

## Influence of Lactation, Liveweight and Lipid Reserves at Mating on Reproductive Performance of Grazing Goats

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**Abstract:** Multiparous goats (n=183) of undefined genotype (native x traditional dairy breeds) kept on a desert rangeland were used to assess the effect of concurrent pregnancy and lactation, liveweight and lipid reserves at the sternum at mating on reproductive performance. The extended lactation during the dry season, concurrent with pregnancy, was associated with a lower (P<0.01) pregnancy rate (60 vs 92% for lactating and dry does, respectively), prenatal wastage (77 vs 4%) and kidding rate (14 vs 88%). Body weight at mating, middle of gestation and parturition, as well as sternum width and skin thickness at the sternum region was not different between dry and lactating does. In a second analysis considering only the dry does, the proportion of does pregnant, as well as kidding rates were not affected by body weight of does at mating, middle of gestation and at parturition. However, mean litter size tended to be higher (P= 0.09) for heavier does at mating ( $1.65 \pm 0.48$  vs  $1.46 \pm 0.51$ ) and at the middle ( $1.65 \pm 0.48$  vs  $1.45 \pm 0.51$ ) of gestation. Mean litter weight also tended to be higher (P= 0.06) for heavier does at the middle of gestation ( $5.40 \pm 0.83$  vs  $4.89 \pm 0.87$ ). Body energy reserves, as reflected in sternum width and skin thickness in the sternum region, tended to be related to kidding rates, with does with higher fat reserves supporting higher kidding rates (94 vs 83%; P<0.01). Litter size and weight did not differ among does with different body fat reserves. These data indicate that, although lactation concurrent with gestation in the dry season was not associated with a major weight loss, it had a drastic cost on reproductive effort. Moreover, mean litter size and weight tended to be positively influenced by body weight at mating but not by levels of sternum energy reserves of does.

**Key words:** pregnancy rate, kidding rate, litter size, lactation, range

### Introduction

Under range conditions in the arid zones of northern Mexico, goat birth is programmed with the summer green-up. Adequate nutrient content of forage during summer and fall allows goats to produce about 60 kg of milk during 6 months and to restore their lipid reserves for their brief once-a-year reproductive season (Mellado *et al.*, 2005). With rains in winter (erratic in this area), some producers keep milking the goats in winter, which deteriorates de body energy reserves of does because of the low forage availability and the concurrence of pregnancy and lactation. In this environment Mellado *et al.* (2001) recommended that pregnant does should not lost weight so as to be able to produce and maintain viable fetuses throughout the gestation period. Failure to gain enough weight and body reserves at the end of lactation (end of summer) may results in delayed response of does to the buck stimulus (Mellado *et al.*, 1994), coupled with poor reproductive performance during the next season (Mellado *et al.*, 2004). An understanding of the reproductive characteristics of the goats in xeric environments as affected by various management factors is a fundamental component in enhancing the productive potential of these animals. This investigation was implemented to assess the influence of prolonged lactations concurrent with pregnancy, liveweight and body lipid reserves, measured via sternum measurements, on the reproductive efficiency of mixed-breed goats under range conditions.

### Materials and Methods

The study was conducted on natural rangelands in the Chihuahuan desert biome of northeast Mexico (101° 20' W, 25° 30' N), in a communal grazing system. The average annual precipitation is 322 mm, with 75% falling from June to October. Average maximum daily temperatures range from 28°C in January to 37.2°C in July. Average minimum daily temperatures range from -0.7°C in January to 12.3°C in July.

The most commonly encountered shrub species was creosotebush (*Larrea tridentata* (DC.) Cov.). Other shrubs commonly found were lechuguilla (*Agave lechuguilla* Torr.), pricklypear (*Opuntia rastrera* Weber.) and tarbush (*Flourensia cernua* DC.). Primary grasses included sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) and Arizona three-awn (*Aristida arizonica* Vasey). The most commonly encountered forb species were globe-mallow (*Sphaeralcea angustifolia* (Cav.) D. Don.) and silver-leaf nightshade (*Solanum elaeagnifolium* Cav.). Historically, this pasture have been heavily stocked by large flocks of goats, bovines and equines.

Multiparous mixed-breed goats (native x traditional dairy breeds; n=183) from a commercial flock were selected at mating. Average live weights at the commencement of the breeding period was  $38.2 \pm 4.4$  kg. Goats grazed on open range year round driven by a herdsman for 8 h per day (from 1000 to 1800 h). Animals were penned near the household at night without access to feed and water. No food supplements and salt mineral mix were provided to the goats throughout the year, and animals had access to water only once a day. Group mating took place during 4 weeks in February 2004. Bucks were adult Boer sires and the doe buck ratio was 35:1. After the breeding season males were not allowed to interact with the females throughout the year. Kiddings occurred in July. Goats were not vaccinated against endemic diseases and were not treated against internal and external parasites. Kids were not weaned, therefore they remained with their dams throughout the lactation period. Stocking rate were approximately 8 ha per goat, which was within the carrying capacity of this rangeland.

Each doe was weighed directly off feed and water at the start of the breeding period, at the middle of gestation (70 days after the initiation of buck exposure) and the day following parturition. Assessment of sternum width and skin thickness in the sternum area was made with a fat-o-meter skinfold caliper (Novel Products Inc., Rockton, Il., USA), an instrument designed for body composition assessment in humans. For pregnancy determination at about 80 days of pregnancy, does were scanned transabdominally, standing, in the right inguinal region, with an Aloka 500 ultrasound equipment with a 5 MHz transducer. Previous to the examinations, the hair in the targeted

region was shaved. At parturition all kiddings were recorded, as well as litter size. Kids were weighed the day of birth.

Because of an extremely low kidding rate of the lactating does, the effect of lactation concurrent with gestation was examined independently to assess lactation on fetus success. One-hundred and eighty three pluriparous does were allocated to two groups. One group (n= 109) was dry at the beginning of the mating period (control), while the other group (n=74) had been milked during 6 months, and lactation continued during the mating and gestation period in the dry season. In a second analysis the reproductive performance of 105 dry goats was assessed taking into account the liveweight of does at mating, middle of gestation and parturition. Additional variables considered were the diameter of the sternum and the skin thickness in the sternum area. Body weights at mating, middle of gestation and parturition were classified into two classes: less or greater than 35 kg, less or greater than 35 kg, and less or greater than 37 kg, respectively. The classes for the diameter of the sternum were <4.9 and >4.9 cm, whereas thickness of the skin in the sternum area was grouped as <0.05 or >0.05 cm.

For the lactating and dry does pregnancy and kidding rates were analyzed using the Chi-square test, while the rest of the data were analyzed using the Student's t-test. For the dry does, pregnancy and kidding rates were analyzed using the Chi-square test. The rest of the data were analyzed by the general linear model procedure of SAS (SAS Institute, 1988). The model took into account body weight at mating, at the middle of gestation and parturition, sternum diameter and skin thickness at the sternum. The dependent variables were the litter traits.

## Results and Discussion

The effect of lactation concurrent with gestation on does reproductive performance and some body traits are presented in Table 1. The extension of milk synthesis during the dry season caused a marked reduction ( $P<0.01$ ) in pregnancy rate of does. Fetal survival in lactating does was much lower ( $P<0.01$ ) than that in dry does, and consequently the kidding rate was 6 times higher ( $P<0.01$ ) in dry does compared with lactating animals. The associations between milk secretion and fertility may run via pleiotropic effects, i.e. via functional pathways (for example related to intake), or linkage of genes and may involve changes in levels of hormones and metabolites (Veerkamp *et al.*, 2003). In the present study apparently milk secretion increased metabolic load via a higher yield per se and/or via physiological processes that facilitate milk yield, compromising fertility in the lactating does. Apparently excessive resources were drawn away from fitness-related traits, such as fertility, to sustain milk production. In addition, resources for maintaining fitness depend on the demands by the environment, and in this harsh environment more resources are required for fitness-related traits than in an optimal environment. The low reproductive performance of the lactating goats was due primarily to the high prenatal wastage (77%) as opposed of failure of does to become pregnant. In this zone, the standing crop of forages during the rainy season (summer and fall) is about double the standing crop during the dry season (winter and spring) (Mellado *et al.*, 2005). Thus it was clear that the low availability of forage in winter was not compatible with the high metabolic state of goats (concurrent lactation and pregnancy), and thus fetal survival was affected adversely. The large effect of under-fed does in arid environments on prenatal wastage (Mellado *et al.*, 2001) support this view.

Non-lactating females and females that experienced lactation in winter did not differ in body weight at the beginning, middle and end of gestation (Table 1). The negative association between lactation and fertility in goats could not be attributed to marked variation in body energy reserves, as the width of the sternum region and skin thickness of the sternum area were not different between lactating and dry does. Thus, although lactation had not a negative effect on mass variation it had a profound reproductive cost.

The effects of body weight and sternum measurements on the reproductive performance of does is presented in Table 2. Neither body weight at mating, middle or end of gestation significantly affected pregnancy and kidding rates. The lack of a detrimental effect of low body weight on conception rate suggests that the majority of does conceived regardless of their body weight. Data of Mellado *et al.* (2004b) indicate that thin goats under range conditions are capable of reaching acceptable conception rates. Mbayahaga *et al.* (1998) also documented that, different to sheep, postpartum body weight loss in goats is not a limiting factor of the estrus and ovarian resumption after parturition. Goonewardene *et al.* (1997) also indicate that weight lost prior to breeding does not affect estrus response and kidding rates in dairy goats. The acceptable pregnancy (Bocquier *et al.*, 1996) and kidding (Sibanda *et al.*, 1999) rates in goats on a low plane of nutrition and the efficient induction of estrus (Mani *et al.*, 1992) in goats under a poor nutrition regime are additional evidence of the reproductive capacity of goats under resource-poor environments. Moreover, goats in the present study did not loss weight during pregnancy, which prevented massive prenatal wastage.

Table 1: Effect of lactation during the dry season concurrent with gestation on reproductive performance and body weight and sternum measurements of goats under range condition

Item	Non-lactating	Lactating
Number of does mated	109	74
Percentage of does pregnant	92 (100/109)	60 (44/74)*
Percentage of does kidded	88 (96/106)	14 (10/74)*
Percentage of prenatal wastage	4.3 (4/92)	76.6 (46/60)*
BW at mating (x± SD, kg)	35.1 ±4.7	34.4 ± 4.9
BW ½ pregnancy (x ± SD, kg)	35.0±4.8	32.8±4.4
Diamjeter of sternum (x ±SD, cm)	4.7±0.35	4.6±0.43
Skin thickness in the sternum (x ± SD, cm)	0.52±0.25	0.47 ± 0.29

\* $P<0.01$

However, mean litter size tended to be higher ( $P= 0.09$ ) for heavier does at mating and at the middle of gestation. Mean litter weight also tended to be higher ( $P= 0.06$ ) for heavier does at the middle of gestation. This effect apparently is explained by a higher stores of metabolic reserves in heavier does at mating, because it exist a strong linear relationship between liveweight and condition score in ewes (Kenyon *et al.*, 2004).

Table 2: Effect of Body weight at mating, middle of gestation, kidding and lipid reserves in the sternum on doe reproductive efficiency

Item	Oes mated (no)	Does pregnant (%)	Does kidded (%)	Kids bom/does	Litter birth weight (kg)
Body weight at mating					
< 35 kg	57	93	85	1.46±0.51a	5.08±0.97
> 35 kg	48	92	89	1.65±0.48b	5.27±0.81
Body weight ½ preg.					
< 35 kg	56	92	84	1.45±0.51a	4.89±10.87 <sup>A</sup>
> 35 kg	49	92	89	1.65±0.48b	5.40±0.83 <sup>B</sup>
Diameter of sternum					
< 38 kg	52	---	83	1.44±0.51	4.97±0.91
> 37 kg	53	---	92	1.62±0.49	5.28±0.86
Diameter of Sternum					
< 4.9 cm	50	90	82 <sup>a</sup>	1.55±0.51	5.25±1.11
> 4.9 cm	55	94	92 <sup>b</sup>	1.56±0.50	5.28±0.70
Skin thickness sternum					
< 0.5 cm	58	90	83 <sup>a</sup>	1.56±0.50	5.15±0.82
> 0.5 cm	47	95	94 <sup>b</sup>	1.54±10.51	5.22±0.97

<sup>A,B</sup> P=0.06, <sup>a,b</sup>P=0.09

These findings are consistent with the observed higher litter size and weight in does (Hoque *et al.*, 2002; Akingbade *et al.*, 2003; Mellado *et al.*, 2004) with the heavier weights at mating. The association between body mass of does and litter size and weight could be attributed to a higher ovulation rate in heavier does, because it has been shown that a drop in body weight in goats is accompanied by a reduction in ovulation rate (Mani *et al.* 1992), whereas ovulation rate increases almost linearly with body weight (Henniawati and Fletcher, 1986). Also, larger percentage of multiple births has been observed in does on good nutrition than those on low nutrition (Sachdeva *et al.*, 1973). The mechanisms by which body weight affects litter size in goats is not fully understood, although studies in sheep indicate that body energy reserves may have a direct effect on hypothalamic and pituitary activity (Rhind *et al.*, 1989; Vinales, 2002; Tanaka *et al.*, 2002). We hypothesized the existence of a threshold weight below which litter size and litter weight in does decreases.

Pregnancy rate was not affected by both width of the sternum and skin thickness in the sternum region, but kidding rates tended to be higher ( $P < 0.09$ ) in does with wider sternum area and thicker skins in the sternum region. In the present study the sternum measurements were considered to reflect body energy reserves, because other researcher have documented that fat thickness in the sternum region is a good predictor of all fat depots and carcass composition traits in goats (Delfa *et al.*, 1995) and ewes (Mendizabal *et al.*, 2003). The higher stores of metabolic reserves of does was associated with higher percentage of kiddings. These results are similar to those on the effect of body condition on fertility seen in goats (Absy *et al.*, 2001; Atti *et al.*, 2001; Mellado *et al.*, 2004a) and sheep (Gunn *et al.*, 1979). The similar pregnancy rate of goats with low and high amount of body fat reserves and the lower kidding rate of the lean does indicate that fetal losses were greater in goats with lower pre-mating fat reserves. The lack of effect of low stores of metabolic reserves on litter traits (Table 2) in the present study contrast with most reports in goats (Kusina *et al.*, 2001) and sheep (Atti *et al.*, 2001 and Lassoued *et al.*, 2004), where larger litter size have been reported in animals with greater body energy reserves at mating. The differences in body lipid reserves of does in the present study apparently were not large enough to affect litter size.

## Conclusions

These data indicate that lactation concurrent with gestation during the dry season is one of the major limiting factors for reproductive success in does in this arid range. Moreover, mean litter size and weight tended to be positively influenced by body weight at mating but not by levels of body energy reserves of does. Thus, to achieve a high reproduction output, farmers should avoid lactations in the dry season, and to ensure does to attain high liveweights and condition scores at mating.

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