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PRODUCTIVE PERFORMANCE OF PRE-WEANED CALVES REARED IN THE PANTANAL

DESEMPENHO DE BEZERROS SUBMETIDOS A DESMAMA PRECOCE NO PANTANAL

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Abstract
Early weaning (EW) has been adopted in cattle breeding farms in Pantanal as a strategy to increase the rate of pregnancy in cows. The primary income of these properties is the production of beef calves, and the price of these animals depends on their weight. Therefore, the calves subjected to EW should present weight similar to or higher than those of calves subjected to conventional weaning (CW). This study aimed to evaluate the productive performance of pure (Nellore) calves and crossbred (Nellore/Angus) calves reared in the Pantanal and subjected to either EW or CW. After EW, the calves were supplemented with concentrate at 1 kg/animal/day (low-energy diet) or 1% of live weight (high-energy diet). The weights adjusted to 300 days of age were higher for EW calves fed the high-energy diet ($p<0.01$) in both genetic groups. No significant differences were observed in the weight of EW animals fed the low-energy diet and CW animals ($p>0.01$), and animal weight was 241.17 and 236.27 kg in crossbred calves and 184.44 and 189.78 in Nellore calves, respectively. The EW adopted in this experimental model did not affect the productive performance of calves raised in the Pantanal.
Keywords: Nutrition, beef calves, supplementation.

Resumo
A desmama precoce (DP) vem sendo adotada nas fazendas de cria do Pantanal como alternativa para o aumento dos índices de concepção das vacas. A principal receita dessas propriedades são os bezerros (as), sendo o seu valor dependente dos seus respectivos pesos. Assim é necessário que os bezerros submetidos à DP, apresentem pesos semelhantes ou acima dos bezerros desmamados convencionalmente. Desta forma o estudo teve como objetivo, acompanhar o desempenho de bezerros nascidos no Pantanal, submetidos à DP ou a desmama convencional (DC), puros (Nelore) ou Cruzados (Nelore/Angus). Após a DP os animais receberam suplemento específico para bezerros, na quantidade fixa de 1 kg/animal/dia (baixa energia) ou ao nível de 1% do Peso Vivo (alta energia).

Os pesos ajustados aos 300 dias de idade foram maiores para os bezerros de DP sob alta energia (P<0,01), em ambos os grupos genéticos. Os pesos dos animais de DP de baixa energia e de DC, não se diferiram (P>0,01), sendo de 241,17 e 236,27 kg para o grupo de bezerros Cruzados e de 184,44 e 189,78 para o grupo de bezerros Nelore respectivamente. A DP adotada no modelo experimental não prejudicou o desempenho dos bezerros nascidos no Pantanal.
Palavras-chave: Nutrição, bezerros de corte, suplementação.

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Introduction

The Pantanal biome in Brazil is a partially and temporarily flooded plain. This biome is located in the states of Mato Grosso (MT) and Mato Grosso do Sul (MS) and is affected by the floods of the rivers of the Upper Paraguay Basin. The primary economic activity in the region is the production of beef calves, and this activity has been exploited sustainably for more than two centuries(1). The cattle herd in Pantanal is composed of approximately 3.86 million animals(2), representing approximately 6.7% of the local herd (MT and MS) and 1.8% of the national herd(3).

The Pantanal plains used for extensive cattle ranching have large pasture fields; however, their low productivity and nutritional quality compromise animal performance and fertility. Conventional weaning (CW) traditionally used in Pantanal is performed from the age of 240 days and leads to a considerable loss of weight and fertility of breeding cows under conditions of nutritional restriction.

Studies on EW found no significant differences in the weight of calves subjected to either EW or CW(3,4). Besides increasing rates of conception (pregnancy) in beef cows, EW did not impair the performance of calves(5,6). With respect to the economic benefits of EW in the Pantanal, a financial return of USD 1.70 was estimated for every USD 1.00 spent(7). The estimated annual production of calves in the Pantanal is 1.10 million animals(2) and may be increased to 1.32 or even 1.54 million animals if weaning rates increase by 10% or 20%, respectively.

According to studies carried out in the region, the performance of pre-weaned calves supplemented with concentrate (1.0 kg per animal/day) for up to 100 days was not compromised compared to calves subjected to CW(4); therefore, the supply of 1.0 kg/animal/day met the nutritional requirements for productive performance to the same extent of maternal breastfeeding and provided a positive return on investment (ROI).

Nonetheless, the performance of calves supplemented with more than 1 kg/animal/day under the pasture conditions of the Pantanal is not known. In addition, the increase in weight gain in calves may help reduce the fattening time and slaughter age of the animals(8), with positive effects on enteric methane emission levels per kg of beef produced.

This study aimed to evaluate the productive performance of Nellore and Nellore-Angus calves receiving different levels of supplementation during EW.

Materials and Methods

The study was conducted at Fazenda São Bento do Abobral, located in the sub-region of Abobral (19°28'47" S and 57°00'55" W), city of Miranda - MS, Brazil, from January 7 to June 3, 2016. The local climate is tropical sub-humid type (*Aw*) according to Köppen's classification. The study was approved by the Research Animal Ethics Committee of Embrapa Beef Cattle (Protocol Nº 002/2015).

The animals were kept in pasture lands containing a mixture of quicuio-da-Amazônia or koronivia grass (*Brachiaria humidicola* (Rendle) Schweick) and native forage grass [predominantly mimosa grass (*Axonopus purpusii*), brownseed paspalum (*Paspalum plicatulum*), carandazal grass (*Panicum laxum*), and knotroot bristlegrass (*Setaria geniculata*)] in the lower areas of the biome (bay margins, ebbs, and floodplains).

EW was evaluated using a factorial arrangement with two breeds [Nellore or crossbred (50% Angus and 50% Nellore)] and two supplementation diets [high-energy (HE) and low-energy (LE)].

From a total of 300 calves, 180 (90 crossbred and 90 Nellore) born in August of 2015 were chosen and distributed in six groups to standardize age and weight between the treatments. All calves born in the study period were produced by fixed-time artificial insemination (TAI) and had a high genetic value (Table 1):

EWC-A (n-30): EW crossbred calves supplemented with concentrate [1% of live weight (LW)];

EWC-B (n = 30): EW crossbred calves supplemented with concentrate (1.0 kg per animal/day);

CWC (n = 30): CW crossbred calves not supplemented;

EWN-A (n = 30): EW Nellore calves supplemented with concentrate (1% of LW);

EWN-B (n = 30): EW Nellore calves supplemented with concentrate (1.0 kg/animal/day);

CAN (n = 30): CW Nellore calves not supplemented.

The EW animals fed an LE diet (EWC-B and EWN-B) were supplemented in the study period (January 3 to June 3, 2016) with 1.0 kg of the pelleted feed/animal/day (Table 2). For the EW animals fed an HE diet (EWC-A and EWN-A), in addition to the supply of 1 kg/animal/day of the pelleted feed, a sufficient amount of ground feed was added to reach 1% of LW. Animals subjected to CW (CWC and CAN) remained with their mothers but were not supplemented with concentrate. The supplements were offered at the same time of day (7:00 a.m.), and the leftovers were collected, weighed, and stored for further analysis and calculation of feed consumption.

Table 1. Animal weight, age, and breed by type of diet during early weaning

Variable	Treatments					
	EWC-A	**EWC-B**	**CWC[1]**	**EWN-A**	**EWN-B**	**CWN[1]**
Weight (kg)	140.45	140.94	140.83	129.3	129.5	129.5
Age (days)	143	143	143	143	143	143
Breed	Crossbred	Crossbred	Crossbred	Nellore	Nellore	Nellore

[1]CWC and CAN, animals were weighed and maintained with their mothers for later conventional weaning.

Table 2. Composition of commercial feeds[1]

Component	Feed		Unit
	Pelleted[2]	Ground	
Crude protein	18.5	18.0	%
Ether extract	2.5	2.0	%
TDN	72.0	73.0	%
NPN	-	5.62	%
Crude fiber	7.0	14.0	%
ADF	10.0	15.0	%
Calcium	12.0	6.0	g/kg
Phosphorus	6.0	3.0	g/kg
Monensin sodium	60.0	40.0	mg/kg
Chromium	0.50	-	mg/kg

[1]Concentrations informed by the manufacturers on the product label in compliance with the requirements of the Ministry of Agriculture, Livestock, and Supply of Brazil.
[2]Pelleted feed enriched with vitamins A, D3, E, Ba, B2, B6, B12, K3, pantothenic acid, folic acid, niacin, biotin, and *Saccharomyces cerevisiae* (1.2 × 10E10).
TDN, total digestible nutrients; NPN, non-protein nitrogen; ADF, acid detergent fiber.

The EW procedures recommended in previous studies for the region were adopted in this study[(4)]. A methodology adapted to native pastures[(9)] was used for the monthly characterization of pasture, involving identifying grazing areas, measuring the distribution and frequency of forage grass species using multipliers[(10,11)], collecting forage to simulated grazing height, and analyzing the chemical composition of the diet[(12)]. The animals were weighed at 56-day intervals after a 12-hour fast.

Forage and supplement samples were collected and stored in a freezer until processing. For the analyses, the samples were thawed, dried in a forced ventilation oven at 55 °C for 72 to 96 hours, and cut milled in a 1-mm sieve for chemical analysis or a 2-mm sieve for digestibility analysis[(13)].

After initial processing, dry matter (DM) (Method No. 930.15)[(14)], ether extract (Method No. 920.39)[(14)], mineral matter (Method No. 942.05), crude protein (CP) (Method No. 976.05)[(14)], neutral detergent fiber (NDF), and acid detergent fiber (ADF)[(15)] were measured. Degradability parameters were determined using the in situ digestibility method[(16)] for up to 240 hours[(13)], and effective degradability was adjusted using a non-linear model[(17)].

For data comparison, performance data (weight and weight gain) were adjusted to 210 and 300 days of age using the following equations because the mean age of the animals at the time of the last weighing was 287.7 days:

PA210 = {[(FW–BW) / (DLW–DB)] × 210} + BW;

PA300 = {[(FW–BW) / (DLW-DB)] × 300} + BW, where

PA210 is the weight adjusted to 210 days of age;

PA300 is the weight adjusted to 300 days of age;

FW is the final weight (last weighing) (kg);

BW is the birth weight (kg);

DLW is the date of the last weighing (days);

DB is the date of birth (days).

With regard to the economic benefits of EW, the challenges were considered the HE treatments (EWC-A and EWN-A) relative to conventional LE treatments (EWC-B and EWN-B). Therefore, the return on investment (ROI) was determined using the following equation, and the result is shown in reais by real spent:

$ROI = (P–C)/C$, where

P is the profit;

C is the cost.

The final expense comprised the difference between HE supplementation minus LE supplementation costs, since other costs were assumed to be similar between treatments. The ROI was estimated by subtracting the estimated profit from the sales of the animals fed the LE diet (EWC-B and EWN-B) from the estimated profit from the sales of the animals fed the HE diet (EWC-A and EWN-A).

The sales price of the animals was estimated by the product between the average price of the calves at auctions in the study region (R$/kg of LW) in the reference month (June/2016)[31] and the price of PA300.

The following equation was used:

$Yij = \mu + Sj + Pk + Eijk$, where

Yij is the variable in animal i supplemented with j;

μ is the overall mean;

Sj is the effect of supplementation with j;

Pk is the effect of period k;

Eijk is the random error.

The study used a completely randomized block design, with a factorial for supplementation levels and genetic groups, with 30 replicates and three weighing intervals per treatment. The data were subjected to statistical analysis using the GLIMMIX procedure of the SAS software version 9.1[18].

Results and Discussion

No significant differences (P>0.05) were verified for the distribution and frequency of forage grass species between the grazing areas; thus, despite its low nutritional value, forage diet had no significant effect on treatments. The most dominant grasses in grazing areas were quicuio-da-Amazônia, mimosa grass, brownseed paspalum, carandazal grass, and knotroot bristlegrass (Table 3).

Table 3. Percentage of primary forage grass species in the study sites at Fazenda São Bento do Abobral – Pantanal Sul, Miranda, Mato Grosso do Sul, Brazil

Treatments	**Forage species**				
	Quicuio-da-Amazônia[1]	**Mimosa grass[2]**	**Brownseed paspalum[3]**	**Carandazal grass[4]**	**Knotroot bristlegrass[5]**
High-energy diet[6]	75.4 a	12.8 a	5.4 a	4.3 a	2.1 a
Low-energy diet[7]	74.3 a	10.9 a	5.8 a	4.8 a	4.2 a
Conventional diet[8]	77.4 a	11.4 a	4.8 a	4.0 a	2.4 a
Average	75.7 a	11.7 a	5.3 a	4.4 a	2.9 a

The means followed by the same letter in each column were not significantly different from each other at a level of significance of 1%. [1]*Brachiaria humidicola* (*Rendle.*) Schweick; [2]*Axonopus purpusii*; [3]*Paspalum plicatulum*; [4]*Panicum laxum*; [5]*Setaria geniculata*;
[6]Diet provided to groups EWC-A and EWN-A; [7]Diet administered to groups EWC-B and EWN-B; [8]Diet provided to groups CWC and CAN.

Table 4. Chemical composition of primary forage species and feed in the study sites at Fazenda São Bento do Abobral - Pantanal Sul, Miranda, Mato Grosso do Sul, Brazil

Variable	**Forage and feed**					
	Quicuio-da-Amazônia[1]	**Mimosa grass[2]**	**Brownseed paspalum[3]**	**Carandazal grass[4]**	**Knotroot bristlegrass[5]**	**Feed**
Dry matter (%)	38.11	36.14	37.27	39.14	40.22	37.62
Crude protein (%)	6.73	6.33	5.70	7.35	5.85	6.58
TDN (%)[6]	52.33	52.00	51.12	51.35	50.87	51.73
Digestibility (%)	54.17	52.51	51.37	50.51	52.23	53.19
PIDA (%)[7]	1.07	1.64	1.89	2.67	2.02	1.26
NDF (%)[8]	75.43	76.21	78.32	77.78	78.93	75.25
ADF (%)[9]	34.25	35.90	37.09	36.67	37.00	34.48
Lignin (%)	3.71	4.03	5.32	7.91	5.80	4.03
Calcium (g/kg)	3.09	3.01	3.32	0.73	4.04	2.98
Phosphorus (g/kg)	1.62	1.52	1.33	1.17	2.51	1.58
Sodium (g/kg)	0.22	0.80	1.06	0.81	2.73	0.41
Potassium (g/kg)	16.48	4.57	7.25	5.65	22.45	14.11
Magnesium (g/kg)	2.35	3.76	2.31	1.80	1.84	2.46
Iron (mg/kg)	70.71	87.45	90.75	40.31	63.81	71.68
Manganese (mg/kg)	202.40	134.80	375.13	118.77	203.24	198.36
Zinc (mg/kg)	30.48	18.38	20.73	16.27	30.96	27.69
Copper (mg/kg)	4.66	0.95	1.29	0.58	1.95	3.77

[1]*Brachiaria humidicola* (*Rendle.*) Schweick; [2]*Axonopus purpusii*; [3]*Paspalum plicatulum*; [4]*Panicum laxum*; [5]*Setaria geniculata*;
[6]Total digestible nutrients, estimated as described previously [27];
[7]Acid-detergent insoluble protein; [8]Neutral detergent fiber; [9]Acid-detergent fiber.

The high NDF levels in the diet (75.25%) associated with the low values of CP (below 7%), digestibility (53.19%), and energy - TDN (51.73%) may have decreased DM consumption [19] and limited the productive performance of calves (Table 4).

Native pastures had higher levels of indigestible protein and lower levels of digestibility when compared with cultivated pastures (quicuio-da-Amazônia). However, the chemical composition of these pastures was similar (Table 4). On the basis of mineral requirement tables, the evaluated pastures presented high levels of sodium, satisfactory levels of iron, manganese, potassium, and magnesium, and low levels of calcium, phosphorus, zinc, and copper[20].

DM consumption in animals fed LE diets is limited by the filling capacity of the digestive tract [21]. Forage consumption by cattle in tropical pastures is inversely correlated with the NDF levels and was estimated at 1.27% of LW[22]. Applying this percentage in the obtained NDF levels yielded an estimated DM consumption of approximately 1.68% of LW, indicating an insufficient supply of nutrients and possible limitations in productive performance[23].

Crossbred animals achieved higher weight ($p<0.05$) than purebred animals (Nellore) using both HE and LE diets (Table 5). The distribution of calves among treatments was balanced since all of them were the offspring of dams from the same herd, and from the same Nellore or Angus bulls. Thus, potential genetic effects on the results were mitigated, making it possible to correctly measure the effects of supplementation on performance.

Table 5. Performance of crossbred calves (50% Angus and 50% Nellore) and Nellore calves after weaning and supplementation

Variables	Treatments						
	EWC-A	EWC-B	CWC	EWN-A	EWN-B	CAN	p-value
Initial weight	140.4 ^{a}	140.9 ^{a}	140.8	129.3 ^{b}	129.5 ^{b}	129.5 ^{b}	<0.001
PA 210 (kg) [1]	237.7 ^{a}	221.6 ^{b}	-	176.3 ^{c}	165.7 ^{c}	-	<0.002
PA 300 (kg) [2]	291.7 ^{a}	247.5 ^{b}	232.1 ^{b,c}	221.9 ^{c}	192.3 ^{d}	194.5^d	<0.001
GPD 210 d	0.989 ^{a}	0.913 ^{b}	-	0.697 ^{c}	0.646 ^{c}	-	<0.001
GPD 300 d	0.872 ^{a}	0.725 ^{b}	0.674 ^{c}	0.640 ^{c}	0.541 ^{d}	0.548 ^{d}	<0.001

[1]Weight adjusted to 210 days of age;
[2]Weight adjusted to 300 days of age;
The means followed by the same letter in each line were not significantly different from each other at a level of significance of 1%.

The higher performance of crossbred animals was also observed in crossbred heifers (50% Charolais and 50% Nellore) supplemented with concentrate (0.9% of LW) when compared to groups with lower levels of supplementation[26].

Crossbred animals receiving the highest amount of supplementation (EWC-A) achieved a higher weight ($p<0.05$) adjusted to both ages (210 and 300 days) than crossbred animals supplemented with concentrate (1.0 kg/animal/day) (EWC-B) (Figure 1). A significant difference ($p<0.05$) in the weight adjusted to 300 days was observed for Nellore animals, corresponding to 221.9 and 192.3 kg in animals fed the HE diet (EWN-A) and the LE diet (EWN-B), respectively.

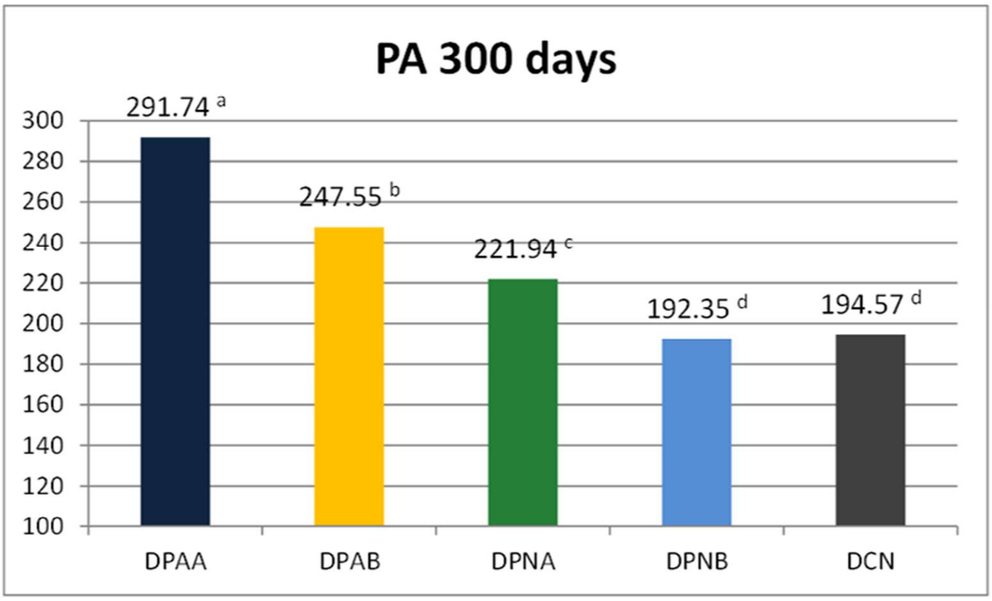

Figure 1. Weight adjusted at 300 days of age in crossbred and Nellore calves subjected to early weaning and fed either a high-energy diet (EWC-A and EWN-A) or a low-energy diet (EWC-B and EWN-B) and Nellore calves subjected to conventional weaning.

No significant difference ($p>0.05$) in the productive performance was verified between EW calves fed an LE diet and CW calves from the crossbred groups (247.5 and 232.1 kg for EWC-B and CWC, respectively) and between Nellore calves (192.3 and 194.5 kg for EWN-B and CAN, respectively), thus confirming the results of previous studies on EW conducted in the study region[(4)].

The limited nutritional value (low CP and TDN) of the diet of cows from pasture may have decreased milk production and, consequently, the productive performance of conventionally weaned calves (CAN) (Table 4).

Measuring weight gain in the first stage of life of beef cattle is fundamental for assessing the economic and environmental benefits (sustainability) of the production cycle. However, the results of supplementation of calves in creep-feeding systems are controversial, and differences in weight gain have been reported[(28, 29, 30)].

Furthermore, higher productive performance in the early stages of the production cycle may shorten the fattening and finishing period of steers, with economic and environmental benefits[(32, 33)].

The supplementation adjusted to 1% of LW in EW calves fed HE diets increased the average daily consumption per animal in 137.94 kg (279.80–141.86 kg) in crossbred calves (EWC-A and EWC-B, respectively) and 90.44 kg (223.44–133.00 kg) in Nellore calves (EWN-A and EWN-B, respectively) (Table 6). Higher supplementation (10% more) and less unconsumed feed resulted in differences in feed consumption among the genetic groups (crossbred × Nellore). Notably, the amount of feed was adjusted biweekly according to the expected weight gain, which was predicted to be 10% higher for crossbred animals.

Table 6. Consumption and cost of concentrate, weight, and price of calves in the reference month (end of the study) according to average prices adopted at auctions in the study region

	Treatments			
	EWC-A	**EWC-B**	**EWN-A**	**EWN-B**
Supplement consumption				
Average daily consumption/animal (kg)	2.027	1.028	1.619	0.964
Total consumption in the period/animal (kg)	279.80	141.86	223.44	133.00
Cost of concentrate				
Price of concentrate (R$/kg)[1]	1.22	1.22	1.22	1.22
Average daily price/animal (R$)	2.47	1.25	1.97	1.18
Total price in the period/animal (R$)	341.36	173.07	272.60	162.26

[1] Price of the concentrate on the farm.

According to the analysis, in the market conditions at the time of the study, the ROI was R$ 1.63 and R$ 1.88 per real spent for animals fed the HE diet (EWC-A and EWN-A) compared to animals fed the LE diet (EWC-B and EWN-B), respectively, indicating a positive financial return (Table 7).

Importantly, this analysis included additional expenses and estimated revenues at the time of the study, and the results may be different in adverse situations.

Table 7. Animal weight, market value, costs, prices, and return on investment of animals fed a high-energy diet compared to animals fed a conventional low-energy diet

	Treatments			
	EWC-A	**EWC-B**	**EWN-A**	**EWN-B**
Animal weight				
PA300 (kg)[1]	291.7	247.5	221.9	192.3
Market value				
Price of calves at auctions (R$/kg of LW)[2]	6.22	6.22	6.00	6.00
Estimated price of one calf (R$)	1,814.37	1,539.45	1,331.40	1,153.80
Return on investment (ROI)				
Cost of the concentrate (R$)	341.36	173.07	272.60	162.26
Profit of production of crossbred calves	168.29	0.00		
Profit of production of Nellore calves			110.34	0.00
Return (R$)	274.92		208.85	
ROI	1.63		1.88	

[1] Weight adjusted at 300 days of age;

[2] Average prices of calves in reference auctions (31) for animals of the same breed with equivalent weight.

Conclusions

Supplementation adjusted to 1% of the live weight of pre-weaned calves increased productive

performance with economic benefits in both genetic groups studied.
Calves subjected to EW at 110 days of age may reach a weight similar to or higher than those of calves subjected to CW inasmuch as the animals are supplemented with concentrate.

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