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Productive potential of local grazing does and their offspring under a pre and post–partum feeding supplementation program

Potencial de producción de cabras locales en pastoreo y su progenie bajo un programa de alimentación complementaria pre y post parto

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ABSTRACT

The production of goat's milk under extensive grazing is very important to ensure an adequate growth of the progeny, but the productivity of local does and their progeny is not accurately characterized, particularly in the semi–arid Region of Northern Mexico. The aim was to evaluate the productive potential performance of local does and their offspring, when does are offered a supplementary feeding program in pre and post–partum period. Twenty–four local does and their progeny (n=40) were used and divided into two groups: 1) Control group; does fed exclusively on grazing, 2) Supplemented group; does were supplemented at 1.5% of live weight 45 d before and 45 d after parturition. Differences due to treatment were found (*P*<0.05) for kid´s weight at sale (KWS), kid´s age at sale (KAS), kid´s daily weight gain (KDWG) and doe's milk production (DMP). Kid's mortality percentage and birth weight, milk fat content and doe's live weight did not differ between treatments (*P*>0.05). High positive correlations between kid´s weight at birth (KWB) and KWS and KDWG were found (*P*<0.0001), but it was negative with KAS. On the other hand, KWS was positively correlated (*P*<0.05) with KDWG and DMP. Finally, KAS was negatively correlated with KDWG (*P*<0.0001) as well as KDWG with DMP (*P*<0.001) and protein content (*P*<0.05). Its concluded that pre and postpartum supplementation in local does helps to express the productive potential for milk production, plus protein and lactose contents at starting of lactation, which in turn enhanced the performance of their progeny.

Key words: Goat; arid zone; rural community; genetic potential

RESUMEN

La producción de leche de cabra bajo pastoreo extensivo es muy importante para asegurar un crecimiento adecuado de las crías, sin embargo, la productividad de las cabras locales y su progenie no ha sido caracterizada con precisión, particularmente en la región semiárida del norte de México. El objetivo fue evaluar el comportamiento del potencial productivo de las cabras locales y sus crías, cuando son sometidas a un programa de alimentación complementaria en el período de pre y posparto. Se utilizaron 24 cabras locales y su progenie (n=40) y se dividieron en dos grupos: 1) Grupo control; alimentado exclusivamente bajo pastoreo, 2) Grupo complementado; se ofreció una complementación alimenticia a razón de 1,5% del peso vivo 45 d antes y 45 d después del parto. Se encontraron diferencias por tratamiento (*P*<0,05) para peso a la venta del cabrito (PVC), edad a la venta de cabrito (EVC), ganancia diaria de peso del cabrito (GDPC) y producción de leche de las madres (PLM). El porcentaje de mortalidad de crías, peso al nacimiento (PN), contenido de grasa de la leche y peso vivo de las madres (PVM) no difirieron entre tratamientos (*P*>0,05). Se encontraron correlaciones positivas altas entre el PN, PVC y GDPC (*P*<0,0001), y negativa con EVC. Por otro lado, PVC se correlacionó positivamente (*P*<0,05) con GDPC y PLM. Finalmente, EVC se correlacionó negativamente con GDPC (*P*<0,0001) así como GDPC con PLM (*P*<0,001) y contenido de proteína (*P*<0,05). Se concluye que la complementación pre y post parto en cabras locales ayuda a expresar el potencial productivo para la producción de leche, además de proteína y lactosa al inicio de la lactancia, lo que a su vez mejora el desempeño de su progenie.

Palabras clave: Cabra; zona árida; comunidad rural; potencial genético

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INTRODUCTION

The production of goat's milk under extensive grazing systems is very important to ensure an adequate growth of the progeny, since rapid growth in a short period minimizes the maintenance cost and provides a greater profit margin from the offspring's sale [1, 2]. However, extensive production systems limit the goat (*Capra hircus*) productivity, since the availability and quality of forages varies throughout the year [3]. Hence, feeding programs that include nutritional supplementation to goats under grazing are essential to ensure their success; however, these programs have not yet been clearly established [4].

On the other hand, undernourishment in gestation and lactation in goats can have negative effects on their productive performance and consequently on the progeny [5]. It is for this reason that the physiological mechanisms involved in pregnancy and its response, particularly during the last third, must be studied, since around 70% of fetal growth and most of glandular development and mammary tissue occur in this period [6]. For this reason, a strategic supplement of high proteic and energetic quality should be offered [7].

Hence, if the greatest potential is to be reached both in the offspring growth and in doe productive performance under extensive production systems, it is necessary to adopt supplementary feeding strategies [8]. The aim was to evaluate the productive potential performance of local does and their progeny when does are offered a food supplement in the last third of gestation and early lactation under extensive grazing conditions in Northern Mexico.

MATERIALS AND METHODS

All the methods and handling of animals used in the study were strictly adhered to the accepted guidelines for the ethical use of the care and welfare of animals used in research, according to international [9] and Mexican institution by Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), with project approval CIRNOC–INIFAP–12363534874.

The study was carried out during the transition period between rainy and dry seasons (September to December), in a commercial farm located in ejido Zaragoza, Viesca, Coahuila, in Northern México. The region is located between the geographic coordinates of 24°N and 102°W, at a height above mean sea level of 1,100 m. The climate is dry or desert, semi–warm with cool winter, with average annual rainfall and temperature of 240 mm and 25°C, respectively.

Twenty–four local does and their offspring (n=40) were selected from a commercial herd (n=125). The does were selected by gestational age [104 d of gestation (GD) at the beginning of the experiment] and were assigned to two homogeneous groups in live weight (LW), body condition score (BCS) and kidding number, under a complete randomized block design. Pregnancy and the number of fetuses were confirmed by trans–abdominal ultrasonography (BMPVet 850; Santiago de Chile, Chile). The treatments were: 1) Control group (n=12 does and 19 kids), with LW of 38.5 ± 4.8 kg, BCS of 1.9 ± 0.2, 2.1 ± 0.9 kiddings·doe^{-1}, were fed exclusively with what was collected and consumed by the goats in the grazing route (TABLE I) and without any type of supplementation; 2) Supplemented group (n=12 does and 21 kids), with LW of 38.3 ± 6.6 kg, BCS of 1.8 ± 0.3, 2.2 ± 1.2 kiddings ·doe^{-1}, where does were offered a food supplement consisting of a whole diet (TABLE II) at 1.5% of the animal's LW 45 d before kidding and until 45 d post–partum.

TABLE I
Average chemical composition of the main plant species consumed by local goats in Northern México

Sampling	Specie	Nutritional content					
		DM	CP	ADF	NDF	ME	NEL
End of the rainy season	*Cynodon dactylon*	94.3	20.4	20.1	30.4	2.4	1.5
	Amaranthus palmeri	94.1	24.5	8.1	26.6	2.3	1.4
	Setaria macrostachia	94.3	15.9	29.9	52.4	2.0	1.2
	Cenchrus ciliaris	95.0	13.1	38.5	55.8	1.8	1.0
	Solanum eleagnifolium	94.5	26.9	16.7	28.3	2.7	1.6
	Spharalcea angustifolia	94.1	27.5	24.0	35.1	2.4	1.5
	Bouteloua barbata	95.5	15.9	38.6	59.2	1.9	1.1
	Malva parviflora	94.5	19.8	22.2	30.8	2.3	1.4
	Amaranthus anus	93.2	25.6	17.7	28.9	2.3	1.4
	Chenopodium album	95.5	15.9	38.6	59.2	1.9	1.1
	Enneapogon desvauxii	94.1	13.1	38.4	66.9	1.8	1.0
	Sinnia spp.	91.4	23.7	20.5	28.4	2.4	1.4
Start of dry season	*Cynodon dactylon*	95.3	5.9	36.9	61.4	1.7	1.5
	Amaranthus palmeri	93.8	14.4	25.9	33.7	2.1	1.3
	Setaria macrostachia	94.0	13.2	37.4	61.4	1.7	1.1
	Solanum eleagnifolium	93.7	22.1	32.6	37.7	2.5	1.3
	Spharalcea angustifolia	94.1	11.9	39.1	51.4	2.0	1.2
	Enneapogon desvauxii	94.8	5.3	44.3	71.0	1.5	0.8
	Cucumis melo[1]	90.7	13.8	33.8	34.1	2.2	1.4
	Cucumis melo[2]	92.9	10.5	30.9	35.7	2.2	1.1

DM: dry matter, CP: crude protein, ADF: acid detergent fiber, NDF: neutral detergent fiber, ME: metabolizable energy, NEL: net energy for lactation, [1]:Vegetative part of the sampled plant (leaves and stems), [2]: Sampled waste fruits consumed by goats in the grazing route

The management of the animals was carried out following the farmer's activities on a daily basis, in order to induce the least possible stress. This management is characterized by a preventive sanitary calendar, in which the animals are vaccinated and dewormed twice a year (in winter and at the beginning of the rains in summer) and considering the availability of economic resources of the producer, as well as a vaccination campaign against Brucellosis to the new animals in the herd. The animals grazed 9 h·d^{-1}, with two water offerings along the grazing route and where an average distance between offerings of 7.0 km was considered. In the afternoon–night the goats returned to rest pens adjacent to the house of the producer, where they always had access to clean and fresh water. The availability of plant species was monitored during the experimental period. At the beginning of the study (end of the rainy season), 14 plant species consumed by goats were found. At the beginning of the dry season (half of the experimental period), only 7 herbaceous and pastures species were found (TABLE I).

A compositional analysis of all the identified species was carried out. The method to collect the forage samples was carried out by accompanying the shepherd to the grazing route (similar to the technique described by Toyes *et al*. [10]) and during the route, samples of the different species consumed by the goats were collected. Forage samples were dried in a forced–air laboratory oven (Shel Lab, California, USA) at 65 °C of temperature until constant weight, grounded in a hammer mill (CF158, Shangdong, China) with a 5 mm sieve and sent to the laboratory (AGROLAB, Gómez Palacio, Durango, México), where a basic analysis was carried out with the NIR equipment.

Returning from the grazing route (18:00 h), the goats of the supplemented group received supplementary feeding (TABLE II) separately from the rest of the herd, in order to minimize the substitution effect on consumption of forage in the grazing route [11], and until goats consumed the total amount offered. LW and BCS were measured on two occasions prior to kidding. The first, when they reached 114 GD and the second approximately 5 d before kidding (~ 145 d of gestation), to avoid stress in the animals. LW was measured with a BAC–300 hanging electronic scale (Rhino, Guadalajara, México) with a capacity of 300 kg ± 100 g, while BCS was defined according to a subjective 1 to 4 scale (1= extremely thin, 4= extremely fat), depending of the amounts of muscle and fat found in the cervical vertebrae, as described by Rivas–Muñoz *et al*. [12]. After kidding, LW and BCS were measured every 15 d.

TABLE II
Ingredients and chemical composition of the whole diet prepared as a pre and postpartum supplementary feeding for local goats under an extensive grazing system in Northern México

Ingredient	**(%)**
Rolled corn	18.0
Rolled sorghum	18.0
Wheat bran	9.0
Soybean paste	9.0
Alfalfa hay	35.0
Molasses	8.0
Urea	1.0
Premixed vitamins and minerals*	2.0
Nutritional content	
CP	18.7
ADF	21.6
NDF	32.7
NME	1.8
NEL	1.5

CP: Crude protein; ADF: acid detergent fiber; NDF: neutral detergent fiber; NME: net maintenance energy; NEL: net energy for lactation; *:Mineral premix Ovi3ways ® BIOTECAP group

At kidding, sex (male, female), birth type (single, double) and birth weight (KWB) of the offspring were measured. In the does, LW, BCS, milk production (DMP) and quality were measured 7 d after kidding, weekly between 6:00 and 8:00 h. Milk production (MP) was evaluated from the 7th d after kidding to ensure adequate colostrum consumption by the kids and was recorded using the weigh–suckling–weigh technique [13]. For this, the offspring were separated from their mother the afternoon before weighing (around 18:00 h). On the control day, the offspring were weighed fasting and placed with their mothers to breastfeed, once they finished the suckling routine they were weighed again and DMP in does was determined by difference in the weight of the kids. DMP, LW of the does and KWB during the experiment were recorded in g using a commercial electronic hook–type scale with a capacity of 45 kg ± 5 g (Metrology, Nuevo León, México). At the end of the experiment, sale LW of kids was recorded (KWS; which was considered as the d the offspring were sold upon reaching the weight and age required by the market), sale age of kids (KAS; calculated as the d between the d of birth and the d of sale of kids, and it is considered this way because the sale of kids is carried out in group on a single d to a single buyer), and daily weight gain in kids (KDWG) was determined (calculated by subtracting KWB from KWS and dividing between the test d). In addition, the mortality percentage of kids born alive and dead in both groups, and the number of kids that survived to 15 d of age were registered. The milk quality was evaluated with a sample (50 mL) of individual production, which was taken in the middle of the breastfeeding routine. The milk sample was transferred to the dairy laboratory of the INIFAP–Experimental Station–La Laguna for compositional analysis using the Milkoscope Expert Automatic® equipment (Razgrad, Bulgaria), which was calibrated specifically for goat milk and the variables measured were milk fat, protein and lactose.

The statistical analysis was performed using the SAS v9.4 statistical package [14]. A repeated measures model was used for the variables LW, BCS, DMP, milk quality and KDWG. The KWB, KWS an KAS data were analyzed under a randomized complete block design. All data were analyzed with the GLM procedure under a fixed effects model and the comparison of means was carried out through the Tukey test. The general model structure was:

$$Y_{ijklmn} = \mu + R_{i(j)} + T_j + BT_k + SX_l + S_m + T_j \times S_m + E_{ijklmn}.$$

Where: Y_{ijklmn}: LW, BC, DMP, milk component (fat, protein or lactose) and/or KDWG; μ: constant that characterizes the population; R_i: fixed effect of the i–th animal within treatment (i=1,2,3...n), T_j: fixed effect of j–th treatment (j=1,2), BT_k: fixed effect of the k–th birth type (k=1, 2); SX_l: fixed effect of l–th sex of offspring (l=1,2) on milk production and/or KDWG (l=1,2); S_m: fixed effect of the m–th week of treatment (k=1,2...,6); $T_j \times S_m$: effect of treatment×week interaction; E_{ijklmn}: random error, which was assumed normally distributed. For mortality percentage analysis, contingency tables were constructed for analysis by means of the chi–square test.

RESULTS AND DISCUSSIONS

No differences were found (P=0.7518) for mortality percentage between groups, observing a mortality of 9.52% in the offspring born in the supplemented group and 26.32% in the control group. All dead offspring were female and had lower KWB in both groups with an average of 2.4 kg in the supplemented group and 1.5 kg in the control group. Some studies indicated that undernourishment during pregnancy results in low kid's birth weight and a harmful postnatal survival rate [1]. Therefore, possibly this phenomenon occurred in the present study, given that the lower mortality and higher weight occurred in the supplemented group, which suggests undernourishment in the early stages of gestation and mostly marked in the control group.

Differences (P<0.05) were found in KWS, KAS and KDWG between treatments and in KWS and KDGW between sex of the offspring. No interaction effects or differences (P>0.05) were found for KWB between treatments, neither between sex of the progeny, nor in KAS between sex of the offspring (TABLE III). These results differ from the report of Ornelas–Marques *et al*. [15] who pointed out that goats fed in prairies of *Panicum maximum* and supplemented with concentrates had higher KWB and prolificacy. This information confirms the fact previously mentioned regarding undernourishment in pregnant females, because in the area where the present study was carried out the quantity and quality of forage in the range is low, as can be observed in TABLE I. In particular in the second sampling, when the vegetation during the start of dry season decreases in quantity and nutritional quality, the consequence is that the animals do not ingest a sufficient quantity of nutrients to have an adequate gestation [4]. In this sense, the supplementary feeding offered at the end of gestation was not enough to ensure higher growth that was reflected in an increased body weight (BW) of the offspring, but it was sufficient to ensure a better productive performance of the does, which is closely related to the DWG of the offspring [2].

TABLE III
Means (±SE) of live weights at birth, sale, sale age and daily weight gain, according to treatment and sex of the offspring

	According to treatment:				
	Supplemented group ± SE	**Control group ± SE**	***P*–value**	**R^2**	**CV (%)**
KWB (kg)	3.2±0.1	2.9±0.1	0.1253	0.15	15.4
KWS (kg)	9.6±0.2^a	8.7±0.3^b	0.0122	0.29	10.4
KAS (days)	41.8±1.6^a	48.5±1.8^b	0.0110	0.23	15.4
KDWG (kg)	0.159±0.01^a	0.122±0.01^b	0.0016	0.35	21.9
	According to sex:				
	Male ± SE	**Female ± SE**	***P*–value**	**R^2**	**CV (%)**
KWB (kg)	3.1±0.1	3.0±0.1	0.6838	0.15	15.4
KWS (kg)	9.6±0.2^a	8.7±0.2^b	0.0191	0.29	10.3
KAS (days)	45.6±1.7	43.6±1.6	0.3484	0.23	15.4
KDWG (kg)	0.153±0.01^a	0.131±0.01^b	0.0268	0.35	21.9

KWB: Kid´s weight at birth; KWS: Kid´s weight at sale; KAS: Kid´s age at sale; KDWG: Kid´s daily weight gain; SE: Standard error; R^2: Coefficient of determination; CV: Coefficient of variation; ^{ab}: Different letters between columns indicate differences (P<0.05)

Regarding DWG, the results coincide with other studies who mentioned that Taggar multicolored kids had DWG's around 160 g, when the animals have birth weights over 3.0 kg [16]. Also, the DWG in males was higher, but with lower values (0.115 kg) than those found in the present study. This behavior is observed in males, because the growth hormone influences a higher growth rate [17]. The foregoing demonstrates the potential of local goats in Northern Mexico to gain weight once the management conditions are improved, specifically, when the nutrition of their mother is improved in the last stage of gestation and early lactation.

TABLE IV shows the results found for DMP and milk quality between treatments. Higher values (P<0.05) for DMP, protein and lactose contents in supplemented group were found; in the same way, differences (P<0.05) for DMP by birth type were found. No interaction effects or differences (P>0.05) were found for fat content between treatments, or fat, protein and lactose content in milk by birth type.

TABLE IV
Doe milk production and quality mean (±SE) due to treatment and birth type of local goats in Northern México

	By Treatment:				
	Supplemented group	**Control group**	***P*–value**	**R^2**	**CV (%)**
DMP (kg)	0.870±0.04^a	0.710±0.04^b	0.0004	0.31	36.6
Fat (%)	3.9±0.2	4.0±0.2	0.3818	0.19	25.6
Protein (%)	3.4±0.02^a	3.0±0.02^b	0.0063	0.62	3.3
Lactose (%)	4.7±0.03^a	4.3±0.03^b	0.0068	0.63	3.3
	By birth type:				
	Single	**Double**	***P*–value**	**R^2**	**CV (%)**
DMP (kg)	0.670±0.05^b	0.930±0.04^a	0.0004	0.31	36.6
Fat (%)	3.8±0.2	4.2±0.2	0.2573	0.19	25.6
Protein (%)	3.0±0.02	3.0±0.02	0.2866	0.62	3.3
Lactose (%)	4.5±0.03	4.6±0.03	0.2196	0.63	3.3

DMP: Doe milk production, R^2: Coefficient of determination, CV: Coefficient of variation, ^{ab}: Different letters between columns indicate differences (P<0.05).

The results found for DMP coincide with Andualem *et al*. [2] where they report a higher DMP and protein content, without differences in fat content. Likewise, Caprioli *et al*. [18] pointed out a positive effect of supplementary feeding on DMP and milk quality in grazing animals. This indicates that the DMP and the content of some milk components are modified by the effect of the nutritional supplements that the animals may receive. Similarly, Celi *et al*. [5] indicated that a dietary restriction during pregnancy modifies the partition of nutrients, since these are directed towards the uterus to maintain fetal growth. In addition, this redirection of nutrients continues during early lactation, which affects DMP, and if the nutrient intake doesn´t improve, the effect will be observed in the growth of the offspring, as in the present study.

The previous information suggests that the local goat genotype of the Comarca Lagunera in Northern Mexico has possibly developed adaptation mechanisms to extreme feeding conditions, since its productive performance is significantly improved once the environmental conditions in which they unfold also improve [19]. Likewise, a medium–high milk production [4] and an accelerated growth of their offspring under precarious feeding conditions are indicative of the productive potential that local goats possess in response to difficult environmental conditions [20]. In this regard, Karrat and Bocquier [21] indicated that Baladi goats increased their milk production (+36%) when subjected to a higher quality diet. This reinforces the argument for the good adaptive response of local goats in Northern Mexico to erratic feeding conditions. Evidence has been found that under grazing conditions in difficult areas goats adjust their diet selection according to their nutritional needs, especially when the cost of gestation increases the demand for nutrients [22]. In this sense, it should be considered that the transfer of technology to producers on this topic should be focused on the effective use of strategic nutrient supplementation [4] and the cost to optimize the productive performance of grazing goats [7].

No differences were found (P>0.05) in LW before kidding, or in subsequent periods; however, BCS in does was higher (P<0.05) in the control group (TABLE V) at the beginning of the experiment (114 GD)

TABLE V
Means (±SE) of live weight (LW) and pre and postpartum body condition score (BCS) of local goats in Northern México

	LW				
	114 GD	**145 GD**	**7 PPD**	**30 PPD**	**60 PPD**
Supplemented group	38.3±1.5	68.0±2.3	43.7±1.4	40.1±1.1	41.9±1.1
Control group	39.3±1.6	64.8±2.1	42.0±1.6	40.9±1.0	41.2±1.1
P–value	0.6487	0.3301	0.4284	0.6103	0.6374
R^2	0.01	0.04	0.03	0.01	0.01
CV (%)	14.4	11.7	11.9	9.4	9.4
	BCS				
	114 GD	**145 GD**	**7 PPD**	**30 PPD**	**60PPD**
Supplemented group	1.7±0.1	1.9±0.1	1.6±0.1	1.5±0.03^b	1.6±0.04
Control group	1.9±0.1	1.9±0.1	1.8±0.1	1.6±0.03^a	1.61±0.04
P–value	0.0461	0.8269	0.0806	0.0196	0.3309
R^2	0.17	0.02	0.14	0.22	0.04
CV (%)	12.8	8.8	13.7	6.8	8.8

GD: Gestation days, PPD: Postpartum days, R^2: Coefficient of determination, CV: Coefficient of variation, ^{ab}: Different letters between columns indicate differences (P<0.05)

and up to 30 d after kidding. This behavior is because the metabolism during pregnancy is not modified by the type of pregnancy (single, double or triple).

However, an improvement in nutritional intake during the last stage of the gestational period is necessary as the number of offspring increases [6]. In this sense, there are studies [23] that indicate a very important effect of the doe's size on KWB; however, this advantage seems to decrease if improvements are not incorporated into the doe's diet. In the same way, the pre–partum live weight of Ganjam goats was improved when energy supplements were offered at a rate of 0.165 to 0.225 kg [24]. The foregoing suggests that the difference in LW may be due to the fact that LW of undernourished animals does not differ from that of those freely fed, since the former may decrease their basal metabolic rate and their maintenance requirements, and thus maintain body weight [25]. Furthermore, when the goat is producing milk and doesn't have a sufficient nutritional contribution to cover its requirements, it tends to mobilize reserves of adipose tissue, mainly to maintain milk production [26]. In this sense, the report of Tadesse *et al*. [27] is relevant for our results discussion, because when a supplement is offered at a rate of 1.5% of the LW in local genotypes for meat production, they have excellent DWG. However, in this study, the increase in DWG was observed in the offspring due to the higher production and better nutritional quality of the milk, which in turn prevented the does from increasing their body reserves (BCS) or LW, thus showing the excellent maternal ability of this genotype, as noted in mountain goats [28].

A positive correlation was found between LW and KWS, KDWG (P<0.0001), and negative with KAS (P<0.0001). KWS was positively correlated with KDWG (P<0.0001) and DMP (P<0.05). Also, it was found that KAS was negatively correlated with KDWG (P<0.0001) and KDWG with DMP (P<0.001) and protein content (P<0.05). Likewise, a high correlation (P<0.0001) was found between some milk quality variables, specifically protein content with lactose (TABLE VI).

TABLE VI
Phenotypic correlation matrix for kid growth variables and milk production and quality of local goats in Northern México

	KWB	KWS	KAS	KDWG	DMP	Fat	Protein	Lactose
KWB	1							
KWS	0.62***	1						
KAS	−0.59***	−0.45	1					
KDWG	0.56***	0.81***	−0.83***	1				
DMP	0.15	0.35*	0.07	0.47**	1			
Fat	0.02	0.54	−0.24	0.52	0.40	1		
Protein	−0.24	0.16	0.31	0.31*	0.37	0.17	1	
Lactose	−0.23	0.13	0.30	0.30	0.33	0.14	1.00***	1

KWB: Kid´s weigth at birt, KWS: Kid´s weigth at sale, KAS:Kid´s age at sale, KDWG: Kid´s daily weight gain, DMP: Doe milk production production, *:P<0.05, **:P<0.01, ***:P<0.001

Regarding this, Hafsa *et al*. [29] found a high correlation between live weight and body condition with milk production and composition in Damasco and Zaraibi goats. Likewise, El–Hassan *et al*. [30] found a positive correlation between birth weight and weaning weight in Sudanese Nubian goats, with better development in those in which supplementary feeding was offered. In this sense, Currò *et al*. [31] indicated a great potential for better quality milk production in local animals (autochthonous or indigenous). Besides, the review by Costa *et al*. [32] points out that lactose increases the energy value of milk and is genetically associated with milk production. Therefore, when observing the relationship between supplementary feeding and milk production and quality, a better performance of the progeny in the supplemented group can be inferred in terms of KWS and KDWG, in addition to the negative correlation between birth weight and survival, but positive with subsequent weight gain [33], as observed in this study.

CONCLUSION

Supplementation during the pre and postpartum period (last third of gestation and early lactation) at a level of 1.5% of the live weight in local goats under the extensive grazing system in Northern Mexico enhances the productive performance of goats in terms of milk production and quality (protein and lactose contents), which in turn positively influences the potential productivity of their progeny, since significant live weight gains are obtained, as well as a higher live weight and lower age at sale. These findings should be considered in the management plans of goat producers in arid and semiarid regions where extensive grazing is practiced, since it implies savings in the time of animal management (suckling of kids), in addition to a higher live weight and lower age at sale, which allows the goat farmer the opportunity to negotiate a better price at marketing. Additionally, there is an extra remuneration for the producer, since the milk that the offspring stop consuming is sold at an earlier time.

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BIBLIOGRAPHICAL REFERENCES

[1] Chanie D, Mekuriaw Z, Taye M. Evaluation of pre-weaning growth performances and survival rate of Western Highland goats under traditional management system in Amhara region, Ethiopia. Livest. Res. Rural Dev. [Internet]. 2014 [cited 20 Apr 2023]; 26(8):1–4. Available in: https://bit.ly/3QMHoEH.

[2] Andualem D, Negesse T, Tolera A. Milk yield and composition of grazing Arsi-Bale does supplemented with dried stinging Nettle (*Urtica simensis*) leaf meal and growth rate of their suckling kids. Adv. Biol. Res. [Internet]. 2016 [cited 20 Apr 2023]; 10(3):191-199. Available in: https://bit.ly/3QLtLFZ.

[3] Fiares de C. W, de Oliveira ME, Azevêdo-Alves A, Lustosa de M. R, Mendes de A. da Silva-Moura R. Energy supplementation in goats under a silvopastoral system of tropical grasses and leucaena, Rev. Ciên. Agron. [Internet]. 2017; 48(1):199-207. doi: https://doi.org/kp4b

[4] Flores-Nájera MJ, Cuevas-Reyes V, Vázquez-García JM, Beltrán-López S, Meza-Herrera CA, Mellado M, Negrete-Sánchez LO, Rivas-Jacobo MA, Rosales-Nieto CA. Milk yield and composition of mixed-breed goats on rangeland during the dry season and the effect on the growth of their progeny. Biol. [Internet]. 2021; 10:220. doi: https://doi.org/kp4c

[5] Celi P, Di Trana A, Claps S. Effects of perinatal nutrition on lactational performance, metabolic and hormonal profiles of dairy goats and respective kids. Small Rum. Res. [Internet]. 2008; 79(2-3):129-136. doi: https://doi.org/fb7zwv

[6] de Souza-Castagnino D, Härter CJ, Rivera-Rivera A, de Lima LD, de Oliveira-Silva HG, Biagioli B, de Resende, de Almeida-Teixeira IA. Changes in maternal body composition and metabolism of dairy goats during pregnancy. Rev. Bras. Zoot. [Internet]. 2015; 44(3):92-102. doi: https://doi.org/kp4d

[7] Kawas JR, Andrade-Montemayor H, Lu CD. Strategic nutrient supplementation of free-ranging goats. Small Rum. Res. [Internet]. 2010; 89:234-243. doi: https://doi.org/ft4z9m

[8] Maldonado-Jáquez JA, Granados-Rivera LD, Hernández-Mendo O, Pastor-López FJ, Isidro-Requejo LM, Salinas-González H, Torres-Hernández G. Use of total mixed ration as a supplement in grazing local goats: Milk production response and chemical composition. Nova Sci. [Internet]. 2017; 9(18):55-75. doi: https://doi.org/kp4f

[9] FASS Writing Committee. Guide for the Care and Use of Agricultural Animal and Agricultural Research and Teaching. [Internet], 3rd ed. Champaign, IL (US): FASS; 2010 [cited 15 Mar 2023]. 177 p. Available in: https://bit.ly/45cXxb5.

[10] Toyes-Vargas EA, Murillo-Amador B, Espinoza-Villavicencio JL, Carreón-Palau L, Palacios-Espinoza A. Composición química y precursores de ácidos vaccénico y ruménico en especies forrajeras en Baja California Sur, México. Rev. Mex. Cien. Pec. [Internet]. 2013 [cited 02 Jun 2023]; 4(3):373-386. Avalaible in: https://bit.ly/3qtpwUQ.

[11] Granados-Rivera LD, Maldonado-Jáquez JA, Bautista-Martínez Y, Garay-Martínez JR, Álvarez-Ojeda MG. El horario de complementación alimenticia modifica la respuesta productiva de cabras lecheras en pastoreo. Rev. MVZ. Cordoba. [Internet]. 2022; 27(1):e2340. doi: https://doi.org/kp4g

[12] Rivas-Muñoz R, Carrillo E, Rodríguez-Martínez R, Leyva C, Mellado M, Veliz FG. Effect of body condition score of does and use of bucks subjected to added artificial light on estrus response of Alpine goats. Trop. Anim. Health Prod. [Internet]. 2010; 42:1285-1289. doi: https://doi.org/brwfc6

[13] Fernández N, Balasch S, Pérez I, Rodríguez M, Peris C. Milk yield estimation during suckling using the double oxytocin injection-milking and the double weighing-suckling methods in dairy goats. Small Rum. Res. [Internet]. 2013; 112(1-3):181-185. doi: https://doi.org/f4wq2v

[14] Statistical Analysis System Institute (SAS). User's Guide. Statistics. Software Version 9.4. Cary, NC. USA. 2015.

[15] Ornelas-Marques R, Gonçalves HC, de Lima-Meirelles PR, Lara-Cañizales I, de Oliveira GM, Barros-Gomes HF, Fernandes S, Oliveira AA, Prestes-Brito E, Carmo RF. Effect of concentrate supplementation during pre-kidding on the productive and reproductive performance of goats raised on Guinea grass (*Panicum maximum* cv. Tobiatã) pasture. Semina. Ciên. Agr. [Internet]. 2016; 37(3):1489-1504. doi: https://doi.org/kp4h

[16] Bushara I, Abdelhadi OMA, Elemam MB, Idris AO, Mekki DM, Muna MM, Abu Nikhiala AM, Elimam I. Effect of sex and litter size on Taggar goat kids performance. Arch. Zoot. [Internet]. 2013 [cited 08 Jun 2023]; 16(2):5-14. Available in: https://bit.ly/47DEOqA.

[17] Ram-Jan G, Datt M, Bhateshwar V, Lal Fogya S. Factors affecting birth weight in Sirohi goat kids. Intern. J. Curr. Microbiol. Appl. Sci. [Internet]. 2018; 7(5):2627-2631. doi: https://doi.org/kp4j

[18] Caprioli G, Kamgang FN, Fiorini D, Scocco P, Trabalza-Marincci M, Acuti G, Tardella FM, Sagratini G, Catorci A. The effects of feeding supplementation on the nutritional quality of milk and cheese from sheep grazing on dry pasture. Intern. J. Food Sci. Nutr. [Internet]. 2020; 71(1):50-62. doi: https://doi.org/kp4k

[19] Rooke JA, Houdijk JGM, McIlvaney K, Ashworth CJ, Dwyer CM. Differential effects of maternal undernutrition between days 1 and 90 of pregnancy on ewe and lamb performance and lamb parasitism in hill or lowland breeds. J. Anim. Sci. [Internet]. 2010; 88:3833-3842. doi: https://doi.org/cxmnwm

[20] Sangaré M, Pandey VS. Food intake, milk production and growth of kids of local, multipurpose goats grazing on dry season natural Sahelian rangeland in Mali. Anim. Sci. [Internet]. 2000; 71:165-173. doi: https://doi.org/kp4m

[21] Kharrat M, Bocquier F. Adaptive responses at the whole lactation scale of Baladi dairy goats according to feed supply and level of body reserves in agro-pastoral feeding system. [Internet]. Small Rum. Res. 2010; 90:120-126. doi: https://doi.org/ds62ks

[22] García-Monjaras S, Santos-Díaz RE, Flores-Nájera MJ, Cuevas-Reyes V, Meza- Herrera CA, Chay-Canul AJ, Rosales-Nieto CA. Diet selection by goats on xerophytic shrubland with different milk yield potential. J. Arid. Env. [Internet]. 2021; 186:104429. doi: https://doi.org/kp4n

[23] Kugonza DR, Stalder KJ, Rothschild MF. Effects of buck and doe size on the growth performance and survival of their progeny. Livest. Res. Rural Dev. [Internet]. 2014 [cited 08 Jun 2023]; 26(47). Available in: https://bit.ly/3KOURlq.

[24] Sahu S, Babu LK, Karna DK, Behera K, Kanugo S, Kaswan S, Biswas P, Patra KJ. Effect of different level of concentrate supplementation on the periparturient growth of Ganjam goat in extensive system. Vet. World. [Internet]. 2013; 6(7):428–432. doi: https://doi.org/kp4p

[25] Gómez–Pastén M, Mora–Izaguirre O, Meléndez–Soto RM, Romano–Muñoz JL, Vera–Ávila H, Shimada–Miyasaka A. Effect of long–term feeding restriction on the subsequent body weight, condition score, and tissue composition of mature goats. Rev. Mex. Cien. Pec. [Internet]. 2010 [cited 03 May 2023]; 1(3):205–219. Available in: https://bit.ly/3KMul2r.

[26] Goestch AL. Recent research of feeding practices and the nutrition of lactating dairy goats. [Internet]. J. Appl. Anim. Res. [Internet]. 2019; 47(1):103–114. doi: https://doi.org/kp4q

[27] Tadesse D, Urge M, Animut G, Mekasha Y. Growth and carcass characteristics of three Ethiopian indigenous goats fed concentrate at different supplementation levels. Springer Plus. [Internet]. 2016; 5:414. doi: https://doi.org/kp4r

[28] Théoret–Gosselin R, Hame S, Côté SD. The role of maternal behavior and offspring development in the survival of mountain goat kids. Oecol. [Internet]. 2015; 178:175–186. doi: https://doi.org/f7db8x

[29] Youssef HFH, El–Gendy ME, Saifelnasr EOH, El–Sanafawy HA, Saba FE. Relationship between body conformation and milk yield and composition in Zaraibi and Damascus goats. Egyptian J. Sheep Goat Sci. [Internet]. 2014 [cited 03 May 2023]; 9(3):83–94. Available in: https://bit.ly/3P2K7Zr.

[30] El–Hassan K, Babikerb SA, Abu–Nikhaila AMA. Growth rates of Sudanese Nubian kids under smallholder system, Intern. J. Dairy Sci. [Internet]. 2008; 3(4):170–178. doi: https://doi.org/cpcxhc

[31] Currò S, Manuelian CL, De Marchi M, De Palo P, Claps S, Maggiolino A, Camanile G, Rufrano D, Fontana A, Pedota G, Neglia G. Autochthonous dairy goat breeds showed better milk quality than Saanen under the same environmental conditions. Arch. Anim. Breed. [Internet]. 2019; 62:83–89. doi: https://doi.org/kp4s

[32] Costa AN, López–Villalobos N, Sneddon L, Shallo M, Franzoi M, De Marchi M, Penasa M. Invited Review: Milk lactose– current status and future challenges in dairy cattle. J. Dairy Sci. [Internet]. 2019; 102(7):5883–5898. doi: https://doi.org/kp4t

[33] Rojo–Rubio R, Kholif AE, Salem AZM, Mendoza GD, Elghandour MMMY, Vázquez–Armijo JF, Lee–Rangel H. Lactation curves and body weight changes of Alpine, Saanen and Anglo–Nubian goats as well as pre–weaning growth of their kids. J. Appl. Anim. Res. [Internet]. 2016; 44(1):331–337. doi: https://doi.org/kp4v