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REGULAR ARTICLES

Does supplementation of beef calves by creep feeding systems influence milk production and body condition of the dams?

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Abstract The aim of this study was to evaluate the effects of beef calves' supplementation in creep feeding systems on milk yield, body weight (BW), and body condition score (BCS) of their dams on tropical pastures using a meta-analytical approach. The database was obtained from 11 experiments conducted between 2009 and 2014 in Brazil, totaling 485 observations (cows). The database consisted of 273 Nellore and 212 crossbred (7/8 Nellore × 1/8 Holstein) cows. All experiments were carried out in the suckling phase (from 3 to 8 months of age of calves) during the transition phase between rainy and dry seasons from February to June of different years. The data were analyzed by a meta-analytical approach using mixed models and taking into account random variation among experiments. Calves' supplementation ($P \geq 0.59$) and the calves' sex ($P \geq 0.48$) did not affect milk yield of cows. The average fat-corrected milk (FCM) yield was 6.71 and 6.83 kg/day for cows that had their calves supplemented and not supplemented, respectively. Differences were observed ($P < 0.0001$) for milk yield due to the genetic group where crossbred cows presented greater FCM yield (7.37 kg/day) compared with Nellore cows (6.17 kg/day). There was no effect of the calves' supplementation on BW change ($P \geq 0.11$) and BCS change ($P \geq 0.23$) of the cows. Therefore, it is concluded that supplementation of beef calves using creep feeding systems in tropical pastures does not affect milk yield, body weight, or body condition of their dams.

Keywords Beef calves · Beef cows · Nellore · Supplements

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Introduction

Continuous weight gain from suckling period until slaughter is a critical feature to the success of beef cattle production in the tropics. However, milk nutrients cannot be enough to supply the calves' nutritional requirements for optimized weight gains after 3 months of age (Henriques et al. 2011). Therefore, the supplementation of suckling calves using creep feeding systems assumes great importance to assure an improved weaning weight (Paulino et al. 2012).

In fact, studies on creep feeding in the tropics have consistently shown increases in the body weight (BW) of calves at weaning (Porto et al. 2009; Valente et al. 2013; Barros et al. 2014; Lopes et al. 2014). However, fewer studies have evaluated the possible effects of creep feeding on body condition and milk production of the cow. Contradictory conclusions have been pointed out by those studies, where creep feeding supplementation of calves either had increase (Nogueira et al. 2006; Souza et al. 2007) or decrease (Sampaio et al. 2010) or produced no effect (Porto et al. 2009; Valente et al. 2013) on cows' productive performance. Nonetheless, most of these studies had a small number of observations and results could be, at least partially, confounded with the variation between the years of evaluation. In this sense, it is believed that increasing the number of observations can improve the inferences and a meta-analytical approach can be useful for this.

Therefore, the objective of this study was to evaluate the effects of beef calves' supplementation in creep feeding systems on milk yield, body weight, and body condition score

(BCS) of their dams on tropical pastures using a meta-analytical approach.

Materials and methods

Data acquisition and experimental procedures

The dataset used to evaluate milk yield, BW, and BCS of cows was obtained from 11 experiments conducted between 2009 and 2014 in Brazil, totaling 485 observations (cows). The experiments were carried out at the Animal Science Department of the Universidade Federal de Viçosa, Brazil (20° 45′ S, 42° 52′ W), in a 90-ha area consisting of 13 paddocks, covered with *Brachiaria decumbens*, and grazing under continuous stocking rate. There were water dispensers and shaded feeders in each paddock. In addition, there were shaded feeders with access restricted to the calves (creep feeders).

Experiments were performed during the suckling phase to evaluate the effects of supplementation on calves' performance (Table 1). The database consisted of 273 Nellore and 212 crossbred (7/8 Nellore × 1/8 Holstein) cows averaging 5 years old.

All experiments were conducted during the transition phase between rainy and dry seasons from February to June of each year according to completely randomized designs. The treatments were applied to calves, and each study included a control treatment without supplementation (calves receiving only mineral mixture) and three to four treatments where calves had access to creep feeding supplements. In all experiments, calves were fed daily at 1100 hours from 3 months of age until weaning at approximately 8 months old. Overall, the crude protein content in the supplements ranged from 80 to 550 g/kg as-fed, and the amount of supplements provided to calves ranged from 450 to 1600 g/day (Table 1). Cows received a mineral mixture ad libitum and 100 g of ground corn per day in feeders located close to creep feeders to allow calves to spend more time in the feeder for intake of the supplement. The mineral mixture consisted of dicalcium phosphate (500.0 g/kg), sodium chloride (471.9 g/kg), zinc sulfate (15.0 g/kg), copper sulfate (7.0 g/kg), cobalt sulfate (0.5 g/kg), potassium iodide (0.5 g/kg), sodium selenite (0.1 g/kg), and manganese sulfate (5.0 g/kg).

Table 1 Summary of the calves' performance in the different experiments

Study	Experimental period (days)	Calf sex	ASI, g/day	ADG, g/day	
				NS	SUP
Paula (2012)	112	Male	583	662	728
Valente et al. (2013)	112	Male	530	608	804
Barros et al. (2014)	112	Female	500	687	769
Lopes et al. (2014)	140	Male	900	727	880
Cardenas et al. (2015)	140	Female	500	619	677
Barros et al. (2015)	140	Male	850	731	843
Marquez et al. (2014)	150	Female	450	628	677
Lopes (2015)	140	Male	1200	720	873
Lima (2015)	112	Male/ female	700	511	631
DM Almeida (2015)[a]	140	Female	800	642	732
LS Martins (2015)[a]	140	Male	1600	500	900

ASI average actual supplement intake in supplemented animals (as-fed), *ADG* average daily gain, *NS* not supplemented calves, *SUP* supplemented calves

[a] Data from DM Almeida (2015) and LS Martins (2015) are unpublished

In all experiments, BCS of the cows was evaluated using a scale from 1 to 9, as recommended by the NRC (1996). Variation of the BCS of cows was estimated by the difference between scores recorded at the end and beginning of the supplementation period. The BCS was taken by multiple evaluators and averaged within each study. For BW evaluations, the cows were weighed at the beginning and end of the supplementation period after 14-h fasting. To minimize possible interference due to differences among cows used in the different experiments, the variation in BW and BCS was scaled according to the following equations:

$$\mathrm{VBWr} = \frac{(\mathrm{FBW}-\mathrm{IBW})}{\mathrm{IBW}} \quad (1)$$

$$\mathrm{VBCSr} = \frac{(\mathrm{FBCS}-\mathrm{IBCS})}{\mathrm{IBCS}} \quad (2)$$

where VBWr is the variation of BW scaled to initial BW, FBW is the final BW (kg), IBW is the initial BW (kg), VBCSr is the variation of BCS scaled to initial BCS, FBCS is the final BCS, and IBCS is the initial BCS.

To estimate the average daily milk yield, two to three milkings were performed in each experiment during the supplementation period. Cows were separated from their calves at 1800 hours. At 0600 hours of the following day, cows were injected with 2 mL of oxytocin (10 IU/mL; Ocitovet®, Brazil) in the mammary artery and immediately milked. The exact time when each cow was milked was recorded, and the milk produced was proportionally converted into a 24-h-based production. Milk samples were analyzed for fat content using infrared spectroscopy (Foss MilkoScan FT120, Hillerød, Denmark). The milk produced was corrected to 4 % of fat-corrected milk (FCM) according to NRC (2001):

$$\mathrm{FCM} = 0.4 \times \text{milk yield (kg/day)} + 15 \times \text{fat yield (kg/day)}. \quad (3)$$

A summary of the dataset on calves' and cows' performance is shown in Tables 1 and 2, respectively.

Table 2 Descriptive statistics of database utilized to access the effects of beef calves' supplementation on productive performance of beef cows

Item	Mean	Minimum	Maximum	*s*	Number
Overall dataset					
IBCS	4.44	2.40	6.80	0.82	468
VBCS	0.11	−1.80	1.70	0.56	468
VBCSr	0.037	−0.300	0.538	0.136	468
IBW, kg	444	311	620	58.5	485
VBW, kg	18.8	−77.0	110.0	20.60	485
VBWr	0.044	−0.161	0.277	0.047	485
Milk yield, kg/day	6.18	1.10	11.80	1.90	477
FCM, kg/day	6.78	0.70	13.70	2.09	477
Without creep feeding					
IBCS	4.50	2.60	6.50	0.87	105
VBCS	0.06	−1.80	1.60	0.63	105
VBCSr	0.028	−0.300	0.524	0.151	105
IBW, kg	439	312	595	62.7	109
VBW, kg	14.1	−77.0	63.0	21.7	109
VBWr	0.034	−0.161	0.159	0.050	109
Milk yield, kg/day	6.04	1.90	11.80	1.82	104
FCM, kg/day	6.73	1.70	11.20	1.95	104
With creep feeding					
IBCS	4.41	2.40	6.80	0.80	363
VBCS	0.13	−1.50	1.70	0.53	363
VBCSr	0.040	−0.222	0.531	0.129	363
IBW, kg	445	311	620	57.3	376
VBW, kg	20.2	−60.0	110.0	57.3	376
VBWr	0.047	−0.107	0.278	0.047	376
Milk yield, kg/day	6.23	1.10	11.60	1.93	373
FCM, kg/day	6.80	0.70	13.70	2.13	373

IBCS initial BCS, *VBCS* variation of BCS during experimental period, *VBCSr* variation of BCS scaled to initial BCS (see Eq. 2), *IBW* initial BW, *VBW* variation of BW during experimental period, *VBWr* variation of BW scaled to initial BW (see Eq. 1), *FCM* fat-corrected milk (see Eq. 3)

Statistical analysis

The data were analyzed according to meta-analysis techniques (St-Pierre 2001) using the MIXED Procedure of SAS 9.4. The basic model included the fixed effects of calves' supplementation (with or without supplementation), genetic group of the cow (Nellore or crossbred), sex of the calves (male or female), and their interactions. The random effect of the different experiments was considered in the parameter estimation. The best (co)variance structures were evaluated using the corrected Akaike information criterion, and the degrees of freedom were estimated according to the Kenward-Roger method. All variance components were estimated using the restricted maximum likelihood method, and the statistical evaluations were performed using 0.05 as the critical level for the probability of type I error.

Table 3 Descriptive level of probability for type I error for the fixed effects of the calves' supplementation (SUP), cows' genetic group (GG), calves' sex (SEXC), and their interactions on productive performance of the cows

Effect	Variable		
	VBCSr	VBWr	FCM, kg/day
SUP	0.89	0.11	0.59
GG	0.42	0.36	<0.0001
SEXC	0.23	0.13	0.48
SUP × GG	0.19	0.40	0.72
SUP × SEXC	0.09	0.93	0.46
GG × SEXC	0.92	0.46	0.87
SUP × GG × SEXC	0.76	0.33	0.31

VBCSr variation of BCS scaled to initial BCS (see Eq. 2), *VBWr* variation of BW scaled to initial BW (see Eq. 1), *FCM* fat-corrected milk (see Eq. 3)

Results

Calves' supplementation ($P \geq 0.59$) and sex ($P \geq 0.48$) did not affect the FCM yield of the cows (Table 3). The average FCM yield was 6.71 and 6.83 kg/day for the cows that had their calves supplemented and not supplemented, respectively. However, there was an effect ($P < 0.0001$) of the genetic group of the cows on milk yield. The average FCM yields were 7.37 and 6.17 kg/day for crossbred and Nellore cows, respectively (Table 4).

There was no effect ($P \geq 0.11$) of calves' supplementation on VBWr of the cows (Table 3). The average VBWr was 0.047 and 0.035 for the cows that had their calves supplemented and not supplemented, respectively (Table 4). Similarly,

Table 4 Least square means (± standard error) for the variables associated with productive performance of the cows according to the effects of the calves' supplementation (SUP), cows' genetic group (GG), calves' sex (SEXC), and their interactions

SUP	GG	SEXC	Variable		
			VBCSr	VBWr	FCM, kg/day
−	C	F	0.058 ± 0.052	0.048 ± 0.014	7.88 ± 0.64
+	C	F	0.056 ± 0.048	0.061 ± 0.011	7.33 ± 0.55
−	C	M	−0.039 ± 0.043	0.021 ± 0.011	7.06 ± 0.54
+	C	M	−0.004 ± 0.040	0.042 ± 0.009	7.23 ± 0.45
−	N	F	0.084 ± 0.050	0.040 ± 0.012	6.45 ± 0.60
+	N	F	0.046 ± 0.046	0.054 ± 0.010	6.42 ± 0.53
−	N	M	−0.017 ± 0.042	0.028 ± 0.011	5.94 ± 0.51
+	N	M	−0.006 ± 0.041	0.032 ± 0.009	5.87 ± 0.45

"−" not supplemented calves, "+" supplemented calves

VBCSr variation of BCS scaled to initial BCS (see Eq. 2), *VBWr* variation of BW scaled to initial BW (see Eq. 1), *FCM* fat-corrected milk (see Eq. 3), *C* crossbred cows, *N* Nellore cows, *F* female, *M* male there was no effect of the genetic group ($P \geq 0.36$) of the cows and calves' sex ($P \geq 0.13$) on VBWr (Table 3).

There was no effect ($P \geq 0.23$) of calves' supplementation, genetic group of the cows, and calves' sex on VBCSr of the cows (Table 3). The average VBCSr was 0.023 and 0.021 for cows that had their calves supplemented and not supplemented, respectively (Table 4).

No interaction was detected ($P \geq 0.09$) in this study (Table 3).

Discussion

According to Vargas Jr. et al. (2011), milk yield would be increased as the calf searching for milk would stimulate the mammary gland. On the other hand, solid intake by the calf is negatively correlated with milk yield (Henriques et al. 2011). Thus, supplementation of calves would, in theory, decrease milk yield of cows due to a decreased suckling stimulation (Fordyce et al. 1996).

However, according to the present study, calves' supplementation did not affect milk yield of the cows. Similarly, other studies in the USA (Gelvin et al. 2004) and Brazil (Barros et al. 2014) also did not find differences for milk yield in beef cows due to calves' supplementation. Thus, it seems that calves' supplementation does not change the suckling behavior of calves and consequently would not affect milk yield.

In fact, several authors in the tropics have found no decrease in milk intake due to creep feeding. Valente et al. (2013) evaluated the behavior of beef calves supplemented with different protein-to-carbohydrate ratios during the suckling phase and did not observe differences in time and frequency of suckling between supplemented and not supplemented calves. Consequently, these authors did not observe a difference in milk yield of cows. Similarly, Lopes (2015), evaluating the effect of increasing the amount of supplement (0, 3, 6, or 9 g/kg BW) for beef calves from 3 to 8 months of age, also did not observe any difference in suckling time and milk yield. The lack of effect of creep feeding on the milk yield probably occurred because calves prefer milk, supplement, and forage, in that order. Therefore, it seems unlikely that calves replace milk by supplement. Thus, calves will usually increase supplement and forage intake only after maximizing milk intake.

In fact, in both studies cited above, a decrease in grazing time was observed with supplementation, which means there was a replacement of the forage by supplement, supporting the lack of alteration in milk intake. Other authors (Barros et al. 2014; Lopes et al. 2014; Cardenas et al. 2015) evaluated the effects of supplementation of beef calves in tropical pastures on the intake of calves and observed that there was no change in milk intake, although forage intake was lower for supplemented calves.

Differences in milk yield were observed with regard to the genetic group of the cows, with crossbred animals being more productive. Similarly, Oliveira et al. (2007) and Valente et al. (2012) observed higher milk yield in crossbred cows compared with Nellore cows. Generally, Nellore cows have been considered to present lower potential for milk yield compared with European or crossbred animals. Greater milk yield of crossbred cows may be explained by their greater genetic potential for milk yield related to the effect of heterosis provided by crossbreeding that uses European animals with higher potential for milk yield and lactation persistence.

The influence of calves' sex on milk yield of beef cows has been reported in some studies. However, the results seem to be contradictory sometimes. Cruz et al. (1997) found higher milk yield for cows with male calves. The authors attributed this behavior to the higher suckling by the male calf due to its greater demand for nutrients, thus stimulating the milk yield of their dams. On the other hand, Espasandin et al. (2001) evaluated milk yield and suckling behavior in five beef cattle production systems and did not find any effect of calves' sex on the suckling time and milk yield. A similar behavior was also reported by Fagundes et al. (2004). Similarly, in this study, no influence was observed for calves' sex on milk yield of their dams.

Suckling frequency influences milk yield and body condition of dams (Kress et al. 1990). Thus, a higher amount of suckling could increase milk yield in response to stimulation and, consequently, it could lead to higher mobilization of reserves and decreased BCS of the cow. On the other hand, as the calf grows up, its ability to eat solid feed increases while milk intake decreases, so that supplementation could reduce its dependence in relation to cow production, resulting in lower variation in BCS of the cow.

However, differences in VBWr were not observed as a consequence of the calves' supplementation. It was observed for all experiments that there was an increase in BW of calves at weaning with adoption of creep feeding. However, provision of supplementation for calves had no favorable results on their dams.

The absence of effect of calves' supplementation on cow BW and BCS variations may be associated with the lack of difference in milk yield due to the calves' supplementation, as discussed previously. It must be emphasized that environmental conditions were the same for all animals and differences should be focused on only the supplementation of calves. Other authors (Duarte 2007; Valente et al. 2012) evaluated the effects of supplementation of beef calves in tropical pastures from 3 to 8 months of age on BW and BCS of their dams and also reported none difference caused by calves' supplementation.

However, Oliveira et al. (2006) highlighted that the evaluation of BCS would be more efficient than BW, because it would be more able to indicate variation in the accumulation of body reserves than a direct measurement of BW variation. Variations in BW could still occur due to variations in rumen fill, physiological condition associated to pregnancy, calving, and tissue hydration, instead of representing consistent changes in the body as fat and protein contents.

Similar to VBWr, there was no effect of calves' supplementation on VBCSr. Overall, the results of the present analysis show that factors such as the availability and quality of forage and the supplementation of cows have much greater effects on cow BW and BCS than does supplementation of calves.

From the results obtained here, it is concluded that supplementation of beef calves using creep feeding systems in tropical pastures does not affect milk yield, weight gain, or body condition of their dams.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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