American Journal of Animal and Veterinary Sciences, 2012, 7 (4), 194-197
ISSN: 1557-4555

doi:10.3844/ajavssp.2012.194.197 Published Online 7 (4) 2012 (http://www.thescipub.com/ajavs.toc)

Nutritional Strategies to Mitigate the Effects of Negative Energy Balance on Reproductive Performance of Early Postpartum Does

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Received 2012-11-01, Revised 2012-11-26; Accepted 2012-12-29

ABSTRACT

The objective of this study was to research nutritional strategies to mitigate the effects of Negative Energy Balance (NEB) on reproductive performance of early postpartum does. Twenty seven does in their second week of lactation and their kids were randomly assigned to three levels of supplement diet, replicated three times. The diets were: (1) Low Energy/Protein supplement level (LEP; Control), (2) Medium Energy/Protein supplement level (MEP), or (3) High Energy/Protein supplement level (HEP). The LEP (control) diet was fed at 0.95%, MEP at 1.50% and HEP at 1.90% of BW on a DM basis. The study lasted 28 days. Supplement level did not ($p>0.10$) reverse the expected loss in doe body condition during the early stages of lactation. The does lost on average 0.056 kg day^{-1} through the duration of the study. The average body condition score of the does at the start of the experiment was 1.80 (on a scale of 1-5) and 1.75 at the end. The HEP kids tended ($p<0.10$) to gain faster than LEP kids; no difference ($p>0.10$) between HEP and MEP or MEP and LEP kids. The HEP kids gained 0.087 kg day^{-1}; MEP kids gained 0.061 kg day^{-1} whereas LEP kids gained 0.022 kg day^{-1}. In conclusion, something in addition to high energy/protein supplement level may be needed to mitigate the effects of NEB which is in part responsible for delayed return of ovulatory events in early postpartum does.

Keywords: Nutritional Strategies, Negative Energy Balance, Reproductive Performance, Early Postpartum Does

1. INTRODUCTION

Reproduction in goats can be described as seasonal, spontaneously ovulating or polyestrous. Thus, factors such as latitude, climate, breed, physiological state, presence of male, breeding system and photoperiod may influence the onset of breeding (Estrada-Cortes *et al*., 2009). In temperate regions, breeding period in goats is in the fall and winterwhereas in the tropics it is year-round. However, animals from tropical regions such as Creole goats lose their year-round breeding potential once they are exposed to the temperate region photoperiod (Chemineau *et al*., 2004). Control of goat reproduction to increase the number of litters per year is in direct response to consumer demand for goat meat and milk year-round. In a review, Fatet *et al*. (2010) postulated that production out of natural breeding season is possible with the use of hormonal treatments, manipulation of photoperiod, by the male effect or nutritional strategies.

In a review, Leroy *et al*. (2010) attributed the lack of estrus events during the early postpartum period in dairy cows to Negative Energy Balance (NEB). Moreover, management around the periparturient period may affect the overall reproductive health status of the recovering female (doe) following birth. Thus, management around this time should aim to assure good postpartum uterine involution including endometrium repair and cleaning of bacterially contaminated contents (Roche, 2006).

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Consequently, compromised immune response and negative energy status can act to delay this process and put at risk future reproductive performance including fertility (Wathes *et al*., 2007).

Negative energy status is a direct consequence of poor or inadequate nutrition during the periparturient period. Animals that are in NEB cannot meet their obligations for energy during this time to support the energy-demanding process of milk synthesis. Early postpartum does respond to NEB by mobilizing large amounts of stored fats and elevated levels of fatty acids may sometimes be a problem.

Inadequate nutrition is often associated with prolonged anestrous and anovulatory periods which results in a reduction in fertility and prolificacy (Delgadillo *et al*., 1997). Furthermore, feed intake could affect the time of cessation and initiation of ovulations during the period of transition to seasonal anestrous and return to estrus activity, increasing the length of anovulatory period (Estrada-Cortes *et al*., 2009). Balanced diets should aim to prevent severe NEB and excessive intake of specific dietary components while providing needed nutrients to enable the animal to prepare for an early resumption of estrous cycles. However, energy rich diets fed to animals in positive energy balance can do more harm than good to the oocyte and embryo. Furthermore, increased mobilization of fats may result in high concentrations of non-esterified fatty acids that tend to be toxic at the ovarian level (Kruip and Kemp, 1999). Leroy *et al*. (2005) postulated that programmed cell death including cumulus cell necrosis during maturation could explain these observations. In cows, protein-rich diets have been found to have direct toxic effects at the oocyte level through the elevated blood levels of ammonia and urea (Sinclair *et al*., 2000; O'Callaghan and Boland, 1999).

Reproduction out of season can be achieved by inducing ovulation via hormonal treatments, manipulation of photoperiod, male effect or nutritional strategies (Fatet *et al*., 2010). Our research will focus on nutritional strategies to prepare postpartum does to resume early ovulatory events and thus reduce the anestrous period to less than 35 days, facilitating early re-breeding to achieve more than one and half litters per doe, per year. Consequently, we tested the hypothesis that high energy/protein supplement level should reverse the effects of negative energy balance (on reproductive performance) and cause an earlier resumption of estrus cycles in early postpartum does.

2. MATERIALS AND METHODS

2.1. Animals and Experimental Design

All experimental procedures involving animals were performed following guidelines approved by the University of Arkansas at Pine Bluff (UAPB) institutional animal care and use committee. The present study was conducted at the UAPB Farm located in Pine Bluff, Arkansas. Animals were housed in a goat barn equipped with sixteen pens of equal size, measuring 2.8×2.5 m each.

Twenty seven lactating adult does in early lactation and their twenty nine kids of mixed breeding (Spanish x Boer x Nubian x Nigerian Dwarf) were used in this experiment. Does were on average two weeks into lactation. All animals were weighed and does scored for body condition at the start and end of the experiment. The experiment started on February 23, 2012 and ended on March 22, 2012. The experiment lasted 28 days. The experimental design was a randomized complete block with pen containing three does and their kids considered the experimental unit. Does were blocked by weight and parity. One week after the experiment ended, two Kiko bucks were introduced to the does for breeding. The breeding period lasted 28 days.

2.2. Diet

Animals were fed a brewer's rice-based concentrate diet daily at 9:00 a.m. Each doe on the LEP (control), MEP and HEP diet received 0.31, 0.51, 0.61 kg DM day^{-1}, respectively. The concentrate diet was a mixture of brewer's rice and soybean meal (**Table 1**) and was formulated to contain 20% CP and ME of 2.90 Mcal kg^{-1} of feed. The diet was formulated to exceed NRC daily requirements for energy and CP, two nutrients that are critical for optimal reproductive performance of early lactating does. Our objective was to maintain a balance of energy needed for metabolism between stored body reserves and feed energy. The expectation was that a high energy and CP supplement level should reverse or mitigate the effects of NEB (which results in the rapid loss in doe body condition) to a point where body condition becomes a non-factor influencing the duration of the anestrous period.

2.3. Statistical Analysis

Analysis of Variance (ANOVA) was conducted on doe and kid data using PROC GLM of SAS statistical software (SAS Inst., Inc., Cary, NC). Contrasts were used to separate kid means. Data including ADG and

BCS change were analyzed as a randomized complete block with pen comprising of three does and their kids within supplement level as the error term. In all cases, significant treatment differences were considered at p<0.05 and trend at p<0.10.

3. RESULTS

Supplement level had no (p>0.10) effect on ADG and BCS change of postpartum does (**Table 2**). Supplementation did not mitigate the effects of NEB on reproductive performance of the does; the anestrous period definitely lasted more than 60 days as none of the does was bred within the 28-day breeding period allowed; none of the does had kids five months following the removal of the bucks (data not shown). Kids on the HEP diet tended (p<0.10) to gain faster than LEP kids; no difference (p>0.10) between HEP and MEP kids or MEP and LEP (**Table 3**).

Table 1. Composition and nutrient content of experimental diet

Diet composition	(%)
Brewers rice	50.2500
Soybean meal	25.8500
Alfalfa pellets	20.0000
Dicalcium phosphate	2.6300
Limestone	0.5700
Salt	0.7000
Nutrient content	
Metabolizable energy, Kcal	2904.0000
Crude protein (%)	20.0200
Calcium (%)	1.1457
Phosphorus (%)	0.8783

Table 2. Effect of supplement level on ADG and BCS of postpartum does

	Supplement level				
Variable	LEP	MEP	HEP	SEM	*P* value
ADG, kg	-0.076	-0.065	-0.026	0.0501	> 0.10
BCS change	-0.015	0.175	0.157	0.3175	> 0.10

Table 3. Effect of supplement level on ADG of kids

	Supplement level					
Variable	LEP	MEP	HEP	SEM	Contrasts	*P* value
ADG, kg	0.022	0.061	0.087	0.0197	HEP Vs LEP	= 0.0851
					HEP Vs MEP	= 0.3357
					MEP Vs LEP	= 0.1880

4. DISCUSSION

Results of this study show that a high energy/protein supplement level may have slowed but did not reverse the loss in body condition as the animal tries to cope with the effects of NEB. Results of this study are in general agreement with reports of Delgadillo *et al*. (1997) and Estrada-Cortes *et al*. (2009) as far as nutritional intervention, albeit unsuccessfully, can go to reverse the effects of NEB on doe return to early estrus. However, additional managements such as early introduction of the male and hormonal treatments as suggested by Fatet *et al*. (2010) may complement nutritional interventions. In our study, the timing of our supplementation should have started during the priparturient period. An unintended consequence of supplement level was the response of the kids. The HEP kids appeared to have benefitted the most from the increased dietary energy and proteins fed to their dams. However, based on experimental design, it is not clear whether the HEP supplement level led to increased milk synthesis benefitting the kids or the kids gained faster because they also consumed the supplement feed.

It is possible that energy/protein supplement level may have had deleterious effects on doe reproductive system as to cause harm to the oocyte and this may have contributed to the lack of estrus events as suggested by reports of Kruip and Kemp (1999); Sinclair *et al*. (2000) and O'Callaghan and Boland (1999).Whereas a complete reversal of this physiological process (which almost always results in loss of body condition or BW) may reduce the anestrous period and increase the number of kiddings in a lifetime, the cost in feeds and effort may not be worthwhile. Furthermore, the long term effect on doe reproductive performance may need to be addressed. In addition, other contributing factors such as genetic merit and animal health may have to be addressed as well. More research is needed to determine the effect of daily removal of the kids from their dams for several hours combined with creep feeding of suckling kids on doe response including the length of NEB in postpartum does, to attain early resumption of estrous cycles and consequent re-breeding.

5. CONCLUSION

Nutritional strategies involving the use of high levels of energy/protein supplement were inadequate to mitigate the effects of NEB in early postpartum does. Other strategies such as early introduction of the male, daily removal of kids for several hours, early weaningor creep feeding of the kids may need to be investigated.

6. ACKNOWLEDGEMENT

This research was supported by funds from Evans Allen E/A Project No. 5038. The authors wish to acknowledge individuals at the UAPB Farm under the leadership of Iesha Anderson-Hall and which included students, for their assistance with field work and data collection.

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