Ethiop. J. Agric. Sci. 24:141-153 (2013)

Effect of Body Condition Score and Nutritional Flushing on the Reproductive Performances of Spanish and Spanish x Boer Crossbred Does

Aberra Melesse[1], Girma Abebe[1], Roger Merkel[2], Arthur Goetsch[2], Lionel Dawson[2], Terry Gipson[2] and Tilahun Sahlu[2]

[1]School of Animal and Range Sciences, Hawassa University, P.O. Box 05, Hawassa, Ethiopia
[2]E (Kika) de la Garza Institute for Goat Research, P.O. Box 730, Langston, OK, 73050

Abstract

The objective of this experiment was to evaluate the effect of body condition score (BCS) and short-term supplementation with high levels of energy and protein sources on the reproductive performance of 180 does consisting of 90 Spanish and 90 Spanish x Boer (60 ½ Boer = F_1-cross; and 30 ¾ Boer = F_2-cross) genotypes. Each of the 3 genotypes was equally distributed to treatments of 2 body condition groups (BCG, low and high) and 3 flushing treatments consisting of no supplementation (control), supplementation with protein mixture (PM) alone and PM + ground corn (PE) in a 2 x 3 x 3 factorial arrangement of treatments. The flushing period lasted 11 days, after which does were exposed to sexually active Boer bucks for 42 days. The results indicated that although not significant, flushing with PM and PE diets numerically increased the body weight and body condition score of all genotypes in high BCG. In low BCG, flushing with PM and PE diets significantly ($p<0.05$) increased the body weight of F_1-cross and Spanish does, respectively. Moreover, in low BCG, flushing with PE diet significantly ($p<0.05$) increased the BCS values by 26.7%, 18.1% and 29% in Spanish, F_1- and F_2-crosses, respectively. Similarly, flushing with PM diet significantly ($p<0.05$) increased the BCS values in Spanish and F_1 genotypes by 19.6% and 10.7%, respectively. In the high BCG, the Spanish and F_1-cross does flushed with PE diet had significantly ($p<0.05$) higher pregnancy and multiple birth rates than F_2 genotype. In the low BCG, the pregnancy and kidding rates of Spanish does flushed with PM diet was significantly ($p<0.05$) higher than those of F_2-cross. The F_2-cross supplemented with PM and PE diets had significantly ($p<0.05$) higher multiple birth rates than both Spanish and F_1-cross. Litter size was significantly ($p<0.05$) higher for F_1 and F_2-crosses supplemented with PE diet. The progesterone concentration was significantly ($p<0.01$) lower in all genotypes before breeding than observed after mating. In conclusion, flushing with protein and energy sources for short period of time was found to be beneficial for improving the body weight and body condition score and subsequently, the reproductive efficiency of does under poor body condition.

Key words: Body condition score; Body weight; Nutritional flushing; Reproductive traits; Spanish x Boer crosses.

Introduction

Goat production has become an attractive alternative livestock enterprise for resource limited farmers in many tropical and subtropical countries. The goat has long been recognized as a significant food source and can convert feed dry matter into milk as efficiently as other ruminants. Apart from milk and meat, skins and fiber from goats are important resources that can be used in making various valuable products (French, 1970).

Nutrition is generally recognized as a significant regulator of reproduction. Several studies in small ruminants have shown that with nutritional flushing ovulation and fetal implantation in the uterus are improved (De Santiago-Miramontes et al. 2008; Fitz-Rodriguez et al. 2009; Urrutia-Morales et al., 2012). Flushing can be accomplished either by allowing animals to graze lush pasture or by feeding energy-rich supplements (Johnson, 2001). Nutritional flushing has been a common practice among sheep producers to increase ovulation, conception rates and the number of lambs born. However, flushing to enhance reproductive performance of goats has not been extensively demonstrated, and only limited effort has been made to assess nutritional effects on reproduction of goats (Walker-Brown and Bocquier, 2001). Furthermore, body condition, or the level of fatness of an animal as affected by previous level of feeding, can influence responses to nutritional supplementation or flushing (Titi et al., 2008). It is also possible that different breeds with known genetic backgrounds may respond uniquely to flushing (Sormunen-Cristian and Jauhiainen, 2002).

Body condition of goats in developing regions of the world varies considerably because of seasonal fluctuations in quantities and qualities of available feeds, and limited economic resources for use of nutrient-dense supplements (Urrutia-Morales et al., 2012). The onset of natural oestrus in goats in Oklahoma 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 does. There is however, a scarcity of scientific information on reproduction of Spanish goats and their crosses with Boer bucks in response to various feeding regimens to help improve goat herd management in countries characterized by hot climates. This study was thus conducted to investigate the effect of short-term flushing with a feed containing a mixture of different protein sources alone or

in combination with ground corn on the reproductive efficiency of Spanish and Spanish x Boer crosses having low and high body condition scores.

Materials and Methods

Experimental Animals

This experiment was conducted at the E (Kika) de la Garza American Institute for Goat Research of Langston University, Langston, OK, USA, and was approved by the Langston University Animal Care Committee. In this experiment, a total of 180 does consisting of 90 Spanish and 90 Spanish x Boer (60 ½ Boer = F_1-cross; and 30 ¾ Boer = F_2-cross) were used (Table 1). Each of the three genotypes was equally distributed to the flushing treatments. In the preparatory phase, the high and low body condition groups (BCG) were created based on degrees of fatness. The does used for this phase were selected randomly from those available animals. The body condition differences among animals were achieved through different levels of feeding. The BCG were low and high, corresponding to body condition scores (BCS) of 1.5-2.0 and 3.0-3.4, respectively on a 5-point scale. Each animal was individually identified using plastic ear tags.

Feeding Design and Feed Compositions

Based on breed type and body condition, does were randomly assigned to 6 treatments of 2 BCG and 3 flushing treatments in a 2 x 3 x 3 factorial arrangement of treatments (2 body condition groups, 3 flushing diets, 3 genotypes). The flushing treatments were: no supplementation (control) and supplementation with a feed containing mixture of protein sources (PM) alone or with ground corn (PE; Table 2). Each group of does was kept overnight in a pen, where they had access to water and a mineral mix. All groups of goats grazed similar type of vegetation separately in padlocked enclosures guided by goat keepers and were treated identically.

Table 1. Allocation of does of various genotypes to treatment groups (N = 180)

	Low body condition group			High body condition group		
Genotypes	Control	PM	PE	Control	PM	PE
Spanish (SP, n= 90)	15	15	15	15	15	15
½ Boer/½ Spanish (F_1-cross, n= 60)	10	10	10	10	10	10
¾ Boer/¼ Spanish (F_2-cross, n= 30)	5	5	5	5	5	5

Control = no supplementation; PM= protein mixture alone; PE= PM + ground corn

The as fed feeding rate of PE was 515 g / head / day of which 125 g was protein source and the rest was ground corn. Daily intakes of mineral and vitamin sources were the same across treatments. For PM and PE supplements, liquid molasses was included to enhance palatability. The control treatment entails daily supplementation with mineral and vitamin sources (at feeding rate of 6.8 g / head / day). A small amount of dried molasses product was included in the control diet to promote consumption (Table 2). Prairie grass hay containing 6.53% CP was fed *ad libitum* to all does in group when they are not grazing.

Table 2. Ingredients and nutritional analysis of dietary treatment 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	7.49
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 (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 supplementation; PM= protein mixture alone; PE= PM + ground corn

Breeding and Ultrasound Examination

The flushing period lasted for 11 days after which does were exposed to sexually active Boer bucks for breeding. The duration of breeding was 42 days long and bucks were rotated among pens on day 21. 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, all animals were treated similarly on a moderate plane of nutrition appropriate as stage of gestation advances.

All goats were subjected to ultrasound 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 caudo-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. Moreover, blood was sampled for progesterone assay three times before the flushing period starts and twice thereafter. Thus, a total of 900 samples (5 x 180) were collected for progesterone assay. Progesterone concentrations were estimated in all samples by a direct solid-phase radioimmunoassay (RIA) using DPC kits (Diagnostic Product Co., Los Angeles, CA, USA) as previously described (Meikle et al., 1997).

Data Collection Protocols

Samples of supplement diets were ground to pass a 1mm screen after drying in a forced air oven at 55 °C for 48 h and analyzed for DM, ash and crude protein (CP) according to AOAC (2006). The NDF content in samples was determined using an ANKOM200 Fiber Analyzer (filter bag technique; ANKOM Technology Corp., Fairport, NY, USA) and were expressed inclusive of residual ash.

Body weight and BCS were registered by three professionals 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 recorded. Pregnancy rate (number of does pregnant per number of does in each treatment group), kidding rate (number of does kidded per total 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 / total kidding) were calculated.

Statistical Analyses

Body weight, BCS, birth weight and progesterone concentration were analyzed by the GLM procedure of SAS (2004) with a model consisting of BCS class, supplement treatment and genotype (2 x 3 x 3 factorial arrangements) in a completely randomized design. Treatment means were then separated by

Duncan Multiple Range Test. Chi-square categorical analysis was also conducted for pregnancy rate, kidding rate, multiple birth rates and litter size. All statements of statistical differences were based on $p<0.05$ unless noted otherwise.

Results and Discussion

Body Weight and Body Condition Score

Body weight and body condition score measured before and after flushing in Spanish goats and their crosses with Boer in high and low BCG are presented in Table 3. Although not significant, the body weight after flushing was numerically higher in all genotypes categorized in high and low BCG than before supplementation and is consistent with the findings of Acero-Camelo et al. (2008). In low BCG, the BCS was variable before and after flushing was consistently increased in Spanish does reared in all treatment diets.

Table 3. Body weight (kg) and body condition score (1-5 scale) measured before and after flushing in Spanish goats and their crosses with Boer categorized in high and low body condition groups

Traits	Control			PM			PE		
	SP	F_1	F_2	SP	F_1	F_2	SP	F_1	F_2
High body condition group									
BW, before flushing	40.1^{b}	47.1^{ab}	53.2^{a}	41.7^{b}	49.3^{a}	49.2^{a}	41.6^{b}	47.2^{ab}	53.7^{a}
BW, after flushing	44.2^{b}	51.7^{ab}	59.5^{a}	45.3^{b}	53.2^{a}	53.5^{a}	45.6^{b}	51.9^{ab}	59.4^{a}
BCS, before flushing	2.41^{b}	2.92^{a}	2.85^{a}	2.38^{b}	2.89^{a}	2.93^{a}	2.46^{bB}	2.85^{a}	3.07^{a}
BCS, after flushing	2.54^{b}	2.88^{a}	3.02^{a}	2.47^{b}	2.82^{a}	2.93^{a}	2.65^{bA}	2.96^{a}	3.00^{a}
Low body condition group									
Body weight, before	36.3^{b}	37.5^{b}	45.4^{a}	35.8^{b}	40.2^{bB}	45.3^{a}	36.0^{bB}	42.4^{a}	44.7^{a}
Body weight, after	40.0^{b}	41.0^{b}	47.0^{a}	39.5^{b}	44.9^{bA}	50.7^{a}	40.1^{bA}	46.8^{a}	50.5^{a}
BCS, before flushing	1.92^{bB}	2.30^{aB}	2.05^{ab}	1.94^{bB}	2.34^{aB}	2.05^{b}	1.95^{bB}	2.27^{aB}	2.00^{bB}
BCS, after flushing	2.35^{aA}	2.61^{aA}	2.33^{a}	2.32^{bA}	2.59^{aA}	2.32^{b}	2.47^{bA}	2.68^{aA}	2.58^{abA}

^{a,b,c} Means between genotypes within treatment diets with different superscript letters are significantly different

^{A,B} Means between flushing time points within each genotype with different superscript letters are significantly different

Control = no supplementation; PM = protein mixture alone; PE = PM + ground corn; BW = Body weight; BCS = Body condition score; SP = Spanish goats; F_1 = ½ Boer and ½ Spanish crossbred; F_2 = ¾ Boer and ¼ Spanish crossbred

Some researchers have reported the lack of response of flushing on body weight and BCS in small ruminants having poor body condition (Godfrey et al., 2003). In the present study, however, flushing with PM and PE diets significantly increased the body weight of some genotypes in low BCG. Accordingly, flushing with PM and PE diets significantly increased the body weight of F_1-cross and Spanish breeds, respectively. Similarly, flushing with PE significantly increased the BSC values by 26.7%, 18.1% and 29% in Spanish, F_1 and F_2-crosses, respectively. Flushing with PM has also significantly

increased the BSC values for Spanish and F_1 genotypes by 19.6% and 10.7%, respectively. These findings are in good agreement with the reports of Acero-Camelo et al. (2008) which suggest that short-term flushing with protein and energy rich feed resources might be beneficial to increase the body condition of goats that are previously characterized as having poor body condition.

Statistical comparisons were made between genotypes within treatment diets. Accordingly, in high BCG, the F_2-cross that received the control, PM and PE supplemented diets was significantly heavier than Spanish goats. Similarly, the F_1-cross flushed with PM diet had significantly higher body weight than the Spanish goat. However, no significance differences were observed in body weight between Spanish and F_1-cross fed on control and PE diets. Before flushing, the BCS values for F_1-cross in low BCG were significantly higher than the other two genotypes across control and supplemented diets. After flushing, however, the PM supplemented F_1-cross had significantly high BCS values compared to Spanish and F_2-genotypes. In low BCG, the F_1-cross flushed with PE diet had significantly higher BCS values than Spanish goats. These findings suggest that Boer bucks could be used to improve the general performances as suggested by Angwenyi and Cartwright (1987) who concluded from crossbreeding studies with East African and Boer goats, that the Boer was a logical sire breed, contributing significant directly additive effects to body weights at 4 to 12 months of age.

Reproduction Traits

Values of reproductive traits of Spanish goats and their crosses with Boer goats categorized in low and high BCGs are presented in Table 4. Walker-Brown and Bocquier (2001) 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. In the present study, the Spanish and F_2-cross does in low BCG responded positively to flushing as measured by high pregnancy and kidding rates compared to those reared in control diet. 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 as suggested by Fitz-Rodríguez et al. (2009).

The greater percentage of pregnant goats observed in the supplemented genotypes vs. the control ones in low BCG indicates a positive influence of quality feed supply upon reproductive efficiency. These results suggest that

flushing to positively affect reproductive response of does under low BCG. The lower reproductive response observed in genotypes of the low BCG reared in the control diet may highlight the importance of keeping a good body condition in breeding does. Under low body condition scenario, does may be forced to redirect their scarce nutrient pool toward vital physiological and metabolic networks other than the neuroendocrine ovarian activation and remain anoestrous as reported by Gonzalez-Bulnes et al. (2011). This may also lead to a reduced responsiveness to the male effect (Urrutia-Morales et al., 2012).

Table 4. Reproductive traits of Spanish goats and their crosses with Boer goats categorized in high and low body condition groups

Traits	Control			PM			PE		
	SP	F_1	F_2	SP	F_1	F_2	SP	F_1	F_2
High body condition group									
Pregnancy rate, %	100^{a}	90.0^{b}	100^{a}	93.3	100	100	93.3^{a}	90.0^{a}	80.0^{b}
Kidding rate, %	93.3^{a}	80.0^{b}	100^{a}	73.3^{b}	100^{a}	100^{a}	86.7^{ab}	90.0^{a}	80.0^{b}
Multiple birth rate, %	78.6^{b}	62.5^{c}	100^{a}	75.0^{ab}	70.0^{b}	80.0^{a}	100^{a}	90.0^{b}	75.0^{c}
Litter size	2.0	1.63	2.20	1.91	2.10	2.00	2.00	2.22	2.25
Birth weight, kg	3.32^{b}	4.0^{a}	3.52^{ab}	3.34	3.33	3.12	3.11	3.02	3.17
Low body condition group									
Pregnancy rate, %	73.3^{a}	80.0^{a}	40.0^{b}	93.3^{a}	80.0^{b}	80.0^{b}	80.0^{c}	90.0^{b}	100^{a}
Kidding rate, %	66.7^{b}	80.0^{a}	20.0^{c}	86.7^{a}	80.0^{a}	60.0^{b}	73.3^{b}	90.0^{a}	80.0^{b}
Multiple birth rate, %	70.0^{a}	75.0^{a}	50.0^{b}	64.3^{c}	87.5^{b}	100^{a}	50.0^{b}	100^{a}	100^{a}
Litter size	1.78	2.00	2.00	1.85	2.00	2.33	1.55^{b}	2.33^{a}	2.25^{a}
Birth weight, kg	3.45	3.44	3.94	3.25	3.23	2.84	3.30	3.30	3.32

^{a,b,c} Means between genotypes within treatment diets with different superscript letters are significantly different
Control = no supplementation; PM = protein mixture alone; PE = PM + ground corn; SP = Spanish goats; F_1 = ½ Boer and ½ Spanish crossbred; F_2 = ¾ Boer and ¼ Spanish crossbred

The overall kidding rate in low and high BCG was 73.3% and 87.8%, 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, and there is a correlation between birth weight of the offspring and the body weight of the dam (Bosso et al., 2007). Improving body condition or live weight of the doe at mating could increase ovulation rate and therefore, litter size of goats, a situation that makes flushing a good management practice. The kidding percentage of Spanish goats in the low BCG of control diet is comparable to reports by De Santiago-Miramontes et al. (2011). The low kidding rate observed for F_2-cross in the low BCG reared in the control as well as PM diets was due to a relatively high abortion rates that occurred during the pregnancy period. This might be explained by the fact that the physical limitation of the rumen in late gestation may lead to insufficient forage consumption to meet

the goat's nutritional requirements, which in turn may cause abortion as suggested by Rumball et al. (2008).

Results of this study indicated that most goats in Oklahoma area are prolific, with twins being most frequent litter size particularly for the crossbreeds. In low BCG, the litter size and multiple birth rate in Spanish breed was consistently lower than crossbred does across treatment diets suggesting possible lower ovulation rates or higher embryonic losses. Similar observations have been made by Meza-Herrera et al. (2008). In studies reviewed by Rhind (1993), greater numbers of big follicles were present and more follicles were oestrogenic, i.e., potentially ovulatory, in high-condition, compared with low-condition animals. This means that fewer follicles become atretic and greater numbers of potentially ovulatory follicles are present at luteal regression in high-condition animals.

In the low BCG, a significantly higher multiple birth rates was found in F_1 and F_2 genotypes flushed with PM and PE diets which agrees with the results of Acero-Camelo et al. (2008). This difference affected the birth weight of the kids, which was numerically lower in PM and PE supplemented groups than the control ones. These results are in agreement with those of Saha et al. (2012) who reported reduced body weight with increase in litter size of supplemented and unsupplemented does. In this study, crossbreeding of the Boer buck with the Spanish does, irrespective of the flushing diets, has improved the birth weight of the kids and is in line with those of Ruvuna et al. (1988). This finding suggests that does should be brought up to a reasonable good mating weight or condition to improve litter size and also provide good-sized offspring.

In the high BCG, the pregnancy and kidding rates of F_1 and F_2 –crosses flushed with PM diet was not significantly different than those supplemented with PE diet which implies that either of the supplements might be used in practical situations. The Spanish and F_1-cross flushed with PE diet had significantly higher pregnancy and multiple birth rates than the F_2-cross (Table 4). Birth weights of kids in F_1-cross reared in the control diet were significantly higher than those of Spanish goats. These findings confirm the positive effect of heterosis which enables the F_1-cross to perform better on low quality feed and are in good agreement with the reports of Ruvuna et al. (1988).

In the low BCG, the pregnancy and kidding rates of Spanish does flushed with PM diet was significantly higher than those of F_2-cross does suggesting the significance of supplementing of these genotypes with protein sources. On

the other hand, the F_2-cross supplemented with PM and PE diets had significantly higher multiple birth rates than the Spanish genotype. Among PE supplemented does, the litter size was significantly higher for F_1 and F_2-cross does than Spanish breeds. These findings are consistent with the findings of Anous and Mourad (1993) who reported that crossing of Alpines with Rove does produced more prolific does and rapidly growing weaned kids which yielded carcasses that were wider and more compact.

Progesterone Concentration

As expected, the progesterone concentration was significantly ($p<0.01$) higher in all genotypes of both BCG after breeding than those of before mating (Table 5). In the high BCG, the progesterone level before and after breeding was similar across genotypes within treatment diets. In the low BCG, however, a significantly high progesterone level was obtained from PM supplemented F_2-cross before and after breeding.

Table 5. Progesterone concentration (ng/ml) measured before and after breeding in Spanish and their crosses with Boer goats categorized in high and low body condition groups

Traits	Control			PM			PE		
	SP	F_1	F_2	SP	F_1	F_2	SP	F_1	F_2
High body condition group									
Before breeding	0.27^{B}	0.31^{B}	0.33^{B}	0.2^{B}	0.26^{B}	0.25^{B}	0.28^{B}	0.44^{B}	0.33^{B}
After breeding	5.94^{A}	5.03^{A}	5.38^{A}	5.30^{A}	5.73^{A}	5.58^{A}	6.13^{A}	5.73^{A}	6.20^{A}
Low body condition group									
Before breeding	0.11^{B}	0.11^{B}	0.10^{B}	0.11^{bB}	0.10^{bB}	0.18^{aB}	0.10^{B}	0.10^{B}	0.10^{B}
After breeding	4.56^{A}	5.34^{A}	6.90^{A}	4.61^{bA}	4.66^{bA}	7.04^{aA}	5.35^{A}	5.83^{A}	5.90^{A}

^{a,b} Means between genotypes within treatment diets with different superscript letters are significantly different

^{A,B} Means between breeding time points within each genotype with different superscript letters are significantly different

Control = no supplementation; PM = protein mixture alone; PE = PM + ground corn; SP = Spanish goats; F_1 = ½ Boer and ½ Spanish crossbred; F_2 = ¾ Boer and ¼ Spanish crossbred

Progesterone concentrations play a fundamental role in determining reproduction efficiency (Mmbengwa et al., 2009). Zarkawi and Soukouti (2001) further suggested that an assessment of progesterone levels during different physiological stages in animals is considered as one of the most important parameters to determine their fertility status. Lucy (2001) reported that low progesterone concentrations during early embryonic development may cause pregnancy failure and thereby decreasing the consequent rate of pregnancy. The progesterone values recorded after breeding in this study are comparable to those reported by Llewelyn et al. (1992) for indigenous goats of Zimbabwe.

The numerically high progesterone concentration observed in PE supplemented Spanish and F_2-cross genotypes in the high BCG after breeding may suggest the presence of multiple corpus lutium in goats. Howard et al. (2006) have reported that increasing peripheral progesterone concentrations at an early stage and late stage (day 15) of the oestrous cycle may help reduce embryonic deaths. Except PM supplemented F_2-cross, in all other genotypes of goats in the low BCG, the mean progesterone concentrations before breeding never exceeded 0.11 ng/ml. This suggests that before breeding, ovarian activity remained low in does exhibiting low body condition score.

In conclusion, short-time flushing with protein and energy sources has significantly enhanced the body weight of Spanish and F_1-cross in the low BCG. The effect of short-term flushing on body condition score of genotypes in the low BCG was also significant while it showed variable trends in those of high BCG. All genotypes in the low BCG responded positively to flushing as evidenced by high pregnancy and kidding rates. Therefore, flushing with protein and energy sources for short period of time was found to be beneficial for improving the reproductive efficiency of does under poor body condition.

Acknowledgements

This project was supported by a grant received from the United States Agency for International Development (USAID) through the Board of Regents of the University System of Georgia (Program No.: P-1-05814) for which the authors are highly grateful. The first author expresses his sincere appreciation to Prof. Seyoum Gelaye (Fort Valley State University) for his unreserved and thoughtful support during the course of the research work.

References

Acero-Camelo, A., E. Valencia, A. Rodríguez, and P.F. Randel. 2008. Effects of flushing with two energy levels on goat reproductive performance. Livest. Res. Rural Dev. 20, Article #136. Retrieved December 8, 2012, from http://www.lrrd.org/lrrd20/9/acer20136.htm.

Angwenyi, G.N. and T.C. Cartwright. l987. Effects of crossbreeding East African, Galla and Boer goats on body size, growth rate and kid survivability in Kenya. Proc. 4th Int. Conf. Goats, Vol II. Abstr. 16, Brasilia, Brazil.

Anous, M.R. and M.M. Mourad. 1993. Crossbreeding effects on reproductive traits of does and growth and carcass traits of kids. Small Rumin. Res. 12 (2): 141-149.

AOAC. 2006. Official Methods of Analysis, 18th edition. AOAC International, Gaithersburg, MD, USA.

Bosso, N.A., M.F. Cissé, E.H. van der Waaij, A. Falla, and J.A.M. van Arendonk. 2007. Genetic and phenotypic parameters of body weight in West African Dwarf goat and Djallonké sheep. Small Rumin. Res. 67 (3): 271-278.

De Santiago-Miramontes, M.A., R. Rivas-Muñoz, M. Muñoz-Gutiérrez, B. Malpaux, R.J. Scaramuzzi, and J.A. Delgadillo. 2008. The ovulation rate in anoestrous female goats managed under grazing conditions and exposed to the male effect is increased by nutritional supplementation. Anim. Reprod. Sci. 105: 409-416.

De Santiago-Miramontes, M.A., J.R. Luna-Orozco, C.A. Meza-Herrera, R. Rivas-Muñoz, E. Carrillo, F.G. Veliz-Deras, and M. Mellado. 2011. The effect of flushing and stimulus of estrogenized does on reproductive performance of anovulatory-range goats. Trop. Anim. Health Prod. 43: 1595-1600.

Fitz-Rodriguez, G., M.A. De Santiago-Miramontes, R.J. Scaramuzzi, and B. Malpaux. 2009. Nutritional supplementation improves ovulation and pregnancy rates in female goats managed under natural grazing conditions and exposed to the male effect. Anim. Reprod. Sci. 116: 85-94.

French, M.H. 1970. Observations on the Goat. FAO Agricultural Series no. 80, Food and Agriculture Organization of the United Nations, Rome, Italy.

Godfrey, R.W., A.J. Weis, and R.E. Dodson. 2003. Effect of flushing hair sheep ewes during the dry and wet seasons in the US Virgin Islands. J. Anim. Vet. Adv. 2: 184-190.

Gonzalez-Bulnes, A., C.A. Meza-Herrera, M. Rekik, H. Ben Salem, and R.T. Kridli. 2011. Limiting factors and strategies for improving reproductive outputs of small ruminants reared in semi-arid environments. In: Semi-arid environments: Agriculture, water supply and vegetation. Ed: Degenovine, K.M. Nova Science Publishers, Inc. Hauppauge, NY, USA., p. 41-60.

Howard, J.M., R. Manzo, J.C. Dalton, F. Frago, and A. Ahmadzadeh. 2006. Conception rates and serum progesterone concentration in dairy cattle administered gonadotropin releasing hormone 5 days after artificial insemination. Anim. Reprod. Sci. 95: 224-233.

Llewelyn, C.A., J.S. Ogaa, and M.J. Obwolo. 1992. Plasma progesterone concentrations during pregnancy and pseudopregnancy and onset of ovarian activity post partum in indigenous goats in Zimbabwe. Trop. Anim. Health Prod. 24: 242-250.

Lucy, M.C. 2001. ADSA Foundation Scholar Award, Reproduction loss in high-producing dairy cattle: where will it end? J. Dairy Sci. 84: 1277-1293.

Meikle, A., C. Tasende, M. Rodriguez, and E.G. Garofalo. 1997. Effects of estradiol and progesterone on the reproductive tract and on uterine sex steroid receptors in female lambs. Theriogenol. 48: 1105-1113.

Meza-Herrera, C.A., D.M. Hallford, J.A. Ortiz, R.A. Cuevas, J.M. Sanchez, H. Salinas, M. Mellado, and A. Gonzalez-Bulnes. 2008. Body condition and protein supplementation positively affect periovulatory ovarian activity by non-LH mediated pathways in goats. Anim. Reprod. Sci. 106: 412-420.

Mmbengwa, V.M., B.M. Gundidza, J.P.C. Greyling, M.D., L.M.J. Fair Schwalbach, J.E.J. du Toit, and A., Samie. 2009. Serum progesterone as an indicator of cyclic activity in post-partum goat does. South African J. Anim. Sci. 39: 306-311.

Rhind, S.M. 1993. Nutrition: its effects on reproductive performance and its hormonal control in female sheep and goats. In: Speedy, A.W. (ed.) Progress in Sheepa nd Goat Research, CAB Intl., Wallingford, UK, pp. 25-51.

Rumball, C.W.H., J.E. Harding, M.H. Oliver, and F.H. Bloomfield. 2008. Effects of twin pregnancy and periconceptional undernutrition on maternal metabolism, fetal growth and glucose–insulin axis function in ovine pregnancy. J. Physiol. 586: 1399-1411.

Ruvuna, F., T.C. Cartwright, H. Blackburn, M. Okeyo, and S. Chema. 1988. Gestation length, birth weight and growth rates of pure-bred indigenous goats and their crosses in Kenya. J. Agric. Sci. 111 (02): 363-368

Saha, N.G., M.R. Alam, and M.M. Rahman, 2012. Effect of feed supplementation on reproduction, lactation and growth performance of Black Bengal goats grazed on native pasture. Bangladesh J. Anim. Sci. 41 (1): 41-46.

SAS. 2004. Statistical Analysis System. User's guide, version 9.0. SAS Institute, INC. Carry. NC. USA.

Sormunen-Cristian, R. and L. Jauhiainen. 2002. Effect of nutritional flushing on the productivity of Finnish Landrace ewes. Small Ruminant Res. 43(1): 75-83.

Titi, H.H., M. Alnimer, M.J. Tabbaa, and W.F. Lubbadeh. 2008. Reproductive performance of seasonal ewes and does fed dry fat during their post-partum period. Livest. Sci. 115(1): 34-41.

Urrutia-Morales, J., C.A. Meza-Herrera, L. Tello-Varela, M.O. Díaz-Gómez, and S. Beltrán-López. 2012. Effect of nutritional supplementation upon pregnancy rates of goats under semiarid rangelands and exposed to the male effect. Trop. Anim. Health Prod. 44: 1473-1477.

Walker-Brown, S.W. and F. Bocquier. 2001. Nutritional regulation of reproduction in goats. In: Proceeding of the 7th International Goat Conference. Tours, France, pp. 389-395.

Zarkawi, M. and A. Soukouti. 2001. Serum progesterone level using radioimmunoassay during oestrus cycle of indigenous Damascus does. New Zealand J. Agri. Res. 44: 165-169.