Animal Reproduction

SHORT COMMUNICATION

Pre-breeding nutritional supplementation in bucks increases testosterone and improves fertility in goats under semi-extensive conditions

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Abstract

In subtropical latitudes, goats are managed under semi-extensive systems grazing natural vegetation without supplementation. During the dry season, reduced forage availability leads to undernutrition and reduced breeding activity in bucks. This study evaluated whether pre-breeding nutritional supplementation enhances testosterone and reproductive performance in bucks joined with anestrous females. On 15 March, bucks were assigned to two groups (n = 6 each) and placed with separate flocks of 90–100 females grazing 9 h/day. Control bucks received no supplementation; supplemented bucks received 600 g/day of concentrate from 15 March to 30 May. Males were fitted with aprons until 1 June to prevent mating. Testosterone was low and similar between groups in March and April ($P > 0.05$). In supplemented bucks, testosterone increased from mid-May to mid-June, reaching higher than controls ($P < 0.05$). Females joined with supplemented bucks had higher fertility (71% vs. 53%; $P < 0.01$), earlier parturition, and a shorter kidding period ($P < 0.0001$). In conclusion, pre-breeding supplementation increases testosterone, improves fertility, and advances and synchronizes kidding under semi-extensive conditions.

Keywords: reproductive seasonality, undernutrition, male effect, goat production systems

Introduction

Goat breeds from subtropical latitudes show marked reproductive seasonality. Nutritional status modifies this pattern. Undernourished bucks exhibit reduced endocrine activity, sexual behavior, and semen production (García-Cruz et al., 2022). Pre-breeding supplementation can reverse these effects, increasing testosterone and fertility (Walkden-Brown et al., 1993; Delgadillo et al., 2021), likely through reduced negative feedback on LH secretion (Walkden-Brown et al., 1994). Sociosexual interactions stimulate reproductive activity in anestrous females. Continuous contact with sexually active males at the onset of the breeding season may induce reproduction (Abecia et al., 2025). In northern Mexico, goats are managed under semi-extensive systems without supplementation. Dry-season undernutrition reduces male reproductive performance (Tejada et al., 2025). This study evaluated whether pre-breeding supplementation improves testosterone and fertility in bucks under semiarid, semi-extensive conditions.

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Methods

The study was conducted in northern Mexico (26°23'N, 104°47'W). Procedures were approved by the Collegiate Body of Research (UAAAN 35-38111-4255010022804) and complied with NOM-062-ZOO-1999 (Mexico, 2001). From 15 March, 4-year-old bucks were allocated to two groups and placed with two pre-existing flocks of 90–100 multiparous lactating goats that had kidded the previous November. The female flocks had similar BC (2.7 ± 0.1), belonged to the same communal land, and grazed daily from 09:00 to 18:00 h on comparable routes with similar semiarid vegetation (Duarte et al., 2008). Females were milked once daily. Control bucks received no supplementation (n = 6; BW: 55 ± 2 kg; BC: 2.1 ± 0.2; TD: 103 ± 2.3 mm; mean ± SEM). Supplemented bucks received 600 g/day of commercial concentrate (1.7 Mcal/kg DM; 14% CP, DM basis) after grazing from 15 March to 30 May (n = 6; BW: 55 ± 5 kg; BC: 2.3 ± 0.2; TD: 98 ± 1.8 mm). To ensure each buck consumed its assigned amount of concentrate, bucks were separated into individual pens for 30 min after grazing and supplemented individually. Females received no supplementation. Bucks were fitted with aprons until 1 June to prevent mating and remained with females until parturition. Seasonal anovulation was confirmed by transrectal ultrasonography during the anestrous-transition in northern Mexico. Body condition (BC), testicular diameter (TD), and plasma testosterone concentrations were measured every two weeks. BC was scored on a 1–4 scale, TD was measured as the greatest testicular width using a caliper, and blood samples were collected by jugular venipuncture into heparinized tubes at 08:00 h before grazing. Samples were centrifuged (2500 × g, 20 min), and plasma stored at −20 °C until testosterone determination by enzyme immunoassay. To minimize variation in testosterone secretion, all samples were collected under the same management conditions. Assay sensitivity was 0.3 ng/mL, and intra-assay CV was 8.7%. Fertility, prolificacy, and parturition dates were recorded.

Statistical analyses

Sample size for males and females was calculated using a two-tailed test ($\alpha = 0.05$; power = 90%) based on expected differences in testosterone concentrations and fertility rates. After testing data normality with the Shapiro-Wilk test, parametric or nonparametric analyses were performed as appropriate. BC was analyzed using the Friedman test for time effects and the Kruskal-Wallis test followed by the Mann-Whitney U test for between-group comparisons at each sampling time. TD and plasma testosterone were analyzed using two-way repeated-measures ANOVA. In addition, within-group comparisons over time were performed using paired t-tests, and between-group comparisons at each sampling time using independent-samples t-tests. The model used was a two-level repeated-measures model for each variable separately (testicular diameter, TD, and testosterone concentration, T). The experimental unit was TD or T, respectively, and the model included treatment (group), sampling time (weeks), and the interaction between these factors. Therefore, the reported interaction includes not only the effect of time but also the effect of group.

The proportion of females that kidded was compared using the Chi-square test, prolificacy by the Mann-Whitney U test, and the interval from apron removal to parturition and parturition date by one-way ANOVA. Analyses were performed using SYSTAT 13. Data are expressed as mean ± SEM or percentages, with $P < 0.05$ considered significant.

Results

BC varied over time ($P < 0.01$) without a group × time interaction ($P > 0.05$). Supplemented bucks showed higher BC than controls in April, May, and July ($P < 0.05$; Figure 1a). TD and plasma testosterone varied over time ($P < 0.01$), with a group × time interaction ($P < 0.05$). TD did not differ between groups ($P > 0.05$) but increased earlier in supplemented bucks (Figure 1b). Testosterone was low in both groups during March and April ($P > 0.05$). In supplemented bucks, testosterone increased from mid-May to mid-June and was higher than in controls ($P < 0.05$; Figure 1c), then declined in July, whereas it remained low in controls. Fertility, prolificacy, mean parturition date, kidding season, and interval from apron removal to parturition differed between groups ($P < 0.01$; Table 1).

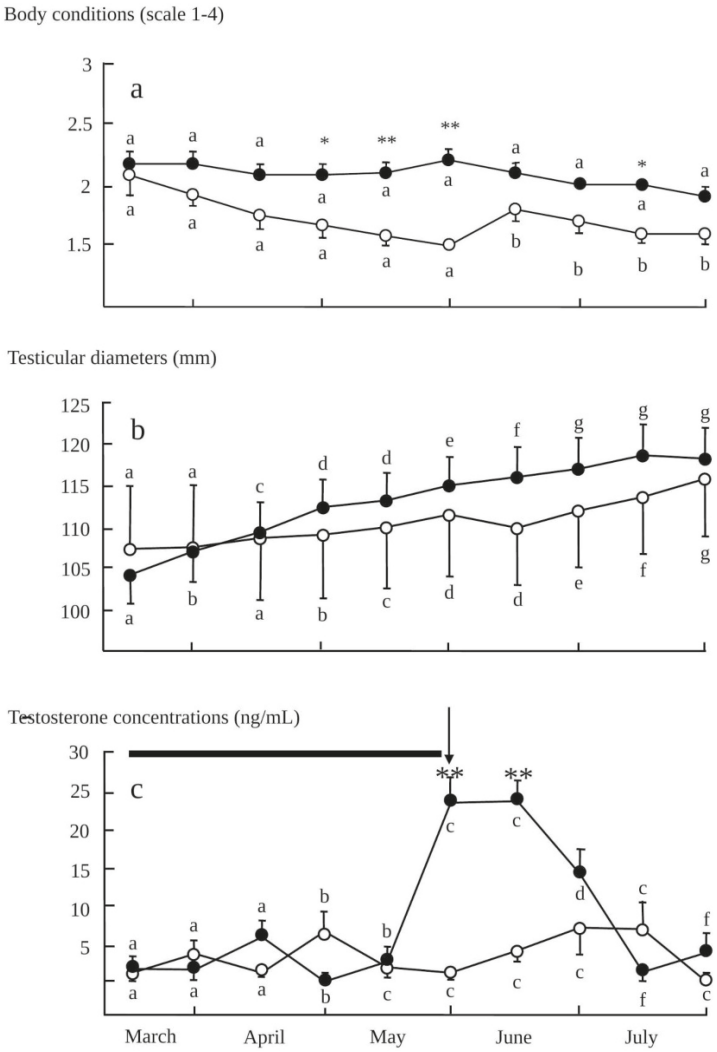


Figure 1. Body conditions (a), testicular diameters (b) and plasma testosterone concentrations (c; mean ± SEM) in control (○) and supplemented (●) bucks managed under semi-extensive conditions. Supplemented bucks received 600 g/day of concentrate from 15 March to 30 May. The black bar indicates the supplementation period; the arrow, apron removal. Measurements were taken every two weeks from March to July. *P < 0.05, **P < 0.01. Different letters indicate differences over time within groups (P < 0.05).

Table 1. Fertility, prolificacy, mean parturition date, kidding season, and interval from apron removal to parturition in female goats joined with control or supplemented bucks under semi-extensive conditions. Supplemented bucks received 600 g/day of concentrate from 15 March to 30 May. Data are expressed as mean ± SEM or percentages.

Variable	Control bucks	Supplemented bucks	P-value
Fertility (%)	53	71	< 0.01
Prolificacy	1.2 ± 0.02	1.5 ± 0.1	< 0.01
Mean parturition date	17 Jan ± 0.8 d	23 Nov ± 0.9 d	< 0.001
Kidding season	29 Dec – 4 Feb	11 Nov – 6 Dec	< 0.0001
Interval from apron removal to parturition (days)	229 ± 0.8 d	174 ± 0.9 d	< 0.001

Discussion

Pre-breeding supplementation increased testosterone and improved reproductive performance in bucks under semi-extensive conditions. Females exposed to supplemented bucks showed higher fertility, prolificacy, and earlier synchronized kidding. BC remained stable in supplemented bucks but declined in controls from April to May (Delgadillo et al., 2021). Testosterone increased in supplemented bucks from mid-May to mid-June, indicating an earlier onset of the breeding season.

Although testicular diameter did not differ between groups, it increased earlier in supplemented bucks, consistent with the temporal pattern of testosterone secretion, which may reflect reduced testosterone feedback on LH secretion, facilitating reproductive activation (Hötzel et al., 2003). The decline in testosterone in July in supplemented bucks may reflect the end of nutritional supplementation on 30 May. Nevertheless, the increase from mid-May to mid-June appeared sufficient to improve reproductive performance, with higher fertility, prolificacy, and synchronized kidding. Females exposed to supplemented bucks kidded 55 days earlier than controls. Female exposure and sociosexual interactions may have contributed to increased testosterone (Walkden-Brown et al., 1994), suggesting that both nutritional and reproductive stimuli influenced reproductive activation. Elevated testosterone may have induced ovulation and fertilization through the long-term male effect (Abecia et al., 2025). In contrast, control bucks fertilized females later, resulting in later, more dispersed kidding (García-Cruz et al., 2022).

Conclusion

Pre-breeding nutritional supplementation in bucks increases testosterone and improves fertility, resulting in an earlier, more synchronized kidding season. It is a practical strategy to enhance reproductive efficiency in goats managed under semiextensive conditions.

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Data availability statement

Research data is only available upon request.

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Author contributions

LMT: Conceptualization, Supervision, Resources, Project administration, Methodology, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. NLM: Conceptualization, Investigation, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. DLM: Conceptualization, Investigation, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. PC: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. JAD: Conceptualization, Supervision, Resources, Project administration, Methodology, Data curation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing.