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Article

Effects of nutrition in the final third of gestation of beef cows on progeny development

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Abstract:

The restriction of nutrient intake by beef cows during pregnancy may influence the progeny postpartum growth potential, therefore, the objective of the present study was to evaluate the effects of nutritional restriction and adequate nutrition or overfeeding during the final third of gestation of the crossbred cows (Charolais x Nellore) kept in the Pampa biome, on the productive performance of the progeny up to 15 mo of age. Eighty-three (83) cows were divided into: control cows on natural pasture under nutritional restriction (RES); Supplementation to meet 100 % of requirements (REQ); Supplementation above requirements (HIGH). REQ and HIGH calves had higher body weight at birth compared to calves from RES cows (39.28, 39.13 *vs* 34.58 kg), without influences on postnatal performance. Females from REQ and HIGH cows presented better postnatal performance and consequently higher weight at 12 mo of age in compared to offspring RES cows (300.71 and 311.79 *vs* 259.47 kg). These female calves reached 60 % of early adult weight (358 and 345 *vs* 405 d) and had a higher percentage of breeding at twelve months of age (73.98 and 84.08 *vs* 34.08 %) than females from RES cows. Supplementing cows to meet 100% requirements, as well as overfeeding during the final third of gestation, improves offspring performance at twelve months of age, with males and females responding differently to maternal nutritional insults during this period.

Key words: Calves, Fetal growth, Nutritional restriction, Myogenesis.

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Introduction

In the calf production system, beef cows are kept in lower quality forage systems and go through periods of lower nutrient supply during pregnancy. Food shortages are common in many regions of the world, resulting in cows under food restriction during pregnancy[1]. This low nutrient intake is associated with future progeny development[2]. In these situations of low nutrient supply, supplementation during pregnancy is an alternative to avoid negative effects of nutritional deficiency during the fetal period on progeny productivity[3].

According to Wilson *et al*[4], dietary nutrient intake affects fetal development as well as future progeny performance. Working with crossbred cows (Angus x Hereford), Bohnert *et al*[5], who obtained heavier male calves at birth (40.8 *vs* 39.3 kg) and at weaning (191.0 *vs* 183.0 kg), when they were born from supplemented cows with distillery grains during final pregnancy. Providing two levels of total digestible nutrients in the final third of pregnancy (100 and 12 5% of requirements) for crossbred Angus x Simmental cows, Wilson *et al*[4] also observed an increase in male calves weight at birth (41 *vs* 44 kg) when the cow's energy intake increased. Better progeny development is the result of better skeletal muscle formation during pregnancy, as female nutrition during this period results in greater synthesis and growth of muscle fibers, as well as increased formation of intramuscular adipocytes, thus favoring the production of quality progeny meat(2). Some researchers(3) added that a decrease in the number of muscle fibers formed during pregnancy due to fetal programming reduces muscle mass and negatively influences performance of the animals.

In addition to improving offspring meat production, cow nutrition during pregnancy also affects productive potential of females. Funston *et al*(6) observed a higher weight at weaning (232 *vs* 225 kg) and lower age at puberty (352 *vs* 366 d) for heifers from crossbred Red Angus x Simmental cows supplemented on winter native pasture and/or corn crop residues during late gestation. Studying the effects of maternal nutrition in the second and third trimester of pregnancy, it was(7) demonstrated that females from crossbred cows (¼ Angus, ¼ Hereford, ¼ Pinzgauer and ¼ RedPoll) submitted to 125 % of the nutritional requirements in the last trimester of pregnancy had a higher calving rate and conceived first during the breeding season than calves of cows receiving 100 and 75 % of the requirements. Based on the hypothesis that the greater intake of nutrients by the pregnant cow improve the productivity of the progeny after birth, the objective of the present study was to evaluate the effects of nutritional restriction and adequate nutrition or overfeeding during the final third of gestation of the crossbred cows (Charolais x Nellore) kept in the Pampa biome, on the productive performance of the progeny up to 12 mo of age.

Material and methods

The protocols used in the experiment were approved by the Animal Use Ethics Committee (CEUA) of the Federal University of Santa Maria, under protocol No. 7920140617 approved on 12/07/2017.

Animals and study factors

The study was carried out at the Department of Animal Science of the Federal University of Santa Maria, Santa Maria - RS, Brazil. The experimental area is located at an average altitude of 95 m, with 29° 43' south latitude and 53° 42' west longitude. The climate of the region is "Cfa" (humid subtropical), according to Köppen's classification, with average annual rainfall between 1600 to 1900 mm, temperature of 18.8 °C, with a minimum average of 9.3 °C and average maximum of 24.7 ºC(8).

A total of 83 beef cows were used, along with their progeny, from the rotary crossbreed between Charolais (CH) and Nelore (NE), which were previously distributed according to age (4 to 12 yr) and percentage of Nelore blood. After diagnosis of pregnancy to determine the time of pregnancy, they were divided into three treatments according to nutritional level in the last third of pregnancy: 28 control cows on natural pasture under nutritional restriction (RES); 28 cows on natural pasture supplemented to meet 100 % energy and protein requirements (REQ); 27 cows on natural pasture with supplementation above energy and protein requeriments (HIGH).

Diets were calculated by nutritional requirements in the last third of gestation of 475 kg body weight cows, consuming 2.1 % of the live weight of forage dry matter, as recommended by the National Research Council – NRC[9]. The concentrate supplement (Table 1) was considered an additive to forage intake, providing 0.28 and 0.98 % of the body weight of supplementation for the treatments REQ and HIGH, respectively. This nutritional plan allowed daily weight gains of -0.103; 0.025 and 0.207 kg d^{-1} during the last third of pregnancy for the RES, REQ and HIGH treatments, respectively, resulting in better body condition of these cows at birth (2.81, 2.92 and 2.99 points, in the same order), following the scale of 1 to 5 points, where 1 is classified as very thin and 5 is very fat. Cows that calved males showed lower daily weight gain during the last third of gestation (-0.02 *vs* 0.11 kg d^{-1}) and calved with lower body condition than those that carried females (2.89 *vs* 2.93 points).

The animals were kept in four natural pasture paddocks, with areas of 20, 21, 41, and 47 ha, and a mineral salt supplement (ProduBeef 60P® - with minimum values of 170, 60 and 130 g kg^{-1} of calcium, phosphorus and sodium, respectively) was available in each paddock, with free access. The native pasture was composed mostly of the summer species, which is of African origin, called capim-annoni (*Eragrostis plana* Ness), and by other warm season grass species, *Paspalum notatum*, *Axonupus affinis*, and *Desmodium incanum*. The cows for each treatment were managed in groups. The paddocks were rotated between treatments every 28 d to reduce the experimental error. The mass and forage supply in the paddocks were 4144.72 kg dry matter ha^{-1} and 11.22 kg dry matter per 100 kg of live animal weight. The average stocking rate was equivalent to 275.21 kg ha^{-1} body weight. Supplementation was provided daily at 1100 h, beginning on August 15, 2017, and lasted until the date of the cows calving. The supplementation period was 95 and 92 d for REQ and HIGH cows, respectively.

Table 1: Composition of the concentrated fraction and nutrient consumption by the cows in the last third of pregnancy

Diet fraction	Treatments[1]		
	RES	**REQ**	**HIGH**
Ingredients of the concentrated fraction (% dry matter)			
Milled corn	-	81.78	91.74
Soybean meal	-	17.22	7.26
Urea	-	1.00	1.00
Bromatological composition of the concentrated fraction (% dry matter)			
Crude protein	-	18.00	15.00
Total digestible nutrients	-	85.00	85.00
Dry matter and nutrient intake for pregnant cows weighing 475 kg			
Native forage[2], kg d^{-1}	9.98	9.98	9.98
Concentrated supplement, kg d^{-1}	-	1.32	4.69
Total digestible nutrients, kg d^{-1}	4.69	5.81	8.60
Crude protein, kg d^{-1}	0.45	0.70	1.15
Total digestible nutrients[3] % dry matter	88.50	109.60	162.30
Crude protein[3], % dry matter	60.00	93.40	153.30

Composition of native forage: Crude protein 4.5%; Total digestible nutrients 47.0%.
[1] RES= cows on natural pasture under nutritional restriction; REQ= cows supplemented to meet 100% requirements; HIGH= cows supplemented above requirements.
[2] Forage consumption estimated at 2.1% of body weight(9).
[3] Consumption in relation to daily requirements of total digestible nutrients (5.30 kg) and crude protein (0.75 kg) described in NRC(9).

After calving, the same management conditions were maintained for all treatments. Calving took place between October 25 and December 15, 2017. At the day of birth, the set of mothers and calves were taken to the management center for weighing and care of the offspring, and then kept on Tifton-85 (*Cynodon* ssp) pasture for 3 wk. After this period, the animals were relocated in natural pastures until the time of conventional offspring weaning, where they were presented on average 165 ± 17 days of age.

Growth of calves

After weaning, the progeny remained for 30 d in tifton-85 pasture receiving 1 % of live weight of concentrated supplementation. The calf supplement consisted of 57.2 % ground corn, 38.14 % soybean meal and 4.66 % mineral salt (ProduBeef 60P®). The combination of these ingredients showed 22.20 % crude protein and 83.54 % total digestible nutrients. Subsequently, they were kept in Black Oat + Ryegrass (*Avena strigosa* + *Lolium multiflorum*) intercropping pasture, up to 12 mo of age. The pasture showed 17.84, 59.97 and 57.36 % of crude protein, total digestible nutrients and neutral detergent fiber, respectively, samples obtained by cutting the forage. All chemical analyzes of the concentrate and forage were performed at the Laboratory of Bromatological analyzes at the

Federal University of Santa Maria. The offspring remained in pasture between June 5, 2018 and November 6, 2018, totaling 155 d. Forage mass and supply in the period were 1087.56 kg ha^{-1} of dry matter and 7.61 kg of dry matter per 100 kg of live animal weight. The average stocking rate in this period was 894.83 kg ha^{-1} body weight. Because the calves were kept in a single group, it was not possible to quantify the animals' forage intake, however, the dry matter intake estimate for this growing category is close to 2.40 % of body weight(9).

Progeny performance measures

Males and female's performance was evaluated separately by weighing at birth, at weaning and at 265 and 335 d of age (± 17 d). The average daily gain of the animals was calculated by dividing the total weight gain by the number of days between the weights, and the offspring weights were later adjusted to 205, 270 and 365 d of age, according to the following equations: PAJUST205 = (ADG birth at Weaning) x 205 + Weight at birth; PAJUST270 = (ADG Weaning at 270 d) x 65 + PAJUST205; PAJUST365 = (ADG Weaning at 365 d) x 160 + PAJUST205, where ADG = average daily gain. To complement the performance evaluations, body measurements of the males were taken, together with the weightings. The body compacity of the calves was calculated following the methodology described by Cattelam *et al*(10), through the quotient of weight by body length, being subsequently adjusted for the 205 and 365 d. Female reproductive aptitude was evaluated based on the target reproductive weight of 285 kg, which represents about 60 % of the adult weight (AW), as recommended by the NRC(9).

Experimental design and statistical analysis

The experimental design used for both males (n= 42) and females (n= 41) was completely randomized with three treatments and varied number of repetitions. The normality of the residues was analyzed by the Shapiro-Wilk test. Transformations and outliers were eliminated when necessary. Subsequently, the data were subjected to analysis of variance by the F test through the PROC GLM procedure, and when significance was found, the means were compared by Tukey test at a 5% significance level ($P<0.05$). Statistical analyzes were performed using the SAS® Studio University Edition statistical (11) package using the following mathematical model:

$\mathbf{Y_{ijk}} = \mu + N_i + I_j + Z_k + \varepsilon_{ijk}$

Where,
γ_{ijk}: dependent variables;
μ: mean of all observations;
N_i: effect of the i-th prenatal nutritional level;
Ij: effect of the covariate cow age;
Z_k: effect of co-variable percentage Nellore breed on cows;
ε_{ijk}: effect of residual random error (error b).

Results

Male performance

The performance of the offspring of cows subjected to different nutritional levels in the last third of gestation is shown in Table 2. REQ and HIGH cows produced heavier male calves at birth in relation to the RES cows (39.28 and 39.13 *vs* 34.58 kg, respectively). Performance of male calves during the lactation phase was not influenced by the cow's nutritional level in the last third of pregnancy (P= 0.1375), with weight adjusted at 205 days of age respectively of 199.75, 220.76 and 215.93 kg body weight for the treatments RES, REQ and HIGH. Weight at 205 d of age is a result of the similarity (P=0.2471) of male daily weight gain during lactation, with an average value of 0.85 kg d^{-1}.

Similar behavior was observed for post-weaning performance of males, which was not influenced by maternal nutrition during the last trimester of pregnancy (Table 2). Males had an average weight of 229.18 and 302.12 kg of body weight respectively at 270 d (P = 0.1305) at 365 d of age (P= 0.3603). Male body weight at 365 d of age is a result of the similarity in performance of these animals during the post-weaning period (P=0.8582). The average daily weight gain of males in this period was equivalent to 0.56 kg d^{-1} body weight, performance that can be considered lower than expected for animals in the initial phase of growth in cultivated pasture.

Performance during the postnatal period up to twelve months of age was not influenced by the cow's nutritional level in the last third of gestation (P=0.5829), where male calves had a daily gain equivalent to 0.70 kg d^{-1} of body weight from birth to twelve months of age. Likewise, there was no effect of the nutritional level of the cow during pregnancy (P>0.05) on the body length of the calves. However, body compacity at birth was higher in REQ and HIGH calves compared to RES (0.59 and 0.59 *vs* 0.54 kg cm^{-1}, respectively), showing greater potential for muscle production per centimeter of carcass.

Table 2: Effects of the nutritional level of beef cows during final third of gestation on the postpartum performance of male calves

Performance	Treatments[1] (n) RES (14)	REQ (16)	HIGH (12)	*P*-value
Pre-weaning performance at seven months age				
Birth weight, kg	34.58^b ± 1.32	39.28^a ± 1.24	39.13^a ± 1.43	0.0248
PAJUST205[2] kg	199.75 ± 7.71	220.76 ± 7.25	215.93 ± 8.35	0.1375
Birth-Weaning, kg d^{-1}	0.80 ± 0.03	0.88 ± 0.03	0.86 ± 0.03	0.2471
Body length, cm	63.58 ± 1.19	64.56 ± 1.15	64.51 ± 1.37	0.8130
Body compacity, kg cm^{-1}	0.54^b ± 0.13	0.59^a ± 0.13	0.59^a ± 0.15	0.0212
Post-weaning performance at nine months of age				
PAJUST270[2] kg	215.97 ± 8.28	238.67 ± 7.50	232.91 ± 8.66	0.1305
Weaning-265 d, kg d^{-1}	0.28 ± 0.04	0.28 ± 0.03	0.26 ± 0.04	0.9498
Body length, cm	108.18 ± 1.69	111.50 ± 1.62	110.94 ± 1.87	0.3447
Body compacity, kg cm^{-1}	1.77 ± 0.05	1.93 ± 0.05	1.94 ± 0.05	0.0813
Post-weaning performance at twelve months of age				
PAJUST365[2], kg	289.15 ± 10.96	308.52 ± 10.30	308.72 ± 11.87	0.3603
Weaning-335 d, kg d^{-1}	0.56 ± 0.03	0.56 ± 0.03	0.58 ± 0.04	0.8582
Birth-335 d kg d^{-1}	0.68 ± 0.02	0.71 ± 0.02	0.72 ± 0.03	0.5829
Body length, cm	125.78 ± 1.97	128.12 ± 1.89	125.12 ± 2.18	0.5388
Body compacity, kg cm^{-1}	2.25 ± 0.08	2.38 ± 0.07	2.45 ± 0.08	0.2438

Values are predicted means ± standard errors mean (SEM). ^{abc} Distinct letters on the same line differ by Tukey test (P<0.05).

[1] RES = cows on natural pasture under nutritional restriction; REQ = cows supplemented to meet 100% requirements; HIGH = cows supplemented above requirements.

[2] Age adjusted weight of calves.

Female performance

Unlike male performance, female birth weight was not influenced (*P*= 0.3730) by cow's nutritional level in the last third of gestation (Table 3), with average value equivalent to 34.08 kg body weight. However, the female calves initial development during the lactation phase resulted in higher body weight adjusted at 205 d of age for the progeny of REQ and HIGH cows compared to those born from RES (211.58 and 210.95 *vs* 187.76 kg, respectively). This result is related to the higher average daily gain of these females during lactation (*P*=0.0336) in relation to the female calves from RES cows (0.86 and 0.86 *vs* 0.75 kg d^{-1}, respectively).

In addition to better performance during the lactation phase, female calves of REQ and HIGH cows presented higher post-weaning performance than those born to RES cows, resulting in higher body weights at both 270 (*P*=0.0105) and 365 d of age (*P*=0.0021). The female calves presented body weights of 200.93, 224.89 and 233.15 kg at 9 mo and 259.47, 300.71 and 311.79 kg at 12 mo of age respectively for the RES, REQ and HIGH treatments.

The superiority in body weight of females can be explained by the daily body weight gains in the post-weaning period offspring (Table 3). In this period, offspring of HIGH cows showed higher gains than those born from RES cows at both 265 (0.34 *vs* 0.17 kg d^{-1}) and 335 d of age (0.45 vs 0.63 kg d^{-1}). Female calves from REQ cows showed similar performance to the other groups studied during the growth phase, with daily gains of 0.21 and 0.55 kg of body weight at 270 and 365 d of age, respectively. The performance from birth to 12 mo of females was higher in female calves from REQ and HIGH cows (P=0.0019) in relation to those born from RES (0.70 and 0.74 *vs* 0.60 kg d^{-1}, respectively).

Cow nutrition during the last third of gestation improved female calves' reproductive aptitude at twelve months of age (Table 3). Female calves from REQ and HIGH cows presented higher percentage of adult weight at twelve months of age (P=0.0021) when compared to those born from RES (63.19 and 65.64 *vs* 54.65 %, respectively), a result that is related to the higher postnatal performance of these females and consequently higher body weight at that age.

Table 3: Effects of the nutritional level of beef cows during final third of gestation on the postpartum performance of female calves

Performance	**Treatments[1] (n)** RES (14)	REQ (12)	HIGH (15)	***P*-value**
Post weaning performance				
Birth weight, kg	32.79 ± 1.25	35.45 ± 1.38	34.01 ± 1.24	0.3730
PAJUST205[2], kg	187.76^b ± 6.46	211.58^a ± 7.28	210.95^a ± 7.08	0.0266
Birth-weaning, kg d^{-1}	0.75^b ± 0.02	0.86^a ± 0.03	0.86^a ± 0.03	0.0336
Post weaning performance				
PAJUST270[2], kg	200.93^b ± 7.08	224.89^a ± 7.71	233.15^a ± 7.48	0.0105
Weaning-265d, kg d^{-1}	0.17^b ± 0.03	0.21^{ab} ± 0.03	0.34^a ± 0.03	0.0103
PAJUST365[2], kg	259.47^b ± 9.60	300.71^a ± 10.83	311.79^a ± 10.51	0.0021
Weaning-335d, kg d^{-1}	0.45^b ± 0.03	0.55^{ab} ± 0.03	0.63^a ± 0.03	0.0043
Birth-335d, kg d^{-1}	0.60^b ± 0.02	0.70^a ± 0.02	0.74^a ± 0.02	0.0019
Adult weight-335 d, %[3]	54.65^b ± 2.02	63.19^a ± 2.28	65.64^a ± 2.21	0.0021

Values are predicted means ± standard errors mean (SEM).

[1] RES = cows on natural pasture under nutritional restriction; REQ = cows supplemented to meet 100% requirements; HIGH = cows supplemented above requirements.

[2] Age adjusted weight of calves.

[3] Females to reach 60% of adult weight (285 kg body weight).

[abc] Distinct on the same line differ by Tukey test (P<0.05).

Discussion

Among the factors that may alter the uterine environment during pregnancy, it can be highlight the effects of maternal nutrition, where both malnutrition and overnutrition can modify calf metabolism and physiology after birth[(12)], with reflections on the potential for progeny production. In our study, the effects of different nutritional levels of beef cows during the last third of gestation were different between male and female progeny, resulting in a separate discussion for the categories.

Male performance

Meeting the requirements or supplementing cows above the maintenance requirements for protein and energy in the final third of gestation provided higher nutrient intake by pregnant cows, an aspect that may have improved the nutritional supply for the fetus and consequently the formation of muscle tissue. Improvement in maternal nutrition resulted in greater birth weight of REQ and HIGH males. Du *et al*[13] state that at this stage of gestation there is the completion of muscle hyperplasia and hypertrophy of preformed fibers, as well as the beginning of adipocyte formation in the fetal skeletal muscle. According to Funston *et al*[6], the development of fetal skeletal muscle has low nutritional priority during pregnancy, a factor that impairs the formation of muscle tissue in situations of low nutrient intake. Corroborating our study, the improvement in body weight at birth of male calves born to cows with higher nutritional status in pregnancy has been reported by several authors who have studied the effects of maternal nutrition on male progeny performance[5,14,15], which justify this result to the effects of fetal programming.

The greater body compactness of REQ and HIGH calves compared to RES (Table 3) may be related to changes in muscle fiber hyperplasia and/or hypertrophy that occur in the final third of pregnancy and were favored by better nutrition of the pregnant cow, as explained earlier[12]. Maresca *et al*[16] calculated the body mass index through the quotient between calf weight at birth by the square root of body length, and obtained a higher muscle index in calves born from Aberdeen Angus cows fed with a higher level of protein in the diet during late gestation. Body compacity represents greater deposition of muscle per unit of body measurement, an aspect that can increase the edible portion of the carcass.

The effects of maternal nutrition during pregnancy were not evidenced after male calves' birth, with similarity (P>0.05) in the adjusted weights for 205, 270 and 365 d of males. This result is related to the daily weight gain of male calves after birth. However, offspring of REQ and HIGH cows were about 10.51 and 8.10 % higher at 105 d of age than males born from RES cows.

Higher weaning weights of calves born to cows supplemented with distillery grains in the final third of gestation were obtained by Larson *et al*[17] and Bohnert *et al*[5], who worked with Red Angus x Simmental and Angus x Hereford cows, respectively. Marques *et al*[18] observed greater weight at weaning of male calves born to Angus x Hereford cows who gained body condition score in the second or third trimester of pregnancy, compared to those fed to gain body condition early in pregnancy or who were supplemented to maintain adequate and inadequate body condition score throughout pregnancy, demonstrating that nutritional stimulation during the stages of myogenesis and adipogenesis results in a male progeny with greater productive potential.

The post-weaning performance of males was similar between the nutritional levels of cows during the last third of pregnancy (Table 2). A meta-analytical study[19] demonstrated that the weight gain of the cow in pregnancy improves the performance of the progeny, and complements that these effects of the best maternal nutrition in the pregnancy are most evident in our initial two months of life.

In general, the literature has shown that fetal programming results are more clearly expressed in the first months of progeny life, especially when related to male performance[5,14,17]. These authors found no differences in weight after weaning, however, comment that the superior body weight observed in the offspring of cows with higher nutritional level during pregnancy, persists or even increases during the growth phases of these animals.

Even without obtaining the forage intake of the calves, the stress caused by weaning and subsequent adaptation to the Black Oat + Ryegrass pasture may have limited the productive potential of the progeny REQ and HIGH during the initial growth period up to 270 d of age, where calves from RES cows had their performance favored in this period (Table 2). Webb *et al*[20] state that nutritional restriction during gestation ends up producing an “economic” phenotype, which according to Greenwood *et al*[21], have a greater capacity for metabolic adaptation to less favorable environments during the postnatal life, may show compensatory gains in challenging environments after birth[22]. These structural and functional changes in the organs serve to allow a rapid adaptation of the developing fetus to the pressure of uterine environmental selection[23], preparing the organism to survive in similar environments in adult life.

Female performance

The effects of fetal programming were also observed in the female calves, however, with distinct effects to those observed in males. Unlike that observed in male progeny, female birth weight was similar between the nutritional levels of cows in the last third of gestation (Table 3). Similar results were observed[6,17)],who studied the effects of fetal programming on the performance of contemporary males and females Red Angus x Simmental. These authors reported different behaviors for the development of males and females, where the males showed differences in birth weight, but similar performances in the later stages of growing. When evaluating the females, Funston *et al*[6] observed similar weights at birth, however, in the postnatal performance, the daughters of cows that received protein supplementation during late gestation presented greater weight at weaning, and this weight difference was maintained until the beginning of reproduction.

In general, females have lower birth weight compared to males, which may represent lower nutritional demand for cow during pregnancy and consequently lower effects of fetal programming on female calves birth weight, as observed in the present study, where offspring of REQ and HIGH cows were only 5.91 % heavier at birth compared to those born from RES cows. Females were on average 10.5 0 % lighter at birth than males, which may justify the hypothesis that females have lower nutritional requirements in the fetal period. This theory is even more evident when is observed that cows that calved females had higher average daily gain during the supplementation period (0.11 *vs* -0.02 kg d^{-1}) and calved with a better body condition score (2.93 *vs* 2.89 points) compared to those cows which calved male, that is, the excess nutrients were stored as body reserves due to the lower nutritional demands for the fetus.

The effects of fetal programming were more clearly expressed on the postnatal performance of females (Table 3), with calves REQ and HIGH on average being 23.50 kg heavier at 7 mo of age when compared to offspring RES. Higher weaning weights of females born to cows supplemented in the last trimester of pregnancy were also observed(24), with crossbred Red Angus cows, and by Funston *et al*(6), being this group of females respectively 7.5 and 8.0 kg heavier in relation to the female calves of cows with lower nutritional level in the same period. Cushman *et al*(7) and Shoup *et al*(25), when studying crossbred cows (¼ Angus, ¼ Hereford, ¼ Pinzgauer and ¼ RedPoll) and Angus x Simmental, respectively, did not observe differences in performance during lactation until weaning of female calves of cows that received or not supplementation during pregnancy, justifying this result by the similarity in weight gains in the lactation phase.

Growth superiority of female of REQ and HIGH cows persisted and increased after the lactation period, and at twelve months of age, these females had respectively 15.89 and 20.16 % more body weight compared to those born from RES. According to Greenwood *et al*(21), feeding restriction during fetal development may limit progeny growth capacity during the postnatal period, with slower offspring growth lasting until 30 mo of age. Delayed development of females during adulthood can result in losses and decline in their productive potential. As a consequence of the higher body development of the REQ and HIGH females during the growing, they had a higher percentage of adult weight at twelve months of age (Table 3). Shoup *et al*(25) did not observe differences in the percentage of adult weight presented by offspring of non-supplemented cows or who received low or high amounts of gestational concentrate, with an average of 51 % of adult weight. Higher percentage of adult mating weight may reflect better reproductive rates, since the female needs to gain less weight during pregnancy until the first delivery. In addition to improving the body structure of females, some authors(7,24) observed higher calving rate in the first 21 d of the birth season in female calves of cows with higher nutrient intake in the last trimester of gestation, indicating that these females conceive at the beginning of breeding, which may result in greater productive longevity of female calves of cows with higher nutritional level during pregnancy(6).

In this sense, it is evident the influence exerted by the best maternal nutrition during pregnancy on the productive potential of the progeny. However, the provision of nutritional requirements or the overfeeding of cows in the final third of gestation did not change the performance of the offspring evaluated until twelve months of age. It is also noteworthy that the effects of fetal programming on the postnatal performance of males and females may be different during the growth phases.

Conclusions and implications

In summary, the results of this study demonstrate that both supplementation above nutritional requirements, as well as meeting 100 % of the requirements for beef cows during the final third of gestation improves the birth weight of males, but mainly the postnatal performance of females up to 12 mo of age, resulting in higher adult weight at 365 d of age for these heifers. Therefore, the male and female progeny respond differently to intrauterine changes caused by maternal nutrition during the last third of pregnancy, and further investigation is needed. Furthermore, overfeeding cows in the final third of gestation does not improve the performance of offspring until 12 mo of age for the parameters evaluated.

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Conflict of interest declaration

The authors declare they have no conflicts of interest with the work presented in this review article**.**

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