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Relationships between body weight, body condition score at breeding and reproductive and progeny performance in Kiko meat goats over two breeding cycles

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ABSTRACT

Body condition scores (BCS) and/or body weights (BWT) are often used as visual or tactile management tools to evaluate and improve reproductive competency in pasture-managed small ruminant animals. This study was designed to evaluate relationships between BCS, BWT and reproductive traits (number born alive and weaned, litter size, birth and weaning weights) in 16 purebred Kiko, 11 purebred Boer and 7 Kiko x Boer crossbred meat goat dams that were semi-intensively managed and bred to both Boer and Kiko bucks. BWT was recorded using a scale and palpable BCS scale of 1 to 5 (1= emaciated to 5= obese) and was subjectively determined at breeding, parturition and weaning. Pearson correlation coefficient (r) analysis was used to determine the relationships between residual values of reproductive and progeny performance and BWT or BCS. Pre-partum BCS and weaning BCS had a correlation of r=0.09. A moderate correlation was observed between BWT at breeding and the number born alive (r=0.36) suggesting that pre-partum BWT is the key body conformation measurement linked to the reproductive performance of dams both at birth and weaning. Both at breeding and at weaning BCS were negatively correlated with litter size (r= -0.11) and birth weight (r=-0.32) and weakly correlated with the number born alive (r=0.06). Also, negative correlations were obtained between BCS at weaning and kid weaning weight (r=-0.58) and number weaned (r=-0.26). Although BCS had no significant (P≥0.05) effect on kg kids born per dam, birth weight of kids, and kids weaning weights, it is evident that a BCS score of 3 at the mating time could optimize reproductive performance. The results of this project established the important roles that pre-breeding BWT and/or BCS have on reproductive performance (kidding rate) in meat goat herds. We recommend their evaluation as a useful management tool for distinguishing differences in the pre-partum nutritional needs of meat goat herds, especially in the pasture-based production system.

Keywords: BCS, BWT, Boer, Kiko, Reproductive Performance

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Introduction

Goats are important for both commercial and subsistence farming systems in rural southeastern United States. Limited resources producers keep goats primarily for meat and cash since most subsistent farmers cannot afford to keep cattle. Meat goats are very versatile because not only do they provide meat but provide services such as vegetation management by eating unwanted vegetation in fields (Solaiman, 2007). The tremendous changes in demand that are ongoing for goat meat (chevon) in the course of the last two decades have created the opportunity for goat production to become widespread (Hart, 2001). However, given the substantial increase in the US chevon imports in recent years, there appear to be continued room for growth in the US meat-goat industry (Sande *et al.*, 2005).

There are 3 primary meat goat breeds managed in the US. The Boer goat is native to South Africa (Malan, 2000) which has become the most popular breed in the US since its introduction in the 1990s. The Spanish goat is a genotype that has evolved from centuries of natural selection in the US (Glimp, 1995). The Kiko goat was developed in New Zealand and introduced to the US during the same time period as the Boer. The composite Kiko breed resulted from a series of crosses involving feral does and varying breeds of dairy bucks (Batten, 1987).

Body condition scores (BCS) are numbers used to suggest the relative fatness or body composition of meat animals. Most published reports in cattle use a range of 1 to 5, with a score of 1 representing very thin body condition and 5 representing extreme fatness. There has not been total coordination by various workers concerning the descriptive traits or measures associated with any BCS score. As a result, scoring done by different people will not agree exactly; however, scoring is not likely to vary by more than one score between trained evaluators.

Body condition scoring (BCS) has been widely adopted for managing the nutrition of meat goat herd, especially under pasture management systems, and for selecting kid goats for purchase and slaughter. In Britain, and now increasingly in Europe, body scoring is based on a subjective assessment of the fat level and muscle thickness on the backbone behind the last rib (Treacher *et al*., 2000).

The relationship between BCS and body weight at calving and BCS loss was used to study the effect of conditioning of cows at calving and the subsequent severity of negative energy balance (EB) (Dechow *et al*., 2001). Body condition or body weight loss, as an indicator of EB, was used to study the impact of negative EB on stress symptoms, by correlating it to yield. Gamez *et al*., (2008) demonstrated that BCS in goats is related to serum leptin concentrations, an important reproductive hormone responsible for the early onset of puberty. The better the BCS scores, the greater the serum leptin concentration during breeding seasons. Zhang and Blache (2005) showed that serum leptin concentration was positively correlated to the BCS of sheep. Positive relationships have been established between BCS and plasma leptin and FSH concentrations in Iranian fat tail ewes at mating time (Towhidi *et al*., 2007). Ewes with a very high level of body condition score show an increase in ova wastage and reduce in reproductive performance (Rhind *et al*., 1989). A low body condition score was related to the prevention of estrus and fertility in ewes (Rhind *et al*., 1989). Selected reproduction criteria fertility (percentage of kidding goats), prolificacy or litter size and fertilization date (deducted from kidding date) were affected by different BCS in ewes (Jalilian and Moeini, 2012). In addition, Jalilian and Moeini (2012) indicated that BCS had a significant effect on the number of kids born per goat. Goats with BCS 3 had more normal estrous, while goats with low BCS had shorter or interrupted estrous period.

Variation in body weight is a function of skeletal size, assumed mostly genetic and of condition (fleshing), assumed to be mostly environmental. Martin *et al*., (1980) confirmed that the reproductive performance of young crossbred ewes is related to body weight at breeding. Furthermore, this study found that the proportion of ewes with successful mating, lambing and of multiple births increased with increased average body weight. No explanation can be given for this trend, which may be indicative of differential fertilization rates or early embryonic mortality due to differences in body weight.

Snyman (2010) showed that body weights before mating and at scanning had a significant positive relationship with the number of kids born per doe mated, the number of multiple births and the number of kids weaned per doe mated. Does carrying twins had higher body weights at scanning than dry does or does carrying single kids. For every kilogram increase in body weight before mating, 0.0237 and 0.0218 more kids were born (Snyman (2010). From the results presented in the literature, it is evident that the body condition of the doe, body weight, and management systems (intensive vs. extensive) all have a significant effect on reproductive competence in meat goats. The body condition and body weight of an animal is vital during each breeding season and must be managed for the greatest reproductive outcome.

This study is designed to identify and quantify relationships between body condition scores, body weights pre-breeding and post-breeding with reproductive variables such as prolificacy (litter size), fecundity (fertility), birth type (single, multiple, and triple), individual and litter birth weights and individual and litter weaning weights in Boer, Kiko, Boer X Kiko meat goats dams raised under a semi-intensive management system. Furthermore, this study seeks to establish body condition scoring and body weight as useful reproductive management tools for distinguishing differences in pre-partum nutritional needs of meat goat herds, especially in pasture based production systems.

Methodology

Animal management

This study was conducted at the Caprine Research and Education Unit of the George Washington Carver Agricultural Experiment Station at Tuskegee University in Tuskegee, Alabama (32.43N, 85.71W). Tuskegee, Alabama is located in the southeastern region of the United States and has an average annual precipitation of 53.57 inches in 2016. The Tuskegee University Animal Care and Use Committee approved herd management protocol used in this project. 16 purebred Kiko (K), 11 purebred Boer (B) dams and 7 Kiko x Boer (K x B) crossbred dams that were semi intensively managed were bred to both Boer and Kiko bucks. The stocking rate was approximately seven to eight does per hectare. Dams were approximately 5 years of age and dewormed twice a year. On a nutritional basis, all animals were managed on tall fescue (*Festuca arundinacea*) and Bermudagrass (*Cynodon dactylon*) pastures, and supplemented with 1133 g of bermudagrass hay (*Cynodon dactylon*) twice a day for *ad libitum* consumption. Animals were also supplemented with grain concentrate of alfalfa (17% crude protein, 1.5% crude fat, 30% crude fiber) and corn (7% crude protein, 3% crude fat, 4% crude fiber) only during late gestation, and had access to free choice mineral salt block from breeding to weaning of kids. All animals had unlimited access to water daily.

Prior to breeding, does and bucks were physically examined. For each doe and buck body weight was recorded using a scale, body condition scores (BCS) were evaluated subjectively (ranging from 1= emaciated to 5= obese). Bucks were also given a breeding soundness examination (BSE) involving both a physical examination of the buck's structural soundness and an examination of reproductive soundness. Additionally, physical evaluation of feet and legs, body condition, vision and other factors that could reduce the buck's ability to breed and settle does were examined.

Further reproductive examination involved measuring and palpating the scrotum and testicles and physically examining the penis; however, no semen was collected or evaluated. Scrotal circumference was measured using tape at the broadest part of the scrotum. Shoulder width (SW) was determined with the aid of a tape measure, as the horizontal distance between the processes on the left shoulder and those of the right shoulder blade. Chest girth (CG) was measured with the aid of a measuring tape around the chest, just behind the front legs; body length (BL) was measured from the sternum to the aitch bone and hip width (HW) was measured using a plastic measuring tape, while height at withers (HTW) was measured vertically from thoracic vertebrae to the ground using a metal ruler.

Goat breeding scheme

Prior to mating, three breeding pens were constructed on three hectares of pasture and does were separated into the pens. Pens # 1 consisted of one Boer buck bred to seven does (three purebred Kiko, one purebred Boer, and three Kiko x Boer cross). Pen # 2 consisted of one Kiko buck bred to nine does (five Kiko purebred and four Kiko x Boer cross); and lastly. Pen # 3 involved one Kiko buck bred to eight purebred Kiko does. The Boer and Kiko bucks were fitted with a marking harness with different crayons (red, orange and blue) to aid in determining breeding dates. Mature bucks were allowed to roam freely with the females.

The mature bucks were exposed to the dams through two heat cycles or approximately 45 days assuring that any doe that missed the first cycle will get bred on the second round. The harness and females were checked periodically during the day. The date on which a crayon mark from the buck's harness on the doe's hindquarters was recorded as the initial date of gestation. Faint colors on her rump indicated that the buck might have mounted but not long enough to inseminate and breed. Once all dams were recorded for mating the mature bucks were removed from the breeding pins and placed back into the buck pens. The breeding pens were removed and dams were released into the paddocks and rotated every two weeks to eliminate the risk of parasite infection.

Parturition management

Following parturition, the birth weights of the kids were recorded within 24 h after birth and ear tagged for identification. Likewise, the body weight and body condition of the doe at breeding were recorded as well. Additionally, the following data were recorded for all breed combinations at parturition: date of kidding, expected weaning date, birth type (single, twins, or triplets), kid ID, number born alive, sex of kid and birth weight of kid. At weaning the following were recorded: body condition of dam, body weight of dam, weight of kids and number weaned. The research concluded following the weaning period.

Statistical analysis

Analysis of Variance (ANOVA) procedures of Statistix 7, 2000 (Analytical Software, Tallahassee, FL) were used for data analysis. Fixed effects in the models included the breed of doe. The interaction of the sire breed and dam breed was added to models for the analysis of kid and growth data. Weaning weights were adjusted on a 90-day basis. Kid sex and litter size were included in the kid weight models. Animals within the breed of doe and breed of sire were specified as random terms in the mixed effects models. Pearson correlation coefficient (r) analysis was used to determine the relationships between residual values of reproductive and progeny performance and BWT or BCS (CORR procedure, SAS Institute, 2007). Probability levels less than 0.05 for the descriptive statistic indicated significant effects.

Results and Discussion

Reproductive and progeny performance

Reproductive and progeny performance (prolificacy; pre-weaning rate; gestation length; body weight at breeding, parturition and weaning; body condition scores at breeding, parturition and weaning; weights of kids at birth and weaning and the number of kids at birth and weaning) for all breed combinations are presented in Table 1.

Table 1. Descriptive statistics of herd prolificacy in Boer and Kiko and their crosses (Mean ± SD).

Item	K B X B	KB X K	K X K	K X B	*P-value
Prolificacy	2.00±0.00	2.25±0.50	1.62±0.65	1.67±0.58	*
Pre-weaning rate	1.00±0.00	2.00±0.00	1.60±0.65	1.33±0.58	NS
Pre-weaning survival rate (%)	100	100	88	79	NS
Gestation Length (days)	149±1.41	148±4.92	147±5.13	152±2.89	NS
Body Weight at Breeding (kg)	30±4.24	66±17.56	49±8.32	34±4.04	**
Body Weight at Parturition (kg)	35±2.12	69±9.95	55±11.93	43±5.51	**
Body Weight at Weaning (kg)	34±2.83	62±14.85	48±9.32	38±2.31	**
BCS at Breeding (1-5)	4±0.00	4±0.00	3±0.51	3±1.00	NS
BCS at Parturition (1-5)	2±0.00	2±0.00	2±0.51	2±0.58	NS
BCS at Weaning (1-5)	3±0.71	3±0.00	3±0.55	3±0.00	NS
No. Born Alive	2±0.00	2±0.50	1.62±0.65	1.67±0.58 [a]	*
Birth Weight of Kids (kg)	3±0.00	3±0.82	3±0.72	4±1.00	NS
No. Weaned	1±0.00	2±0.00	1.62±0.65	1.33±0.58	*
Kid Weaning Weights (kg)	17±1.41	15±7.41	20±8.22	21±2.65	**

**Significant if (P≤0.05)*
***Highly Significant (P≤0.01)*
NS = Not Significant

The overall prolificacy values (no. of kids born per does mated) for all breed combination include a mean value of 1.77 kids/doe. Significant (P≤0.05) breed combination differences in prolificacy 1.62±0.65 (K X K), 2.25±0.50 (KB X K), 2.00 ± 0.00 (KB x B) and 1.67±0.58 Kids/doe (K x B), respectively. Prolificacy is a measure related to the number of fertile ova produced per doe at each estrus (Das *et al.*, 1996). The general conclusion that can be drawn from the prolificacy analysis is that the Boer x Kiko (dam) and Kiko (sire) are the most prolific of the four-breed combination indicating heterosis and although the pure Boer and Kiko lines tend to have similar prolificacy rates. Mean value of 1.59 ± 0.59 was obtained for pre-weaning rate – (percentage of kids that survived until weaning). Non-significant (P≥0.05) breed combination differences 1.60 ± 0.65 (K X K), 2.00 ± 0.00 (KB X K), 1.00 ± 0.00 (KB x B) and 1.33±0.58 (K x B) were obtained. Body condition scores at breeding, parturition and weaning showed non-significant breed combination variations (P≥0.05; Table 1). Doe body weights at breeding (30±4.24, 66±17.56, 49±8.32 and 34±4.04 kg) parturition (35±2.12, 69±9.95, 55±11.93 and 43±5.51 kg) and weaning (34±2.83, 62±14.85, 48±9.32 and 38±2.31 kg) showed highly significant breed combination variations (P≤0.01; Table 1).

Pre-weaning kid mortality and fecundity rates

Pre-weaning rate – percentage of kids that survived until weaning were 88%, 100%, 88% and 79% for K x K, KB x K, KB x B and K x B breed combinations, respectively (Table 1). These values were compared favorably with results (77% - 92%) obtained by Otuma and Osakwe (2008) who evaluated Red Sokoto goat x West African Dwarf goat in the rain forest agro-ecological of southeastern Nigeria. Kid goat survival rate has a direct effect on genetic progress by its effect on selection pressure that is the percentage of kids that must be retained as replacement. Moreover, high kid mortality can seriously affect the economic viability of small ruminant enterprise and jeopardize the beneficial impact of flock fertility and fecundity. Casey and Van Niekerk (1988) identified low birth weight, slow growth rate; low doe milk production as major constraints associated with pre-weaning kid goat mortality and this is responsible for the reduction of the total productivity.

The low fecundity of Boer dams reported in this study contrast with results obtained in Boer females in semi-arid environment, suggesting a strong environmental impact of all measures of prolificacy in this animal. Even though prolificacy is important and useful when looking at the maternal ability of the doe, the number of kids weaned per doe is of more practical significance when measuring reproductive efficiency.

The Boer goat is also known for its prolonged prolificacy with females having the ability to stay in production for long periods of time (Greyling, 1998; Malan, 2000). According to the South African National Department of Agriculture records, Boer goat females under extensive conditions with a precipitation of 295 mm, have an average conception rate of 90%, kidding rate of 187%, fecundity (kids born/does kidded) of 210%, and weaning rate (kids weaned/doe mated) of 149% over a twenty-year period (Malan, 2000). Casey and Van Niekerk (1988) reported mean litter size for Boer goat females of 1.93 kids per parturition. The litter size of Boer goat females varied from 15.2-24.5 % kids born as singles, 59.2-67.5% born as twins and 15.3-16.3% born as triplets (Erasmus *et al*., 1985; Greyling, 1998). Fielding (1983) observed that it is a common experience that multiple births in goats are associated with a high mortality rate.

Overall gestation length was 147.17±2.58 days and agrees with reports by Wilson (1984) on the Mubende goat in Uganda (146 1/2 days). Das *et al*. (1996) studied gestation length, birth weight and growth rates of pure-bred indigenous goats and their crosses in Kenya. Data on gestation period of 701 indigenous East African and Galla dams and pre- and postweaning growth of 810 pure-bred and cross-bred kids were analyzed by least squares statistical analysis. Breeds of kids were East African, Galla, Toggenburg × East African, Toggenburg × Galla, Anglo-Nubian × East African and Anglo-Nubian × Galla. Average gestation length was 149 days and was significantly ($P < 0.05$) affected by type of birth of the kid, year–month of kidding, and age of dam. Does carrying twins have shorter gestation length than does carrying singles. Sex and breed of kid did not have significant effect on gestation length. Although, the average gestation lengths do not differ among all breed combination groups. However, the pregnancy lengths were reduced with increasing body condition scores ($P > 0.05$). Similarly, Jalilian and Moeini (2012) showed that the kilograms lamb born in mated Sanjabi ewes with a body condition score of 3 were significantly more than in other groups.

Body condition scores

As shown in Table 1, body condition scores (BCS) did not differ significantly at breeding, parturition or at weaning ($P>0.05$) for all breed combinations. Acero-Camelo *et al*. (2008) evaluated the effects of supplementation with two concentrate levels (CL) on the body condition score (BCS), and body weight (BW) of breeding goats, the number of kids born, birth and weaning weight, and rate of weight gain of the offspring. Flushing improved the BCS in all nannies, but there were no significant differences between supplementation CL. The mean initial BCS of all goats was 2.8 and in both groups, it increased to values above 3 in the breeding and gestation seasons. Dapoza *et al*. (1995) recommend a BCS of 3.0 to 3.5 as optimal for goats in the breeding season. Body condition at mating has been shown to influence conception (Spahr, 2004).

According to Luginbuhl and Poore (1998), animals with extremely good body condition tend not to respond to flushing. Dapoza *et al*. (1995) in a study in sheep to evaluate the effect of BCS on ovarian activity, recommend flushing for females with BCS below 2.5. When goat nannies present poor BCS, they often have low conception rates, low twinning rates and kids with low birth and weaning weights (Luginbuhl, 1998). Goats lose body condition with the progressive deterioration of pasture in the dry season. This condition can be improved with a sufficient level of concentrate supplementation. Because the greatest potential for goats is to raise them in pasture under a semi-intensive management system, this study used a 1 to 5-point graduated scale, adapted from the beef system used in Alabama. In that graduated scale, thin is 1 to 2, moderate is 3 and fat is 4 to 5. In most situations, goats should be in the range of 3 to 4. Scores of 1 to 2 indicate a problem.

Most of researchers (Goonewardene *et al*., 1997) have reported that the absolute effects of BCS and live weight than their variations have greater impact on sheep reproduction efficiency, which suggest the importance of breed and interactions with nutritional and physiological conditions and its impact on reproduction efficiency (Atti *et al*., 2001). A correlation exists between BCS, live weight and amount of body fat reserves (Ducker and Boyd, 1977).

Body weight, body condition score at breeding, parturition and weaning versus reproductive and progeny performance

Body weight at breeding and gestation length showed a negative correlation ($r = -0.14$) lowly correlated with BCS at breeding ($r = 0.28$), moderately correlated with the number of kids born alive ($r = 0.36$) and showed a negative correlation with kid birth weight ($r = 0.31$) and kid weaning weight ($r= -0.42$) (Table 2). Body weight at breeding had a positive impact on the number of kids weaned ($r = 0.40$). Pre-breeding body condition scores (BCS) and gestation length showed a negative correlation ($r = -0.23$), lowly correlated with the number of kids born alive ($r = 0. 06$) and showed a negative correlation with kid birth weight ($r =0.32$) and kid weaning weight ($r= - 0.45$) (Table 2).

Table 2. Correlation Coefficients (r) between Body Weight (BWT), Body Condition Score (BCS) at breeding, parturition, and weaning, and reproductive and progeny performance in meat goats.

Parameter	*r*
BWT at Breeding vs. Gestation Length	-0.1444
BWT at Breeding vs. BCS at Breeding	0.2887
BWT at Breeding vs. No. Born Alive	0.3635
BWT at Breeding vs. Kid Birth Weight	-0.3189
BWT at Breeding vs. Kids Weaning Weight	-0.4271
BWT at Breeding vs. No. of Kids Weaned	0.4077
BCS at Breeding vs. Gestation Length	-0.2309
BCS at Breeding vs. No. Born Alive	0.0651
BWT at Breeding vs. Kids Weaning Weight	-0.4271
BCS at Breeding vs. Kid Birth Weight	-0.3229
BCS at Breeding vs. Kids Weaning Weight	-0.4589
BCS at Breeding vs. No. of Kids Weaned	0.0675
BWT at Parturition vs. Gestation Length	-0.2356
BWT at Parturition vs. BCS at Parturition	-0.2722
BWT at Parturition vs. No. Born Alive	0.3001
BWT at Parturition vs. Kid Birth Weight	-0.1866
BWT at Parturition vs. Kids Weaning Weight	-0.4177
BWT at Parturition vs. No. of Kids Weaned	0.3163
BCS at Parturition vs. Gestation Length	0.2097
BCS at Parturition vs. No. Born Alive	-0.3789
BCS at Parturition vs. Kid Birth Weight	0.0521
BWT at Parturition vs. No. of Kids Weaned	0.3163
BCS at Parturition vs. Kids Weaning Weight	0.0535
BCS at Parturition vs. No. of Kids Weaned	0.0267
BWT at Weaning vs. BCS at Weaning	0.3956
BWT at Weaning vs. Kids Weaning Weight	-0.3321
BWT at Weaning vs. No. of Kids Weaned	0.2540
BCS at Weaning vs. Kids Weaning Weight	-0.5813
BCS at Weaning vs. No. of Kids Weaned	-0.2643

No significant correlations were established between BWT at parturition with most parameters of reproductive and progeny performance (Table 2). However, BWT and BSC at weaning showed a moderate and positive correlation (r = 0.40). Although correlation estimates of BWT and BSC at weaning with the number of kids weaned and kid weaning remained low. The obtained results of the present study showed that the fertility and fecundity traits at the mating time were lowly correlated and affected by does Body Condition Score (BCS) (Table 2). The fertility rate in dams appeared highest and in medium body condition score does (3.5 or more) was lowest in thin does (< 2). The kids born/does at mating and kilograms kids born in does with BCS = 3 were significantly more than those in other BCS groups. Kids born per joined does in dams with BCS = 3 and 3.5 were 140 vs. 105%,

A negative correlation between gestation length and BCS (r = -0.23) was obtained. Pregnancy period in does with BCS = 3.5 was lowest but this trait in BCS = 2 was the highest. Kids' birth weights were not significantly impacted by these phenomena. BCS had no obvious significant effect (p>0.05) on Kids born per doe at mating and reproductive performance in a doe with BCS = 3 was better, while in does with BCS <3 or more the kidding rate appeared reduced. Bell *et al.* (1990) concluded that changes in pre-partum nutritional intake that results in altered pre-calving body condition influence the subsequent pregnancy rate of beef cows. Body condition scores before parturition and at the start of the breeding season were the dominating factors influencing subsequent pregnancy rates. They also suggested that the effect of BCS at calving was modulated by the body weight change during gestation. Cows with similar body conditions at calving may differ in rebreeding performance due to body condition changes during mid-gestation.

Gunn and Doney (1979) reported that ewes with high BCS (more than 4), have more early abortions and followed by, a decline in reproduction efficiency. Gunn *et al.*, (1988) observed that BCS of more than 3 at mating caused to decrease in born lambs. In this study, the number of kids born per joined does was highest in does with BCS = 3 group and followed each unit increases in BCS, these findings were in agreement with the results of Kenyon *et al.*, (2004). In present study there is no significant difference (P≥0.05) was observed between does conceive per joined does in all breed combinations. However, this trait in BCS 3.0 – 3.5 group was lower than in other groups (<3 and >4). Kenyon *et al.* (2004) also obtained similar results. The overall effect of doe's BCS on mean kid weaning weight was not significant (P≥0.05), but kid weaning weight was elevated to approximately 3.5 kg in dams with BCS of 3.5 following dam body weight increases, kids born per joined does and body weight of kids born at birth increased. Moeini and Jalilian (2014) established that parallel to body weight increases, the rate of multiple births is enhanced and it was in line with the results of the current study.

General Discussion and Conclusions

Various definitions of fertility exist in literature such as conception rate, fecundity, prolificacy, birth rate, etc. In small ruminants, a general definition of fertility is the number of ewes lambing or does kidding divided by the number of ewes/does mated. Fertility is affected by factors such as nutrition, age, diseases and season of mating. In most cases, there is a positive effect of supplementation. Age of the ewe or doe is also an important factor. Fertility increases with age and also starts to decline with old age. Since, fertility traits have low heritability and are more difficult to record than BCS (Kadarmideen and Wegmann, 2003), results of different studies suggest that BCS can serve as an indicator for estimated breeding value for fertility traits (Kadarmideen, 2004). BCS is used in dairy cattle to assess body composition and energy balance, and besides that, fertility in dairy cattle is affected by both extent and the duration of negative energy balance (De Haas *et al.*, 2007). Cows that are in negative energy balance, particularly in early lactation, may be yielding milk at the expense of reproduction. Thus, the mobilization of body tissue plays a role in the genetic control of fertility (Pryce *et al.*, 2000). Most studies reported a moderate genetic correlation between average BCS and fertility traits (Kadarmideen and Wegmann, 2003). However, there is a tendency that BCS in mid-lactation expressed the strongest genetic relationship with improved fertility (De Haas *et al.*, 2007).

Body condition or changes in body condition, rather than live weight or shifts in weight, are a more reliable guide for evaluating the nutritional status of an animal. Live weight is sometimes mistakenly used as an indication of body condition and fat reserves, but gut fill and the products of pregnancy prevent weight from being an accurate indicator of condition. Live weight does not accurately reflect changes in nutritional status. Two animals can have markedly different live weights and similar body condition scores. Conversely, animals of similar live weight may differ in condition score. Groups of cows with an average BCS of 4 or less at calving and during breeding will have poor reproductive performance compared to groups averaging 5 or above. Individual cows may deviate from the relationships established for groups; however, the relationship is well documented for herd averages. Body condition scores of 5 or more ensure high pregnancy rates, provided other factors such as disease, etc., are not influencing conception rates.

Body condition score (BCS) is an easy, inexpensive but subjective method to evaluate the body tissue reserves of lactating cows, independent of frame size and body weight (BW). During the early lactation period, mobilization of body reserve for milk production induces a negative energy balance that has been reported to affect the reproductive performance of dairy cows (Edmonson *et al.*, 1989). However, the effects are inconsistent; for example, some researchers have reported that BCS had no effect on reproductive indices (Pryce *et al.*, 2001), whereas others have reported significant effects (Bell *et al.*, 1990). Herd and Sprott (1986) reported that greater BCS changes during the early lactation period were associated with a reduced probability of conception at 1st service in multiparous cows, but not in primiparous cows. Thus, many factors, such as feeding system and level, the system of milk production, the cow's genetic background, and parity, might influence the reported results. Compared with the attention paid to the relationship between BCS and reproductive performance in dairy cattle, there have been few reports regarding associations between the more objective measure of BW and reproductive traits in meat goats. Senatore *et al.* (1996) reported significant effects on the reproductive performance of primiparous cows due to BW at parturition and BW loss during the early lactation period. Buckley *et al.* (2003) analyzed field data from 74 dairy herds under pasture-based seasonal calving condition and suggested that BW is potentially an important determinant of the likelihood of reproductive success.

The ideal BCS just before the breeding season is between 3 and 4 to maximize the number of kids born. Simply looking at an animal and assigning it a BCS can easily be misleading. Rather, animals should be touched. The easiest area to feel and touch to determine the body condition of an animal is the rib areas, on either side of the spine, by running a hand over those areas and pressing down with a few fingers. In doing so, one is able to determine the amount of fat covering the ribs. Other areas to monitor are the shoulders, the tail heads, the pins, the hooks, the edge of the loins and the backbone. There is a little information of BCS in Kiko or Boer goats in southeast Alabama. Rhind *et al.* (1989) reported that in ewes with high BCS (more than 4.0) the primary embryo wastage increased and reproductive performance decreased. In beef cattle, BCS had an impact on fertility rates (Venkatachalapathy *et al.*, 2015). Rhind *et al.* (1989) showed that a BCS of more than 3.0 at mating caused low lamb production and the number of born lambs per ewe at mating was highest in the ewes with a BCS of 2.75.

Body weight alone has been considered a poor indicator of the reproductive performance of dairy cows because it is affected by frame size and gastrointestinal fills and does not reflect the bioenergetically important tissue (Chagas *et al.*, 2007). Recently, it was reported in a pasture-based, seasonal-calving dairy system that BW is potentially an important determinant of the likelihood of reproductive success (Roche *et al.*, 2007). Herein, the BW loss (%) that indicates the rate of decrease from the prepartum BW during the early post-partum period was evaluated to eliminate the effect of frame size on the BW measurement. In contrast to the BCS changes, the BW changes were not affected by the cow's parity. Early recovery in BW might be a result of increased dry matter intake that enhanced the gastrointestinal fill of the cows. It is speculated that the recovery of BW, which includes gastrointestinal contents, was initiated at 30–33 days postpartum, regardless of parity and that the recovery of body fat reserves, which is initiated at BCS nadir, might be delayed about 15 and 25 d from the BW nadir in primiparous and multiparous cows, respectively. The responses to prepartum BW change may depend on body condition at parturition. Pregnancy rates of cows in good body condition at calving are affected little by minimal BW changes either before or after parturition (Rae *et al.*, 1993) dramatic BW losses after calving can reduce pregnancy rates (Whitman, 1975).

In conclusion, the results of the present study showed that BCS had an effect on the kidding rate. So, we recommend using flushing before mating for lower BCS meat goat dams (BCS <3) and body weight of (40-60 kg), and this might lead to significant improvements in reproduction efficiency and profitability of meat goat enterprise.

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