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Impact of Protein Supplement on Reproduction of Tswana Goats in Semi-Arid Area of North West Province of South Africa

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ABSTRACT

This study evaluated the impact of protein supplements on the reproduction performance of female Tswana goats. Twenty-four female weaner goats 3 months old and 10.56±1.28 kg body weights were used. Animals were grouped into three treatments of eight in a randomized block design according to live weight, supplemented with concentrate mixtures consisting of 10% of maize, grass and soybean meal, informed based on their weight (3.5% of body weight) as treatment group 1 to 3. Observations on reproduction performances were made by following planned standard procedures. The results are that feeding of goats with more protein diet significantly increases production. Goats that received high concentrations of protein gave birth to twins as compared to others. The study revealed that protein supplementation effectively influences twinning. Finally, the survival rate of kids correlated with protein supplementation to the extent that the highest survival rate was observed among kids born from animals supplemented compared to control treatment.

Keyword: Body weight, Dietary, Progesterone, Serum, Twinning.

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INTRODUCTION

The production of meat from goats and sheep plays an important role in the supply of animal protein for the people in the North West country of South Africa. Goat production in the villages is mostly done through the traditional husbandry system using the extensive system without any supplementation and this is characterized by the poor growth rate, high mortality and low reproductive rates (Kabir et al., 2004). One critical issue regarding kid survival in goat and sheep production is the nutrition of dams during pregnancy. Laporte-Broux et al.(2011) revealed that undernourished pregnant goats give birth to kids with reduced birth weight and heightened mortality rates while Hashemi et al. (2008); Mahboub et al. (2013) reported that supplemental feed during late pregnancy has shown to reduce kid mortality by improving birth weight and enhancing the immune system, and reducing the incidence of hypothermia. Abecia et al. (2012), mentioned that reproductive efficiency is directly related to the viability of offspring, kidding, kidding interval and length of the reproductive cycle. Kunbhar et al. (2016) observed that goat reproduction could be improved with better management practices and knowledge of normal physiology of reproduction and performance of indigenous goat breeds. Sheep and goats are very important species due to their biological identities, such as short generation interval, twinning, short growth periods and medium space requirements (Kunbhar et al., 2016). The most ideal approach to evaluate the state of an animal is to assess whether it has the correct weight for its age and physiological stage (Mahmoud et al., 2015). Very little work has been done to assess the effects of supplemental feeding on reproduction of Tswana goats. Therefore, the present study was conducted to investigate the effects of supplemental feeding on the reproductive performance of Tswana goats in the North West Province.

MATERIALS AND METHODS

The procedures used for supplementing goats were reviewed and approved by the Animal Research Ethics Committee, North-West University, Mafikeng Campus (AREC-MC) (approval no. NWU-00019-14-S9). The feeding experiment was conducted at Molelwane Farm of North-West University (25º40.459' S, 26º10.563' E), South Africa. Ambient temperature ranges between 27 and 37°C in summer and between -3C and 25°C in winter months, respectively. Annual rainfall ranges between 300 and 600 mm. Twenty-four female Tswana weaner goats (3 months of age and 10.56±1.28 kg BW) were bought from local farmers around Mafikeng. Animals were supplemented with concentrates mixtures consisting of 10% of maize, lucerne grass and soybean meal which was informed based on their weight (3.5% of body weight) and goats nutritional requirements as follow Treatment 1: maintenance X1; Treatment 2: Maintenance X 2 and Treatment 3: Maintenance X 3 Based on live weight, the animals were randomly allocated into three treatment groups (8 goats per treatment) in a completely randomized design (CRD). Goats were also fed basal diet of hay ad libitum and had free access to fresh water.

Weight Changes and Reproductive Performance

Animals were offered diets for an adaptation period of 10 days, after which they were weighed (initial weight). Animals were weighed and their weight recorded bi-monthly until the end of the trial (for a period of seven months). Age at puberty, gestation period, sex, birth weight of kids and dams were also recorded after parturition. Blood was collected to analyse the level of hormone such as progesterone and to assess reproductive maturity and pregnancy.

Blood Collection

Blood collection was done by a qualified animal health technician using the jugular vein. 10 ml of blood was collected immediately after restrain to minimise the effect of excitement on the mineral levels of blood, especially phosphorus (McDowell et al., 1982). Blood was collected on the first day of the experiment and every second-week post-feeding into one set of sterilised bottles, Blood samples were drawn from goats into serum tubes containing no anticoagulant and allowed to clot at room temperature for 30 min. Serum was separated by centrifugation and samples stored at -20°C until analysis.

Sample Analysis

Hormonal Analysis of High-Performance Liquid Chromatography (HPLC)

Progesterone was analysed through the High-Performance Liquid Chromatography (HPLC) model Shimadzu SPD-M20A and the Ultraviolet Detection method according to Augustine et al. (2014), with minor modifications. Blood samples were drawn from goats into serum tubes containing no anticoagulant and allowed to clot at room temperature for 30 min. Serum was separated by centrifugation and samples stored at -20°C until analysis. Samples were thawed on ice and 0.5 mL of serum transferred into a 10 ml centrifuge tube. Samples were run in duplicates and required 1.5 mL of serum per analysis. 1 ml of potassium phosphate and 4 ml pentane were added to the samples. The mixtures were vortexes thoroughly to mix, shaken for 15 min at room temperature and centrifuged at 1250 rpm for 10 min Occasionally, a gel interface formed between the aqueous and organic layers. This was observed more often if the samples were placed on ice or refrigerated for an extended period of time. When this occurred, the samples were vortexed thoroughly and centrifuged at a higher rate to obtain a clean solvent phase separation (approximately 1800 to 3000 rpm). After centrifugation, the organic phase was collected into a separate clean 10 ml centrifuge tube and the extraction repeated as above with 2 ml pentane.

The organic phases (from the first and second extraction) were combined and subsequently dried under a stream of nitrogen gas. The dried samples were reconstituted in 100 HPLC sterile water/methanol (50/50) while being cautious to wash down the sides of the tube and mix thoroughly. Brief centrifugation at 1250 rpm for 5 min was performed to concentrate the sample in the base of the centrifuge tube. The samples were then transferred into injection vials for analysis by HPLC. The HPLC analytical column stood at C18 (300X4.0 mm id). Progesterone standard and samples were analysed using a UV detector minimum wavelength 495 nm to a maximum of 516 nm in a condition and temperature of between 360 and 400C, HPLC pump flow rate of 1ml per minute and injection volume of 100 µl. The retention time of the standard was 5 min while for the samples, it was 8 min. The concentration of the standard ranged from 200 to1000 ng/ml.

Statistical Analysis

Blood nutritional metabolite data were analysed

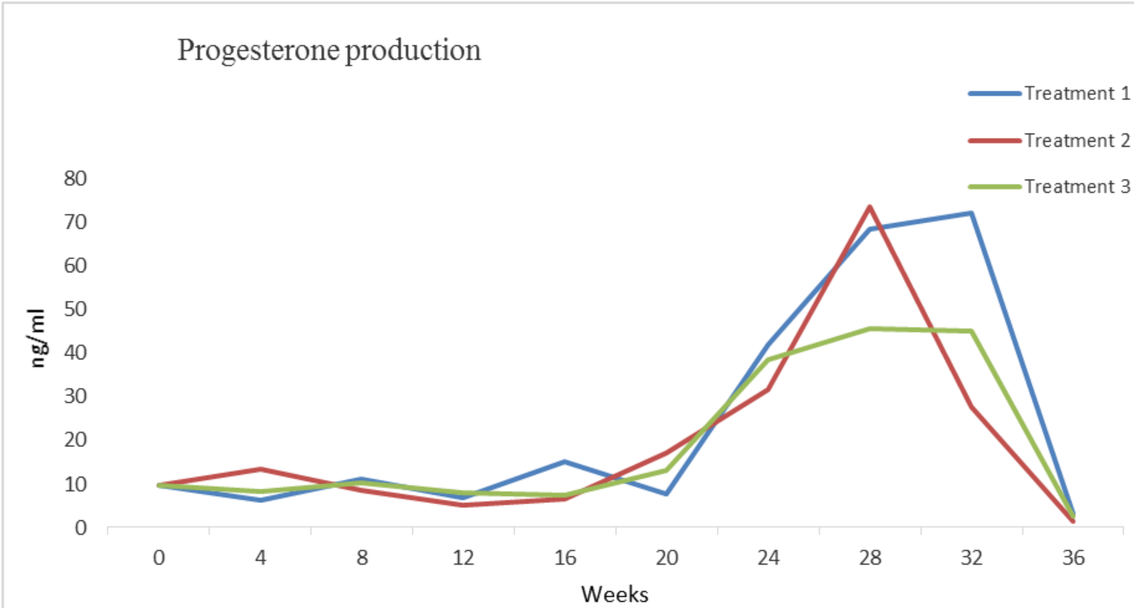

Figure 1. Variations of progesterone among different groups fed with different dietary protein supplementation using HPLC.

using repeated measures on the procedures of SAS (SAS, 2015) on the General Linear Model (GLM) according to the following linear model:

$$Y_{ij} = \mu + D_i + E_{ij},$$

Where: *Yij*=observation of the dependent variable *ij; μ* = fixed effect of the population mean for the variable; D_i= effect of dietary treatment (*i* = 4); and E_{ij} = random error associated with observation *ij*, assumed to be normally and independently distributed. Statistical significance was declared at P<0.05. When the analysis of variance revealed the existence of significant difference among treatment means, the probability of difference (PDIFF) option in the LSMEANs statement of the GLM procedure of SAS (2015) was used to separate the means. The level of significance was set at p<0.05.

RESULTS

The results obtained in Figure 1 on the effects of dietary supplementation on the progesterone levels showed there was significance at week 4 between treatment 2 and 1. The concentrations increased from week 20 and reached the peak at week 28 for animals fed in treatment 2 which was significantly higher (P<0.05) among groups with the value of 13.45 weeks 32 for (treatment 3) and 33 for treatment 1 (Figure 1). Dietary protein had an effect on week 4. The level of feed on other weeks had no significant effects and was observed from weeks 0 up to 20. The levels of progesterone in female animals in all diets increased from weeks 20 until 28 and dropped immediately afterward until week 36, except the level of progesterone in female animals receiving treatment in group 1 where there was an increase in week 32. In general, it was found that the three treatment groups with regard to protein supplementation there was no significant difference in the levels of progesterone. It was observed that the level of progesterone (from weeks 0 to week 28) increased gradually and reached the peak around week 28 of age, which correlates with puberty in most goats in treatment group 1.

The levels of progesterone reached the peak during weeks 28 to 32. The results showed gain of body weights from weeks 1 to 32 with (P<0.05 among the three groups. Treatment group 1 showed high (P<0.05) weight gain (50(9.46±0.5 kg), followed by treatment group 3 (8.36±0.6 kg) and diet 2 (7.79±0.5kg), respectively. Protein supplementation did not significantly affect any parameter in Table 1. Treatment group 1 had five kid mortalities whereas treatment group 3 experienced only two. However, in treatment group 3, only four goats (twins), while no mortalities were experienced in treatment groups 1 and 2. Feeding of goats with high protein treatment (P<0.01) increased protein intake (3X maintenance vs 1 X maintenance) compared to low protein treatment. However, (P>0.05) difference was observed between low protein and high protein treatment for the value of dry matter intake on live birth weight, twinning rate on goats and live weight gain, although there was a tendency to increase live weight gain in goats given the high protein data. Goats fed in 3 Maintenance did not gain weight.

Table 1. Weight gain (Kg) in female Tswana goats supplemented with different dietary protein.

	Weeks								
Treatment	**4**	**8**	**12**	**16**	**20**	**24**	**28**	**32**	**36**
Treatment 1	1.33±0.3	3.24±0.4	4.17±0.4	5.17±0.4	6.38±0.4^{b}	7.99±0.5^{b}	9.09±0.6	9.46±0.5^{b}	6.00±1.3^{b}
Treatment 2	1.500±0.3	2.08±0.4	3.01±0.4	3.83±0.4	4.75±0.4^{a}	6.01±0.5^{a}	7.41±0.6	7.79±0.5^{a}	2.50±1.2^{a}
Treatment 3	1.40±0.3	2.36±0.5	3.30±0.5	4.57±0.5	5.36±0.5^{ab}	6.32±0.6^{a}	7.76±0.7	8.36±0.6^{ab}	4.44±1.1^{ab}

a,b Means with different superscripts on the same column are significantly different (P<0.05). Treatment 1= maintenance X1; Treatment 2 = maintenance X 2; Treatment 3 = maintenance X 3.

Table 2. Length of gestation, live birth weight, twinning and mortality of kids fed protein supplementation.

	Treatment		
Parameters	**Treatment 1**	**Treatment 2**	**Treatment 3**
Kidding	8 (100%)	7 (87.5%)	12 (150%)
Kid survival	3 (47.5%)	(50) 100%	(50) 100 %
Live birth weight (Kg)	1.79±0.14^{b}	1.92±0.11^{b}	2.04±0.18^{a}
Twinning (%)	0	0	4 (50%)
Length of gestation (days)	151.6±8.4^{a}	150.1±7.2^{a}	149.2±6.1^{a}

Treatment 1= maintenance X 1; Treatment 2 = maintenance X 2; Treatment 3 =maintenance X3.

Weight gain in different groups was not significantly influenced by the treatment (Table 2). However, it was observed that group 1 had the highest weight gain, followed by group 3. Weight gain increased with time and reached its peak at week 32, then dropped after they had parturition (progesterone decreased after parturition). The mortality rate of kids born as twins was lower in treatment group 3. In addition, weight increased with age from the beginning of the experiment until week 32, then decreased drastically afterward.

DISCUSSION

In this study, a significant difference was observed between different groups of goats fed with three different protein concentrations. The group that received the highest (3X maintenance) had higher body weight gain than treatment group 2, while group 1 had the highest body weight The results obtained in this study are in line with other studies (Madibela et al., 2002; Kabir et al., 2004; Sahu et al., 2013) in which a correlation was found between body weight gain of goats and protein supplementation. The body weight gain observed after supplementation is also confirmed by Andesogan et al. (2006), who found that feeds of high nutritive value promote high levels of production and that the performance of ruminants is greatly influenced by the amount of nutrients consumed. However, the explanation as to why the treatment group 1 had gained more body weight than the other two groups (treatment groups 2 and 3) cannot be clearly explained. However, Bouchard et al. (1990), in their well-controlled study to determine whether there are true differences in responses among individuals to long term overfeeding, found that there is a possibility that genotypes are involved in such differences and would be involved. It is important to indicate that differences in the energy efficiency of growth and/or of weight maintenance are most likely to play a role in the susceptibility to weight gain (Galgani and Ravussin, 2010). It is important to also indicate that the role of protein in body weight gain regulation, compared to other macronutrients, consists of different aspects such as satiety, thermogenesis, energy efficiency and body composition, which are partly related to each other (Meza-Herrera et al., 2011).

In addition, it has been found that protein increases satiety when given iso energetically (Westerterp-Plantenga et al., 2006. It was also observed that under conditions of slight body weight regain (aimed at weight maintenance), a high protein diet shows reduced energy efficiency related to the body composition of the body weight regained (Acero et al., 2008). This might explain why animals in treatment group 1 gained more weight compared to those in treatment groups 2 and 3 in this study.

The results were observed among different experimental groups regarding weekly body weight gain from weeks 0 to 20. However, a significant body weight gain (P <0.05) was observed from weeks 20 to 32 and then dropped subsequently (Table 1) after parturition. This significant increase was higher in the treatment group 3 compared to treatment group 2. The significant increase from week 20 could be explained by the fact that at the time, animals reached their puberty and were pregnant. Body weight gain drop was observed from week 32 due to parturition. The results obtained in this study concur with those of Sahu et al. (2013) who reported that the last month of gestation is the period of rapid foetal growth, necessitating supplementation of pregnancy allowance to economies production and minimizing reproduction loss in goats. These results are also in agreement with those of the drastic decrease after week 36, in body weight, was due to parturition. Reproductive functions in small ruminants are influenced by other extrinsic factors, for instance, social and sexual interactions and nutritional status (Deribe and Taye, 2014). Rahman (2006) reported that progesterone (the hormone responsible for gestation) is the key hormone important for preparing the uterus for implantation and maintaining myometrium quiescence. The results obtained in this study concur with those of other researchers (Mutinani et al., 2013; Mohebbi-Fani et al., 2012; Arianmanesh et al., 2011; Xiao 2013). The increase in body weight, through time, could be explained by the fact that protein and energy do improve antioxidant status in animals, which consequently, enhances growth performance and animal production (Meza Herrera et al., 2010). According to Meza Herrera et al. (2010); Mmbengwa et al. (2009) and Terzano et al. (2012), in ruminants, changes in metabolic hormone plasma concentrations are important signals which inform the reproductive axis about nutrition status of the animal, thus affecting their reproductive performance.

The results of this study showed that protein supplementation had no significant effects on the level of progesterone (Table 1). The concentrations were stable, varying between 6.8 and 17 ng/ml in all groups from weeks 1 to 20. It is important to emphasise that progesterone is a pregnancy-associated hormone, which increases in concentration during the oestrus cycle around the ovulation period and remains high until the end of pregnancy, allowing the hormone of parturition such as Prostaglandin, cortisone, relaxin and oxytocin to take over (Rahman, 2006). Although no significant differences were observed in terms of progesterone concentration between the three groups, the results showed that the consumption of additional proteins induced early attainment of puberty in treatment groups 2 and 3 (from week 16) compared to treatment group 1 (from week 20). There was a difference between treatment groups 2 and 3 with treatment group 3 having higher concentrations. These results are in line with those of Titi and Awad (2007); Mauboub *et al*. (2013) and Yong Zhuo et al. (2014), who did not observe differences in mean plasma progesterone in supplemented goats and gilts. Hong et al. (2014) also noted that changes observed in hormonal concentrations could be predicted by changes in secreted hormones and gene expression in the hypothalamus pituitary-gonadal axis to a high concentration of protein. These results are in line with those of Madibela et al. (2002) and Mugerwa et al. (1993) who obtained 81 and 91% of fertility in goats. This is an indication that nutrition has an effect on reproduction. This is also confirmed in this study given the twinning rate (which stood at 50% in the group fed with dietary protein in treatment 3) (Table 2). There is a correlation between feed supplement and twinning. These results are in line with those of Titi and Awad (2007) who obtained a twinning rate of 86.67, 93.33 and 40% at 0, 3 and 5% fat supplementation. The increase in the rate in treatment group 3 could be explained by the fact that animals, in addition to maintenance, do accumulate energy, which can be used in reproduction.

The twining could be explained by the fact that supplemented animals had more active ovaries (Titi and Awad, 2007) and size (Hightshoe et al., 1991) hence, more twining. Other researchers (Lucy et al., 1991; De Fries et al., 1998) have also explained that fat supplementation provides metabolites that are critical components for goat, which may result in enhanced follicle growth. In addition, fat supplementation may result in increased syntheses of prostaglandin PG 2a and, therefore, a better conception rate. Kids live weight at birth showed a significant difference ($P<0.05$) between kids in the three treatment groups with kids born from supplemented groups weighing more than those from the control group. Other similar results (Titi and Awad, 2007; Madibela et al., 2002; Safari et al., 2003) have been reported and confirmed those of this study. No correlation ($P<0.05$) was found between the body weight of the doe and kids live weight at birth. Such results were also observed by Madibela et al. (2002). This study recorded kids' mortality of 62.5 and 14.2%, respectively in Treatment groups, 1 and 3 Kid mortality reported were due to bacterial infestation. Laboratory findings at the North-West University, after post-mortem, revealed that two kids died from Treatment group 1 due to septicaemia. Furthermore, the three kids that died within 24 h in Treatment group 1, were diagnosed with pulpy kidney. One of the two goats that aborted in Treatment group 3, had twin foetuses from which Toxoplasma gondii and Staphylococcus aureus were isolated. Kid mortality is a major concern for all farmers as this affects their productivity (Bakunzi et al., 2012). Kid mortality was high in the control group compared to Treatment group 3. This contradicts the report of Kulkarni et al. (2014) who observed that kids born single were much healthier than those born as twins. In addition, Ershaduzzaman et al. (2007); Kamal-EL-Hassan et al. (2009) and Shreedhar (2009) also confirmed that kid live birth weight significantly influenced kid mortality in post-partum. It is possible that there was a decrease of estradiol-17β concentrations as well as a decrease of progesterone clearance rate and its conversion into oestrogen at the end of gestation, thus prolonging the gestation period in this study; the long supplementation of protein had an opposite effect as explained earlier Tolera et al. (2010). These findings show that early and prolonged supplementation did not significantly reduce the length of gestation in goats.

CONCLUSION

Tswana goats have been identified as one of the most commonly kept breeds in the North West Province, South Africa by rural communities. To improve productivity and develop the farming of this breed in rural areas (which is one of the objectives of the National Development Planning of the Government of South Africa), there is need to assess different sources of feeding and their impact on reproduction and health. The aim of this study was to determine the effect of incremental levels of protein supplementation on reproductive and growth performance and health of female Tswana goats. To achieve this aim, supplemented animals were weighed regularly, during puberty and kidding. The weight and number of offspring were also recorded. The results revealed that high protein supplementation influenced the weight of Tswana goats and also during puberty and kidding, the weight and number of kids.

Productivity of this breed has been one of the challenges faced by farmers in these areas. Shortage of good quality feed, especially during the long dry season in tropical and subtropical areas, has increased the need to provide supplementary feed to sustain livestock production, particularly goats. Incorporating maize and soybean in the diets of goats fed with low-quality roughages could lead to better performance. It is concluded that improved feeding with better management could ensure an improvement in reproductive performance of Tswana goats. Furthermore, in order to optimise production in the goat industry, management programmes should be implemented to improve the reproductive aspects of goats since they are the source of animal protein and to alleviate the need in developing countries, which helps in the social upliftment of rural poor communities. Apart from research, several recommendations could be made to enhance goat productivity in rural areas of the North West Province.

The major aspects are feeding management, training of farmers, marketing management and management of goats. Training of farmers requires the cooperation of the Department of Agriculture, research institutions, universities and other stakeholders. The training of extension officers, who will, in turn, train communal goat farmers, could go a long way in realising and exploiting the potential of goat production. There is a need to improve marketing management and policies in most countries in Southern Africa. Resource-poor farmers need to form co-operatives and pool their animals together prior to marketing. The main challenge with the marketing of goats in communal areas is the dissemination of information on prices and market requirements. Provision of premium prices for animals in better conditions will motivate farmers to invest in improved animal feed and management technologies. There is also a need to establish more formal markets to enable farmers to sell their products. The study still needs to be extended to educate farmers that cost-benefit analysis is needed even where farmers have crop residues in their farms. To optimise the productive potential of Tswana goats, it is important that the reproductive management programme be implemented for the improvement of reproductive aspects of goats.

It is, therefore, concluded that improved feeding with better management could ensure the improvement of reproductive performances of Tswana goats. Thus, the adoption of improved supplementary feeding practices by communal farmers could be enhanced by creating awareness among farmers with regard to the rearing of goats through on-farm trials and participatory approaches. Future studies on supplementation feeding by goat farmers in the study areas could be conducted to assess the impact of supplementary protein on growth performance and reproductive health of Tswana goats reared in extensive production systems.

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