Reproductive Performance of Pubertal Alpine Goats Supplemented with Bypass Fat and Minerals

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Abstract: The aim of the present study was to evaluate the effect of bypass fat and mineral supplementation, on estrous percentage (PE), hours to estrus (HE), ovulation rate (TO), pregnancy rate (PG), lambing percentage (PP) and prolificacy (Pr). Twenty eight Alpine puberal goats were fed with a total mixed ration (TMR). Four groups were formed and randomly assigned to supplementation: Energetic: TMR + 37.5 g d^{-1} bypass fat, Mineral: TMR + 37.5 g d^{-1} of a mineral premix, Combined: TMR + 37.5 g d^{-1} bypass fat + 37.5 g d^{-1} of a mineral premix and Control: TMR. HE, TO and Pr variables were analyzed by PROC GLM. The PE, PG and PP variables were analyzed by PROC FREQ. PE, HE, TO and PP variables were not affected by supplementation with bypass fat and/or mineral elements. The PG was higher for treatments with energy and mineral supplementation, than combined treatment and control ($P < 0.01$). The Pr was higher ($P < 0.0330$) in treatments with supplementation than the control treatment. In conclusion, energetic and/or mineral supplementation in puberal female goats not affect the manifestation of estrus, TO and PP; however, PG and PR were increased.
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1. Introduction

The reproductive performance in goats can be modified through feed supplementation (Herrera-Camacho *et al*., 2011; Vázquez-Armijo *et al*., 2011a; Bindari *et al*., 2013). Bypass fat supplementation can be modify the secretion of steroid hormones in the female goat (Nieto *et al*., 2010), the population of large follicles and oocyte quality (Meza-Villalvazo *et al*., 2013), and the implantation process and the embryos quality (Petit *et al*., 2013).

Some studies have been conducted to evaluate the effect of mineral supplementation on (in vitro digestion (Salem *et al*., 2014) and onproductive performance of small ruminants in confinement (Domínguez and Huerta, 1994). Some improvements in weight gain and feed conversion were obtained with mineral supplementation, but the results are not consistent.

Based on the above, the objective of this work was to evaluate the effect of bypass fat and mineral supplementation on estrus and ovulation rate, pregnancy rate, the percentage of parturition and prolificacy in primiparous Alpine goats.

2. Material and Methods

The experiment was conducted at the Department of Metabolic Studies of Centro Universitario UAEM Temascaltepec, which is located at 19°02'42" N and 100°02'47" W, at 1300 m asl, with an average annual temperature of 20 ºC. Annual rainfall varies from 800-1600 mm (INEGI, 2009).

Twenty eight puberal Alpine goats, averaging 7.38 ± 1.35 months and 27.61 ± 3.66 kg of body weight (BW) were used, which were distributed randomly in individual cages (0.82 × 1.24 m). At the beginning of the experiment subcutaneous 12,000 IU vitamin A/kg BW, 1,700 IU of vitamin D_3/kg BW and 1.20 IU vitamin E/kg BW were administered. The control of internal parasites was performed every 30 d, by subcutaneous parenteral of 10 mg ivermectin/kg BW and 100 mg clorsulon/kg BW. All goats were fed with a TMR (40:60 forage: grain), which was performed to meet the requirements of energy and protein of puberal Alpine goats, according to the recommendation of the NRC (2007) (Table 1).

Table 1. Ingredients and chemical composition of total mixed ration

Ingredient	g/kg, as fed basis
Corn stover	244
Corncob	397
Soybean meal	107
Wheat bran	127
Molasses cane	94
Urea 46% N	9
Mineral premixƒ	22
Chemical compositionϕ	(g/kg DM)
Crude protein	155.7
Neutral detergent fiber	345.5
Acid detergent fiber	176.1
Metabolizable energy (Mcal)	2.75
Dry matter	896.6
Organic matter	924.4

ƒContained per kilogram of mineral premix: 230 g/kg of calcium, 39 g/kg of phosphorus, 120 g/kg of sodium, 12 g/kg of magnesium, 1870 mg/kg of zinc, 1700 mg/kg of manganese, 220 mg/kg of cooper, 65 mg/kg of iodine, 5 mg/kg of cobalt, 20 mg/kg of selenium.

ϕ Analyzed values at the Laboratory of Animal Nutrition of Centro Universitario UAEM Temascaltepec.

TMR was offered at three frequencies: 07:00, 13:00 and 19:00, at the rate of 750 g per frequency. The feed offered and refused was recorded daily before the morning feed, allowing adjust feed intake weekly. Water was provided ad libitum during the experiment.

Four groups were assigned randomly, with seven goats each one. Each group was assigned, randomly, the following treatments:

Bypass fat and mineral supplementation (BM): TMR + 1.23 g of myristic acid, 9.28 g of palmitic acid, 1.58 g of palmitoleic acid, 6.79 g of stearic acid, 14.35 g of oleic acid, 2.32 g of linoleic acid, and 0.19 g of linolenic acid, which was provided by 37.5 g/d of bypass fat (ENERVIT®, ZUAVIT SA de CV, Ecatepec, Mexico) + 8.63 g/kg of calcium, 1.46 g/kg of phosphorus, 4.50 g/kg of sodium, 0.45 g/kg of magnesium, 70.13 mg/kg of zinc, 63.75 mg/kg of manganese, 8.25 mg/kg of copper, 2.44 mg/kg of iodine, 0.19 mg/kg of cobalt, and 0.75 mg/kg of selenium, which was provided by 37.5 g/d of mineral premix (Premin GL, Forrajes el Nogal S. A. de C.V., Ocotlán, Jalisco).

Bypass fat supplementation (BP): TMR + 37.5 g/d of bypass fat + 0.0 g/d of mineral premix.

Mineral supplementation (MS): TMR + 0.0 g/d of bypass fat + 37.5 g/d mineral premix.

Control: TMR + 0.0 g/d of bypass fat + 0.0 g/d mineral premix.

The goats were treated with a progestagen for 14 d. For which it was inserted an intravaginal sponge impregnated with 20 mg of chronolone (Chronogest® CR, Intervet® Productions SA, Igoville, France) (Scudamore, 1988). At sponge withdrawal 200 IU of equine chorionic gonadotropin (eCG) (Folligon®, Intervet®, Boxmeer, Holland) were applied. Goats in estrus were mated by natural mating between 24 and 36 h after the onset of estrus.

The percentage of estrus (PE) and the hours to estrus (HE) were determined by male goats markers that were introduced every 30 min with 10 min sessions. Goats of all treatments were placed in a single pen to determine the incidence and distribution of estrus, at the end of this activity, ≈36 h, the goats were again placed in its respective cage. Goats detected in estrus were separated from the group and returned to its cage to facilitate detection of estrus in females remaining. Ovulation rate (OR) was determined on day 7 of oestrus cycle (oestrus d = 0), by counting the corpora lutea of surface of ovaries through exploratory laparoscopy. A rigid laparoscope lens of 10 mm diameter and 220 mm long (IFT®) connected to a light source (Loen Endoscope LG-150, Loen®, Zhejiang, China) means a fiber optic cable and two trocar cannulas was used. The pregnancy rate (PG) was determined by trans-rectal ultrasound scanner at 45 d post-mating. A veterinary ultrasound (Chison®, Chison 8300VET, Wuxic, China) equipped with a mechanical sector probe at 5.0 megahertz was used. Percentage or parturition (PP) was determined by counting of goats concluding pregnancy ended in parturition. Prolificacy (Pr) was determined by counting of goat kids born at birth.

Statistical analysis of HE, TO and Pr was performed by analysis of variance (ANOVA), with the GLM procedure (SAS, 2009), with a completely randomized design with seven replicates. The means of the significant variables were compared using the Tukey test at significance $\alpha = 0.05$ (Steel and Torrie, 1989). PE, PG and PP variables were analyzed using chi-square tests, using the FREQ procedure of SAS statistical package (2009).

3. Results

The percentage of puberal Alpine goats in estrus, in response to treatments shown in Table 2. The total percentage of goats in estrus was 96.43%. No effect of supplementation with bypass fat or minerals on estrus, in comparison with the control treatment, was found. HE and OR were not affected by bypass fat and mineral supplementation in goats, as shown in Table 2.

Table 2. Estrus manifestation and ovulation rate in puberal Alpine goats with and without bypass fat and mineral supplementation

Variable	BM	BP	MS	Control	SEM	*p*
PE (%)	86	100	100	100	---	0.0700
HE (h)	37.41	33.37	31.75	28.68	2.40	0.3207
OR (cl/ov$_x$)	3.6	2.9	2.6	3.2	0.26	0.3281

BM: bypass fat and mineral supplementation; BP: bypass fat supplementation; MS: mineral supplementation; SEM: standard error of mean; *p*: probability; PE: percentage of estrus; HE: hours to estrus; OR: ovulation rate (corpora lutea in ovaries).

The distribution of estrus is shown in Figure 1, where no difference was observed between treatments with respect to time when oestrus occurs.

The PG was higher for treatments with bypass fat and mineral supplementation, with respect to mixed supplementation and the control group (Table 3). Treatments showed no effect on the PP (Table 3). The Pr obtained in goats with synchronized estrus is shown in Table 3; which shows that supplementation had greater ($p < 0.0330$) Pr than the control treatment.

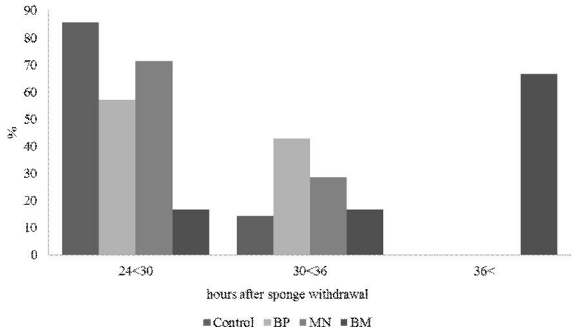

Figure 1. Estrus distribution in puberal Alpine goats with or without bypass fat and mineral supplementation

Table 3. Gestation percentage, percentage of goats lambing and prolificacy in primiparous Alpine goats with or without bypass fat and mineral supplementation

Variable	BM	BP	MS	Control	SEM	*p*
PG (%)	66^b	100^a	100^a	57^b	---	0.0100
PP (%)	43	57	57	28	---	0.4902
Pr	1.66^a	1.5^a	1.66^a	1.0	0.244	0.0330

BM: bypass fat and mineral supplementation; BP: bypass fat supplementation; MS: mineral supplementation; SEM: standard error of mean; *p*: probability; PG: percentage of gestation; PP: percentage of parturition; Pr: prolificacy. Different superscripts in the same row indicates difference ($p < 0.05$).

4. Discussions

The PE and HE obtained in this work were similar to those obtained in bypass fat supplemented ewes with different thickness of dorsal fat (Nieto *et al*., 2010). The PE found in this study is considered acceptable with respect to breed and physiological state of the experimental units (Greyling, 2000). Herrera-Camacho *et al*. (2011) mentioned that despite knowing the effects of fat supplementation on reproduction in ruminants is still not totally precise amount of fat supplementation necessary to cause an effect on reproductive function. The mechanisms of action that occur with energy and mineral supplementation on reproductive processes are not clear; however, Espinoza *et al*. (2008) mentioned that fat supplementation increases the concentration of total cholesterol lipoprotein precursor for synthesis of steroid hormones. Supplementation provided in this study could be low compared as recommended by some authors to observe effects on reproduction in ruminants. Thomas *et al*. (1997) mentioned that the amount of vegetable oil needed to achieve a positive effect on ovarian should not be less than 4%. In this study, supplementation with inert fat was around 3.75%, which may explain why the treatments had the same ovarian response, as measured by the PE, the HE and OR. The effects of mineral supplementation in ovarian activity are unknown, but may participate at organ level, since it has been reported that during the follicular phase of the estrous cycle ovarian tissue requires large amount of Zn (Brem *et al*., 2003); however, in our work, no differences were found on ovarian response. Vázquez-Armijo *et al*. (2011a) found no differences in the concentrations of Zn in serum during the follicular phase and the luteal phase in goats cycling, mentioning that such situation could be explained because Zn is not required in the blood circulation if not in the gonad, organ where were detected high concentrations of Zn (Favier, 1992). The Pr obtained in this study was higher in

supplemented goats than the control group; this effect may be because many of the mediated processes in the implantation process and embryo development are mediated by mineral elements such as Se (Vázquez-Armijo *et al*., 2011b); in addition to higher production of P_4 in response to bypass fat supplementation (Jaramillo *et al*., 2013). The results obtained about supplementation in goats is not yet conclusive, however special attention should be on the presence of these micronutrients in diets for goats, given its effect on some reproductive traits in this species. In conclusion, bypass fat and mineral supplementation in female primiparous Alpine goats not alter the manifestation of estrus, ovulation rate and percentage of lambing, however the pregnancy rate and litter size are increased, so it is recommended supplement to the goats with bypass fat and mineral elements.

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