × 2 factorial design. The factors in the design were age (young, 3-4 years old versus old, 5-6 years old) and nutritional flushing regime (pasture alone versus pasture plus concentrate supplementation). The young does gained more weight and body condition (2.0±0.30 kg; 0.53±0.10 units; p>0.05) over the 6-wk nutritional flushing period than the old does (1.4±0.30 kg; 0.40±0.10 units), but the old does were heavier (p<0.05) at mating. The overall mean (±SE) total serum protein was 86.1±0.76 g/l at mating and did not differ (p>0.05) between treatments. The serum glucose concentrations were also similar for the treatment groups and averaged 2.6±0.10 mmol/l at mating. At the end of the nutritional flushing period, supplemented does had a higher (p<0.05) serum concentration of insulin (19.1±0.63 versus 15.1±0.63 <mu>IU/ml) than the unsupplemented does. Young does also had higher (p<0.05) serum insulin concentrations (19.8±0.63 <mu>IU/ml) than old does (14.3±0.63 <mu>IU/ml). Serum Luteinizing Hormone (LH) concentration at mating was similar for supplemented and unsupplemented does, but was higher (p<0.05) for young does (11.8±0.23 < mu>IU/ml) than for old does (1.8±0.23 <mu>IU/ml). Young does had a higher litter size (1.81±0.12) than old does (1.50±0.12) and supplemented does had a larger litter (1.81±0.12) than the unsupplemented does (1.50±0.12). These differences were, however, not statistically significant (p>0.05). There was, however, an interaction between age of doe and nutritional flushing treatment with young does that were supplemented having a mean (±SE) litter size of 2.13±0.18 compared to 1.50±0.18 for each of the other three treatment groups. It was concluded that young (3-4 years old) does may benefit from concentrate supplementation of wet season grazing, but that old does (5-6 years old) will not benefit from this supplementation if they are in moderate body condition six weeks before mating.

Key words: Age, condition score, goat, native pasture, reproduction, supplementation

INTRODUCTION

The West African Dwarf goat is the predominant goat breed in Ghana. This breed can be bred all year-round and has been shown to be potentially prolific. A litter size of 1.8 (Devendra, 1990; Awotwi and Fynn, 1992) and fertility rate of 99.0% (Awotwi and Fynn, 1992) have been reported for the breed in Ghana and elsewhere. But others have reported litter sizes of 1.67 and 1.56 (Ikwuegbu *et al.*, 1994) and as low as 1.30 (Reynolds 1989; Baffour-Awuah *et al.*, 2005) for the breed. Nutrition and age differences partly account for the variation in the reproductive performance reported for the breed (Adeoye, 1985 and Chowdhury *et al.*, 2002).

Nutrition is generally recognized as a significant regulator of reproduction. Flushing has, therefore, been reported to positively affect the body condition, fertility and ovulation rate of dams with poor nutritional status just before or during mating. Flushing can be accomplished either by allowing animals to graze lush nutritious pasture or by feeding energy-rich supplements (Luginbuhl and Poore 1998; Johnson, 2001). But meat goat production can be more profitable only if maximum use is made of quality pasture and browse (Luginbuhl and Poore, 1998). The small stature of the WAD goat suggests that flushing with lush native pasture, which is possible at the start of the rains, can be successful, but traditionally flushing is associated with concentrate feeding. African goats are reported by some researchers to reach their optimum reproductive performance between the ages of three and four years while others put it between five and six years (Adeoye, 1985; Webb and Mamabolo, 2004). This experiment was, therefore, to investigate whether WAD goats, segmented according to age, will gain reproductive advantage from concentrate supplementation of wet season grazing.

MATERIALS AND METHODS

Location and duration of experiment: The experiment was conducted at the National Goat Breeding Station at Kintampo, a town in the Brong Ahafo Region of Ghana, located at 08°03'N and 01°43'W. The area falls within the transitional or derived savannah ecological zone, which lies between the forest zone and the interior savannah. The vegetation is a mixture of tall trees, shrubs and grasses. The mean annual rainfall is about 1300 mm. About 69 and 31% of the rains occur in the wet (April-

October) and dry (November-March) seasons, respectively. The mean monthly temperature is 27°C while relative humidity values are 73.8% at 09.00 h and 56.7% at 15.00 h. The nutritional flushing commenced in April, at the end of a 5-month dry period and at the start of the rainy season and lasted for six weeks.

Experimental design: A two-way factorial design was applied to 32 pluriparous West African Dwarf does after weaning their kids. The mean (±SE) weight of the does was 16.3±0.35 kg with a body condition score of 1.75±0.09 units on a 5-point scale. The does were stratified into two age groups; young (3-4 years, n = 16) and old (5-6 years, n = 16). Within each age group, the does were allocated at random either to a supplemented or unsupplemented (control) group. The supplement was a home-made concentrate made up of 36.4% brewers' spent grain, 18.2% cassava root meal, 22.7% palm kernel meal and 22.7% soybean meal. Each of the supplemented does received 420 g DM/d of the concentrate supplement in separate troughs. All does grazed native pasture made up mainly of *Panicum maximum* and *Centrosema pubescens*.

Management and breeding: The does were grazed in paddocks from 08.00-16.00 h daily during the 6-wk nutritional flushing period. They were confined after grazing in two roofed dwarf-walled barns with concrete flooring. Each supplemented doe was tethered and fed the home-made supplement in individual feed troughs. At about 08.30 h the next morning the leftover feed was weighed and the intake determined by difference.
At the end of the nutritional flushing period, the oestrous cycles of all 32 does were synchronized with Cloprostenol, a $PGF_{2á}$ analogue (twice i.m. injection, 62.5 µg, 11 d apart). The does were observed in four pens for natural mating using bucks of proven fertility. Each pen contained a servicing buck and eight does which were balanced for age group and nutritional flushing regime. The goats were given generous amounts of grass while in confinement. Salt lick and drinking water were made available to the stock at all times. After all the does had been mated, they were let out to graze native pasture in paddocks. The does were monitored after mating till each one of them gave birth.

Body condition scores and live body weights: The body condition scores and live body weights of the does were recorded at the start and at the end of the nutritional flushing period. The 5-point scale described by Kinne (1995) was used for the condition scoring (1 = poor, 5 = obese). The body weights were taken with a weigh bridge (Salter, C and H Engineering).

Feed analysis: Samples of forages grazed by the stock were taken at the start of the experiment and then once every other week till the end of the nutritional flushing period. The samples were placed in rubber bags and stored in a deep freezer (-18°C). At the end of the nutritional flushing period the stored forages were bulked and a representative sample was taken for proximate analysis. Three batches of the experimental concentrate feed were used and samples from the batches were also bulked and sampled for proximate analysis. The proximate analysis was done using procedures outlined by the AOAC (AOAC, 1997).

Serum metabolic and hormonal assays: Blood samples were harvested from the stock by jugular venipuncture at the end of the nutritional flushing period. These samples were taken prior to grazing at about 07.30 h and were used for the assay of serum glucose, total protein and insulin. Blood samples were again taken 30 h following the second Cloprostenol injection for the synchronization of oestrus to analyze for Luteinizing Hormone (LH).
The concentrations of serum glucose and total protein were determined by the enzymatic colorimetric and photometric colorimetric tests, respectively. The kits were supplied by Human Biochemistry and Diagnostic Company, Germany (www.human.de). The Enzyme Linked Immunosorbent Assay (ELISA) technique (Kits supplied by Calbiotech Inc., California, USA, www.calbiotech.com) was used for the assay of insulin and LH.

Statistical analysis: The data were analyzed by the univariate analysis of variance using LSD to separate significant difference at the 5% level of significance. The SPSS computer statistical package (SPSS, 2006) was used for the statistical analysis.

RESULTS

Feeds and physical status: The chemical contents of sample forages and concentrate supplement used in the experiment are given in Table 1. The overall mean (±SE) daily concentrate feed intake was 373.1±4.13 g. The old does consumed slightly more of the concentrate supplement than the young does (378.8 versus 367.4 g/d; se = 5.84; p>0.05). The body condition score and live body weight changes in the does during the experiment are shown in Table 2. The mean live body weight and body condition score of the does on the two flushing treatments were similar throughout the experiment. The overall mean (±SE) live body weight and body condition score rose from 16.3±0.35 to 18.0±0.03 kg and 1.75±0.09 to 2.22±0.09 units, respectively. The mean (±SE) daily live weight gain for all does was 40.8±4.97 g.

Serum metabolites and hormones: Table 3 presents the levels of metabolites and hormones in the blood

Table 1: Proximate composition of sample forages and concentrate supplement eaten by West African Dwarf goat does subject to nutritional flushing for six weeks prior to mating

	Mean (g/kg dry matter)	
Constituent	Forages	Concentrate
Dry matter (g/kg wet weight)	294	935
Crude protein	97	231
Crude fibre	273	110
Ether extract	26	56
Ash	193	60
Nitrogen free extract	471	543

serum of the WAD does at mating. The overall means (±SE) for serum glucose, total protein, insulin and LH were 2.6± 0.10 mmol/l, 86.1±0.76 g/l, 17.1± 0.44 µIU/ml and 6.8±0.16 <mu>IU/ml, respectively. The mean serum glucose and total protein values did not vary between treatment groups. Age of doe and nutritional flushing regime, however, influenced ($p<0.05$) serum insulin concentrations. Serum LH concentration was also affected ($p<0.05$) by age of doe. There was an interaction ($p<0.05$) between age of doe and nutritional flushing regime with young does that were supplemented having a higher mean (±SE) serum insulin concentration of 25.2±0.89 µIU/ml compared to 14.5±0.89 µIU/ml for young does not supplemented, 12.9±0.89 µIU/ml for old does supplemented and 15.7±0.89 µIU/ml for old does not supplemented.

Litter size: The mean (±SE) litter size for all does was 1.66±0.09. The birth ratio was 12:19:1 for singles, twins and triplets, respectively. The only triplet birth occurred among the young does which were supplemented. Young does had a higher litter size (1.81±0.12 versus 1.50±0.12) than the old does and the supplemented does (1.81±0.12) had a higher litter size than the unsupplemented does (1.50±0.12). The differences were, however, not statistically significant ($p>0.05$). There was an interaction between age of doe and nutritional flushing regime with young does that were supplemented having a mean (±SE) litter size of 2.13±0.18 as against 1.50±0.18 recorded for each of the other three treatment groups.

DISCUSSION

Physical status: The present results show that the does improved in body condition and live body weight following six weeks of nutritional flushing. The does had come out of five months of dry season where herbage was in short supply and so they may have taken advantage of the lush pasture available at the start of the rains to gain rebound growth. It is generally accepted that if the feeding regime improves in healthy mature animals nutritionally deprived to the extent of resulting in a low weight-to-frame ratio, they will have rapid and efficient gains for a while before fat deposition starts (Luginbuhl and Poore, 1998). Goats are also known to be very selective browsers and so the present does may have selected and eaten only the nutritious parts of plants thereby resulting in improved body condition and live body weight during the 6-wk period of nutritional flushing.

Even though the dry matter intake of the native pasture could not be estimated in the current experiment, it appears that grazing was curtailed in anticipation of the supplement, thus reducing the expected total feed intake in the supplemented does. Van Eys *et al.* (1986) observed in Indonesian goats that feeding supplementary leucaena and gliricidia caused a reduction in grass intake. Bonsi *et al.* (1995) also reported substitution of teff straw with sesbania or leucaena in Ethiopian Menz sheep. Also, intake of napier grass was depressed when steers offered it were supplemented with *Gliricidia sepium* (Abdulrazak *et al.*, 1996). Minson and Milford (1967) reported that the stimulating effect of forage supplements was due to the supply of nitrogen. It, therefore, seems likely that the Crude Protein (CP) content of the present forages (97 g/kg DM) did not limit the intake and that once the rumen microbial requirements for Nitrogen (N) had been met, additional high quality feed did not have any stimulating effect on the forages (Abdulrazak *et al.*, 1996). The probable substitution of forages with the concentrate supplement may help to explain why the performance of the unsupplemented does could match those of the supplemented does. In any case, Acero-Camelo *et al.* (2008) reported no difference between does supplemented with either low or high level of concentrate in body condition score, body weight and litter size at birth. Him Aun (2002) also reported similarly in Cambodia that goats grazing native vegetation did not vary in growth and reproductive performance when compared to their counterparts supplemented with *Gliricidia sepium*.

Serum metabolites and hormones: The lowest mean value recorded in this experiment for total serum protein (85.3 g/l) was higher than the top of the range 58.8-61.3 g/l reported for 1-2 year old WAD bucks supplemented in Nigeria with leguminous browse for eight weeks (Ajala *et al.*, 2000). The variation in the two results may be attributed to age and sex differences. Tighe and Brown (2003) provided reference interval of 59.0-74.0 g/l for Canadian goats and explained that the levels may vary from laboratory to laboratory and may depend on the method used, as well as the breed, sex, age and the environment of the animal. Perhaps, the higher values recorded for the WAD does in this experiment reflect a rising metabolism due to improvement in the native pasture grazed by the does following the start of the rains or may indicate a more dehydrated status due to

Table 2: Body condition and body weight changes in young and old West African Dwarf goat does subject to nutritional flushing for six weeks prior to mating (mean±SE)

Variable	Age: Young (3-4 yrs; n=16)	Age: Old (5-6 yrs; n=16)	Flushing regime: Pasture grazing only (n=16)	Flushing regime: Pasture grazing plus Concentrate (n=16)
Body Condition Score*:				
Initial	1.59±0.13^{a}	1.91±0.13^{a}	1.72±0.13^{a}	1.78±0.13^{a}
Final	2.13±0.13^{a}	2.31±0.13^{a}	2.29±0.13^{a}	2.14±0.13^{a}
Total gain	0.53±0.10^{a}	0.40±0.10^{a}	0.57±0.10^{a}	0.36±0.10^{a}
Weight (kg):				
Initial	14.8±0.50^{a}	17.8±0.50^{b}	16.4±0.50^{a}	16.2±0.50^{a}
Final	16.8±0.46^{a}	19.2±0.46^{b}	18.1±0.46^{a}	17.9±0.46^{a}
Total gain	2.0±0.30^{a}	1.4±0.30^{a}	1.7±0.30^{a}	1.7±0.30^{a}
Daily weight gain (g)	47.3±7.03^{a}	34.2±7.03^{a}	40.5±7.03^{a}	41.1±7.03^{a}

*Body condition was assessed on a scale of 1-5; ^{ab}Main effect means with different superscripts are significantly different ($p<0.05$)

Table 3: Serum metabolic and hormonal characteristics of young and old West African Dwarf goat does subject to nutritional flushing for six weeks prior to mating (mean±SE)

Variable	Age: Young (3-4 yrs; n = 16)	Age: Old (5-6 yrs; n = 16)	Flushing regime: Pasture grazing only (n = 16)	Flushing regime: Pasture grazing plus Concentrate (n = 16)
Total protein (g/l)	86.9±1.08^{a}	85.3±1.08^{a}	85.7±1.08^{a}	86.6±1.08^{a}
Glucose (mmol/l)	2.6±0.15^{a}	2.5±0.15^{a}	2.7±0.15^{a}	2.5±0.15^{a}
Insulin (μIU/ml)	19.8±0.63^{a}	14.3±0.63^{b}	15.1±0.63^{b}	19.1±0.63^{a}
LH (<mu>IU/ml)	11.8±0.23^{a}	1.8±0.23^{b}	6.5±0.23^{a}	7.1±0.23^{a}

^{ab}Main effect means with different superscripts are significantly different ($p<0.05$)

tropical climate since total serum protein concentrations can be altered by the level of dehydration or over hydration (Tighe and Brown, 2003). The lack of treatment effect on serum glucose concentrations in this experiment conforms to an earlier observation made by Tanaka *et al.* (2004) that dietary restriction caused no variation in weekly plasma glucose levels between treated and control goats before breeding.

The higher ($p<0.05$) levels of serum insulin observed in the young does that were supplemented may signify a better ability of the young than the old does to change from lipostatic condition to rebound metabolism in response to improvement in feeding (McCann and Hansel, 1986). Young does may suffer a more severe stress than their older counterparts in the dry season where nutrition may not be adequate and this will put them in good stead for rebound growth when nutritious herbage becomes abound with the onset of the rains. Insulin is recognized as a metabolic hormone which provides signals to the reproductive system for the coordination of ovarian function with changes in metabolic status (Garnsworthy *et al.*, 2008). The delay in first ovulation observed in dairy cows selected for high genetic merit for milk yield has been shown to be associated with a lower circulating insulin concentration (Webb *et al.*, 2004). In contrast, feeding diets specifically designed to increase circulatory insulin concentrations during early lactation can advance the first ovulation post partum (Gong *et al.*, 2002). Similarly, infusion of insulin into beef heifers increased both the diameter of the dominant follicle (Simpson *et al.*, 1994) and ovulation rate in energy deprived heifers (Harrison and Randel, 1986). Also, insulin is reported to enhance GnRH-induced secretion of LH (Sen *et al.*, 1979 and Adashi *et al.*, 1981). McCann and Hansel (1986) have observed that re-feeding heifers on day 16 of the fasted cycle caused striking increases in their plasma LH concentrations. Archer *et al.* (2002) similarly observed in sheep that reproductive neuro-endocrine output (GnRH/LH) is stimulated by current increase in feed intake and not by high adiposity or body reserve. The higher ($p<0.05$) serum insulin and LH concentrations recorded for the young does that were supplemented in the present experiment may, therefore, be an indication of better improved nutritional status and greater reproductive capacity.

Litter size: Improved nutrition resulting in improved body condition and live body weight was expected to increase ovulation rate. But this did not translate into higher litter size in the current experiment. The litter size of 1.66±0.09 obtained in this experiment was lower than the 1.91 (Akusu and Ajala, 2000) and the 1.8 (Devendra, 1990; Awotwi and Fynn, 1992) earlier reported for the WAD breed. It was, however, similar to the litter sizes of 1.56 and 1.67 reported by Ikwuegbu *et al.* (1994) and higher than the 1.3 reported by others (Reynolds, 1989; Baffour-Awuah *et al.*, 2005) for the breed. Energy is needed to reduce failure of ovulation and to promote multiple ovulation (Fogwell, 1997), ovum pick up (Hafez, 1993) and implantation (Luginbuhl and Poore, 1998), but tropical pastures decline in quality soon after the start of the rainy season. A possible decline in the nutritive value of the native pasture after mating may have impacted negatively on the litter size of the does. Diskin *et al.* (2001) reported that a sudden reduction in energy intake for two weeks after insemination reduced embryo survival by 30% in cattle. Perhaps feed supplementation should have continued to at least 2-6 weeks after mating to ensure adequate implantation of the foetuses in the uterus and hopefully higher litter size at birth (Luginbuhl and Poore, 1998; Johnson, 2001). The relatively higher litter size of the young does that were supplemented in this experiment may have been engendered by their higher circulating insulin and LH concentrations (Webb *et al.*, 2004), perhaps due to their better response to high plane of nutrition.

Conclusion: It is concluded that 3-4 years old WAD does may benefit from concentrate supplementation of wet season grazing, but that 5-6 years old WAD does of moderate body condition six weeks prior to mating will not benefit from this supplementation.

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