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Effect of Flushing with Energy and Protein Source Diets on the Reproductive Performances of Meat Goats with High and Low Body Condition Scores

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Abstract- The objective of this experiment was to evaluate the effect of short-term flushing with energy and protein sources on the reproductive performances of meat goats for 21 days. A total of 180 Spanish and their crosses with Boer goats (Spanish X Boer) were randomly assigned to 6 treatments consisting of 2 body condition score (BCS) classes (Low and High) and 3 flushing treatments consisting of no supplementation (control), supplementation with protein mixture (PM) and combination of protein and energy (PE) in a 2 x 3 factorial arrangements. The results indicated that the BCS class had significant effect on pregnancy ($P < 0.01$) and kidding rates ($P < 0.05$) in which does in high body condition class had higher pregnancy and kidding rates than those in the low condition. The number of does diagnosed as pregnant was 67 and 81 and as non-pregnant was 23 and 9 for Low and High BCS does, respectively. Likewise, there were 24 and 11 does that did not kid and 66 and 79 that did for Low and High BCS, respectively. Litter size and weight was greater ($P < 0.05$) for Spanish X Boer than for Spanish does.

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Abstract- The objective of this experiment was to evaluate the effect of short-term flushing with energy and protein sources on the reproductive performances of meat goats for 21 days. A total of 180 Spanish and their crosses with Boer goats (Spanish X Boer) were randomly assigned to 6 treatments consisting of 2 body condition score (BCS) classes (Low and High) and 3 flushing treatments consisting of no supplementation (control), supplementation with protein mixture (PM) and combination of protein and energy (PE) in a 2 x 3 factorial arrangements. The results indicated that the BCS class had significant effect on pregnancy ($P < 0.01$) and kidding rates ($P < 0.05$) in which does in high body condition class had higher pregnancy and kidding rates than those in the low condition. The number of does diagnosed as pregnant was 67 and 81 and as non-pregnant was 23 and 9 for Low and High BCS does, respectively. Likewise, there were 24 and 11 does that did not kid and 66 and 79 that did for Low and High BCS, respectively. Litter size and weight was greater ($P < 0.05$) for Spanish X Boer than for Spanish does. Both initial and final body weights were greater ($P < 0.05$) for the High vs. Low BCS class and for Spanish X Boer than for Spanish does. Change in body weight was similar among supplement treatments for High BCS does but greater for PM and PE vs. Control for the Low BCS class. The body weight of Spanish X Boer does tended ($P = 0.068$) to increase more than that of Spanish does during the period of supplementation. There were ($P < 0.05$) effects of supplement type (PM vs. PE) on final and change in BCS, with values greater for PE vs. PM does. There were interactions ($P < 0.05$) between BCS class and breed in final and initial BCS. The BCS was greater for Spanish X Boer than for Spanish does, with a greater difference for the High than Low BCS class. In conclusion, flushing with PM and PE sources for short period of time was found to be beneficial for improving the reproductive efficiency of meat type does particularly those with poor body condition scores.

Keywords: body condition score, body weight, boer goats, flushing, reproductive traits, spanish goats.

I. Introduction

Deposition of lipids is the main form of energy storage in goats and is important in determining body condition score (BCS). When does present poor BCS, they often have low conception rates, low twinning rates and kids with low birth and weaning weights (Luginbuhl and Poore 1998; Urrutia-Morales et al., 2012). Goats lose body condition with the progressive deterioration of pasture in the fall season. Under such condition, protein or energy-based supplementary feeding (flushing), around the time of mating usually improves reproductive performance by increasing the expression of estrus, conception, fecundity and twinning rates of goats (Kusina et al., 2001; De Santiago-Miramontes et al., 2008; Fitz-Rodriguez et al., 2009; Hafez et al., 2011).

In goats, the effect of flushing has not been exhaustively studied and the existing results are often variable and inconsistent depending on factors such as genotypes (Sormunen-Cristian and Jauhiainen, 2002), body conditions (O'Callaghan et al., 2000), timing and duration of flushing (Acero-Camelo et al., 2008; Sabra and Hassan, 2008; Karikari and Blasu, 2009), the quantity and quality of dietary supplements (Acero-Camelo et al., 2008), the grazing background (Molle et al., 1995; Safari et al., 2011; Urrutia-Morales et al., 2012) and grazing season (Safari et al., 2011; Naqvi et al., 2012).

Henniawati and Fletcher (1986), Kusina et al. (2001), Islam et al. (2007) and Urrutia-Morales et al. (2012) observed increase in ovulation rate with an improved nutritional plane. Flushing has also been reported to increase the body condition and weights of does not only at mating (static effects) but also during their post-partum period (Titi et al., 2008). Other scholars reported no response in flushing of goats in body weight, body condition score and reproductive performance traits (Titi and Awad, 2007; De Santiago-Miramontes et al., 2011; Hafez et al., 2011; Safari et al., 2011). Furthermore, body condition, or the level of fatness of an animal as affected by previous level of feeding, can influence responses to nutritional supplements (Sejian et al., 2009). It is also probable that different breeds respond uniquely to the flushing practice (Amoah et al., 1996; Sormunen-Cristian and Jauhiainen, 2002).

In goats, energy was found to be more critical than protein (Sachdeva et al., 1973; Hafez et al., 2011; Naqvi et al., 2012). However, there are some reports in

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which ovulation rate has been increased through use of high-protein feedstuffs, particularly ones high in ruminally undegraded protein and in branched chain amino acids and arginine (Robinson, 1996; Molle et al., 1997). The onset of natural oestrus in goats in Oklahoma State coincides with a period of low forage availability and (or) low forage quality. Furthermore, because of low summer rainfall and usual weaning in mid to late summer, does often are in low body condition in the breeding season unless considerable supplemental feedstuffs are provided. Flushing may reverse the adverse effect of low body condition in the dry doe. Therefore, this experiment was conducted to study short-term supplementation strategies with protein mixture sources alone and combinations of protein mixture with ground corn for improved reproductive performance of meat goat does categorized in low and high body condition groups

II. Materials and Methods

a) Experimental animals

The study was carried at the E (Kika) de la Garza American Institute for Goat Research of Langston University (Langston, OK, 35° 56′ N; 97° 15′ W; 299 m) and was approved by the Langston University Animal Care Committee. In this experiment, 90 pure Spanish and 90 Spanish x Boer (60 ½ Boer and 30 ¾ Boer) does were used with the average age of 4.8 and 3.9 years, respectively. Each genotype was equally distributed to the flushing treatments. In the preparatory phase, goats with variable body condition scores (BCS) were created based on degrees of fatness. The body condition differences among animals were achieved through different levels of feeding. The BCS classes were Low and High, corresponding to scores of 2.06-2.09 and 2.65-2.69 on a 1-5 point scale. Each animal was individually identified using plastic ear tags.

b) Feeding design and feed compositions

Based on breed type, body weight and body condition, does were randomly assigned to 6 treatments with 2 BCS classes and 3 flushing treatments (2 x 3 factorial design). As presented in Table 1, the flushing treatments were: no supplementation and supplementation with a mixture of protein sources alone (PM) or the PM plus energy (PE). Each group of does was kept overnight in a pen, where they had access to water and a mineral mix.

Table 1 : Experimental design and distribution of does across flushing treatments in low and high body condition score classes

Flushing treatments	High BCS	Low BCS	Total
Control	30	30	60
Protein mixture (PM)	30	30	60
PM + ground corn (PE)	30	30	60
Total animals	90	90	180

Control = no flushing with concentrate feedstuffs; PM = 125 g/day of a mixture of protein meals (as fed basis); PE = 125 g/day of a mixture of protein meals and 390 g/day of ground corn (as fed basis); BCS = body condition score

The composition of the supplement of protein and energy sources is given in Table 2. The as fed feeding rate of does flushed with PM was 125 g/day of a mixture of protein meals whereas that of PE flushed does was 515 g/day of which 125 g/day of a mixture of protein meals and 390 g/day of ground corn (as fed basis). For PM and PE supplements, liquid molasses was included to enhance palatability. The rate of molasses for PM and PE were 3.05 and 0.74% on DM basis, respectively (Table 2). The control treatment entails daily supplementation with mineral and vitamin sources (at feeding rate of 6.8 g/head/day) which were also included in PM and PE supplements. A small amount of dried molasses product was also included in the control diet to promote feed consumption (Table 2). Prairie grass hay (containing 6.53% CP) was provided *ad libitum* to all control and supplemented does and had access to pasture for browsing.

c) Breeding and ultrasound examination

The flushing period started on November 3 and ended November 23 lasting for the duration of 21 days. Breeding started on day 14 (November 17) after the beginning of the flushing by introducing sexually active Boer bucks. The duration of breeding was 42 days long and bucks were rotated among pens on day 21 (December 8). Bucks were fitted with marking harness to enable recording of the date of oestrus/mating. Breeding dates and oestrus was recorded daily. At the end of the flushing period (November 24), diets were changed to normal.

Table 2 : Ingredients and nutritional analysis of flushing treatments fed to does

Ingredients (%)	Control	PM	PE
Ground corn	0	0	75.75
Blood meal	0	30.87	7.49
Fish meal	0	30.87	7.48
Corn gluten	0	30.87	7.49
Liquid molasses	0	3.05	0.74
Dried molasses	25.4	0	0
Dicalcium phosphate	24.6	1.43	0.35
Vitamin A,D,E premix	26.2	1.53	0.37

Trace mineral salt	23.8	1.39	0.34
Total	100	100	100
Nutrients (on DM basis, %)			
Dry matter	98.7	96.8	95.7
Ash	9.52	11.3	8.14
Crude protein	5.37	27.4	30.3
Neutral detergent fibre	65.5	15.2	15.2

Control = no flushing with concentrate feedstuffs; PM = 125 g/day of a mixture of protein meals (as fed basis); PE = 125 g/day of a mixture of protein meals and 390 g/day of ground corn (as fed basis)

All goats were subjected to ultrasound (with 5.0 MHz transducer; Supply, Inc., Tequesta, Florida, USA) examination at about 22-25 days after the introduction of bucks, in order to detect the presence of *corpus luteum*. At 45-55 days of breeding, the second ultrasound measure was made on abdomen to assess number of embryos. To this effect, does were restrained while standing, and the transducer probe was placed on the hairless caudal ventral abdominal wall cranial to the udder. Before running the ultrasound test, alcohol of 70% was sprayed around the upper part of the udder to enhance the quality of ultrasound image.

d) Data collection protocols

Body weight and BCS (1-5 scale) were registered prior and after flushing. The BCS were evaluated by palpating the fullness of muscling and fat cover over and around the vertebrae in the loin area. The animals were weighed in a platform scale in the morning before leaving for grazing. Birth type (single, twins or triples), birth weight and sex of kids were also recorded. Pregnancy rate (number of goats pregnant per number of does mated in each treatment group), kidding rate (number of goats kidding per number of does mated in each treatment group), litter size (number kids born per number of does kidding in each treatment group) and twining rates (number of twins/triples born) were calculated.

e) Statistical analyses

Body weight, BCS, litter size, birth weight, and litter weight were analyzed by the GLM procedure of SAS (2010) with a model consisting of BCS class, supplement treatment, breed, and all interactions. The three-way interaction was not significant ($P > 0.10$) for any variable. Additional means separation was carried out by orthogonal contrasts for effects of BCS class, supplementation (Control vs. mean of PE and PM), type of supplement (PE vs. PM), breed, and two-way interactions. Chi-square categorical analysis was also conducted for pregnancy and kidding rates as well as litter size.

III. Results

As expected, both initial and final body weights were greater ($P < 0.05$) for the High vs. Low BCS class and for Spanish X Boer than for Spanish does (Table 3). There was an interaction ($P < 0.05$) between BCS class and flushing, although the magnitude was not great. Change in body weight (BW) was similar among flushed treatments for High BCS does but greater for PE and PM vs. Control for the Low BCS class. The body weight of Spanish X Boer does tended ($P = 0.068$) to increase more than that of Spanish does during the period of supplementation. There were effects ($P < 0.05$) of supplement type on final and change in BCS, with values greater for PE vs. PM does (Table 3). There were interactions ($P < 0.05$) between BCS class and breed in final and initial BCS. The BCS was greater for Spanish X Boer than for Spanish does, with a greater difference for the High than Low BCS class. However, the magnitude of this interaction was slightly less in final vs. initial BCS, with a greater increase in BCS during the supplementation period for Spanish vs. Spanish X Boer ($P < 0.05$), which is opposite the tendency for a breed difference in BW change. Moreover, the BCS of Low BCS does have increased during the supplementation period more than that of goats of the High BCS class.

Table 3 : Effects of initial body condition, different flushing treatments and breed of meat goats on body weight and body condition score (N = 180)

Performance traits	BCS classes		Flushing treatments			SE	Breed		SE
	Low	High	Control	PM	PE		Spanish X Boer	Spanish	
Initial body weight	38.9[b]	45.2[a]	41.4	42.2	42.6	0.83	45.5[a]	38.6[b]	0.68
Final body weight	42.9[b]	49.5[a]	45.4	46.2	47.0	0.89	50.0[a]	42.5[b]	0.72
Change							4.41	3.87	0.21
Low	-	-	3.30[b]	4.35[a]	4.23[a]	0.355	-	-	-
High	-	-	4.65	3.82	4.49	0.234	-	-	-
Initial BCS	-	-	2.36	2.37	2.38	0.037	2.56[a]	2.18[b]	0.04

Final BCS	-	-	2.58[b]	2.54[b]	2.69[a]	0.030	2.74[a]	2.47[b]	0.03
Change	-	-	0.22[ab]	0.16[b]	0.31[a]	0.030	0.17[b]	0.29[a]	0.02

[a,b] Means between variables with different superscript letters are significantly different (P < 0.05); SE = Standard error of the mean; BCS = Body condition score; Control = no flushing with concentrate feedstuffs; PE = 125 g/day of a mixture of protein meals and 390 g/day of ground corn (as fed basis); PM = 125 g/day of a mixture of protein meals (as fed basis)

As shown in Table 4, the number of does diagnosed as pregnant and that kidded was 145 and 148, respectively. The only factor having significant effect on pregnancy and kidding rates was BCS class (P = 0.006 and 0.014, respectively). Therefore, frequencies of pregnancy and kidding rates for the two BCS classes were not independent of one another.

Table 4 : Effect of initial boy condition score, different flushing treatments and breed of meat goats on reproductive performance traits (N = 180)

Reproductive traits	BCS classes		Flushing treatments			Breed	
	Low	High	Control	PM	PE	Spanish	Sp X Boer
Pregnancy rate	P = 0.006			NS		NS	
Pregnant does	37.2 (67)	45 (81)	26.1 (47)	27.8 (50)	28.3	40.6 (73)	41.7 (75)
Non-pregnant	12.8 (23)	5 (9)	7.22 (13)	5.56 (10)	5.00	9.44 (17)	8.33 (15)
Kidding rate	P = 0.014			NS		NS	
Kidded does	36.7 (66)	43.9 (79)	25.0 (45)	27.8 (50)	27.8 (50)	39.4 (71)	41.1 (74)
Not kidded does	13.3 (24)	6.11 (11)	8.33 (15)	5.56 (10)	5.56 (10)	10.6 (19)	8.89 (16)
Litter size	1.93	2.01	1.91	2.02	1.98	2.09[a]	1.85[a]
Birth weight (kg)	3.32	3.32	3.52	3.20	3.24	3.34	3.30
Litter weight (kg)	6.26	6.50	6.59	6.30	6.25	6.77[a]	6.00[b]

[a,b]Means between effects within each variables with different superscript letters are significantly different (P < 0.05); Values in parenthesis are observed individuals; BCS = Body condition score; Sp = Spanish; Control = no flushing with concentrate feedstuffs; PE = 125 g/day of a mixture of protein meals and 390 g/day of ground corn (as fed basis); PM = 125 g/day of a mixture of protein meals (as fed basis)

The number of does diagnosed as pregnant was 67 and 81 and as non-pregnant was 23 and 9 for Low and High BCS does, respectively. Likewise, there were 24 and 11 does that did not kid and 66 and 79 that did for Low and High BCS, respectively (Table 4). The number of does with litter size 1, 2, 3, and 4 was 31, 87, 26, and 1, respectively. There were non-significant effects on litter size of BCS class, supplement treatment, and all interactions except for BCS class × breed for litter size 1, as shown in Table 5. Even though the only difference in litter size detected with chi-square analysis was for breed and litter size 1, with analysis as a continuous variable litter size was greater for Spanish X Boer than for Spanish (P < 0.05; Table 4). Birth weight was different between breeds, resulting in greater litter weight (P < 0.05) for Spanish X Boer. Average birth weight was decreased (P < 0.05) by supplementation, although there was no effect (P > 0.10) on litter weight because of a tendency for greater litter size.

Table 5 : Frequency and chi-square analysis of litter size for meat goat does of different body condition score (BCS) classes and breeds

		Low BCS		High BCS	
Litter size	P value	Spanish x Boer	Spanish	Spanish x Boer	Spanish
1	0.038	3	12	9	7
2	0.331	23	18	21	25
3	0.920	6	3	11	6
4	>0.90	1	0	0	0

IV. Discussion

Flushing significantly improved the BCS in all supplemented does which is in good agreement with the reports of Vinoles et al. (2005) and Acero-Camelo et al. (2008). In the present study, does in low BCS responded positively to flushing as measured by high kidding rate compared to non-supplemented ones. While the kidding percentage is determined by several factors, much of the variation between comparable flocks results from differences in percentage of goats ovulating, which is influenced by their body condition and plane of nutrition (Mellado et al. 1996; Fitz-Rodríguez et al. 2009).

The overall pregnancy rate in Low and High BCS classes was 37% and 45%, respectively. The lower pregnancy rate observed in Low BCS class may be explained by the unimproved reproductive outcomes due to low nutritional status, a physiological scenario that reflects the importance of keeping a good body

condition in breeding does as suggested by Flores-Najera et al. (2010) and Rosales-Nieto et al. (2011). Under such scenario, does may be forced to redirect their scarce nutrient pool toward vital physiological and metabolic networks other than the neuroendocrine ovarian activation, remaining anoestrous as suggested by Gonzalez-Bulnes et al. (2011). This decreased metabolic status may also lead to a reduced responsiveness to the male effect (Urrutia-Morales et al., 2012).

The overall kidding rate in Low and High BCS classes was 36.7% and 43.9%, respectively. This finding suggests that a sufficiently high live weight of does is essential in maintaining good reproductive performance as well as growth performance and survival rates of kids. Weight changes of does during pregnancy often indicate pre-natal development of the foetus as evidenced by significant correlations between birth weight of the offspring and the body weight of the dam (Bosso et al., 2007).

Breeding of does in low BCS suggests potentially lower ovulation rates or higher embryonic losses than when breeding goats in good body condition. Similar observations have been made by Kusina et al. (2001) and Meza-Herrera et al. (2008). It is well documented that steady increase in body weight (Henniawati and Fletcher, 1986; Kusina et al., 2001; De Santiago-Miramontes et al., 2009) or short-term feed supplementation before mating (De Santiago-Miramontes et al., 2008) increases ovulation rate in goats.

Walkden-Brown and Bocquier (2000) suggested that availability of energy has a key influence on reproductive performance, due to sensitivity of the reproductive axis to the adequacy of nutrition and stores of metabolic reserves. Although not significant, a better kidding rate observed in supplemented does may be due to ovary stimulation. It seems that the ability to improve the body condition of the doe at mating could improve ovulation rate and therefore litter size of goats, a situation that makes "flushing" a realistic part of proper management practice in areas characterized by shortage of feed sources during dry season.

In the present study, numerically higher litter size was observed in supplemented does which agrees with the results of Acero-Camelo et al. (2008). This difference affected the birth weight of the kids, which was significantly lower in PE supplemented does than control ones. These results are in agreement with Amoah et al. (1996), Kusina et al. (2001) and Acero-Camelo et al. (2008). They found that twinning rate was significantly higher with the high energy treatment than low level supplementation.

Birth weight of the kids was numerically higher in non-supplemented does than those of supplemented ones which could be attributed to the low litter size. It is apparent that singles are heavier than twins or triples. Moreover, twins and triples compete for nutrients of the same mother while developing in the womb making them lighter than singles. It was found that litter size influenced birth weight of kids in which low litter size contributed to high birth weight of kids in control group than that of supplemented groups. These results are in good agreement with those of Saha et al. (2012) who reported similar effects of litter size on the birth weight of supplemented and unsupplemented does.

V. Conclusion

The body condition score class had significant effect on pregnancy and kidding rates in which does in high body condition class had higher pregnancy and kidding rates than those in the low condition. Litter size and weight was greater for Spanish X Boer than for Spanish does. Change in body weight was similar among flushed treatments for High body condition score does but greater for PM and PE vs. Control for the Low BCS class. The body condition score of Low BCS does increased during the supplementation period more than that of goats of the High BCS class; and was greater for Spanish X Boer than for Spanish does.

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