Acta Scientiarum

http://periodicos.uem.br/ojs/acta
ISSN on-line: 1807-8672
Doi: 10.4025/actascianimsci.v40i1.34519

ANIMAL PRODUCTION

# How the calving order of cows affects the performance of Nellore calves

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**ABSTRACT.** This study aimed to verify the effect of age of dam on the performance of male and female Nellore calves, using the following variables: average daily gain (ADG), adjusted weight for 205 days of age (W205), and number of days to reach 160 kg (D160). Information were collected from a commercial herd consisting of 1,122 calves and 1,009 heifers and their mothers. To classify animals with similar performance based on the cows' calving orders (age of dam), the multivariate cluster analysis was adopted through the complete linkage hierarchical method. The best performance was observed in the calves of cows in their sixth calving at most; for heifers, the best performance was seen in those born to cows in their eighth calving at most. Cows in their eighth calving should be discarded.

**Keywords:** average daily gain, cluster analysis, cow age, number of days to reach 160 kg, weaning weight.

## Ordem de parto da matriz sobre o desempenho de bezerros da raça Nelore

**RESUMO.** Objetivou-se com este estudo verificar o efeito da idade da vaca sobre o desempenho de bezerros e bezerras da raça Nelore, utilizando-se as variáveis ganho médio diário (GMD), peso ajustado para os 205 dias de idade (P205) e o número de dias para atingir 160 kg (D160). Foram coletadas informações de um rebanho comercial composto por 1.122 bezerros e 1.009 bezerras e suas respectivas mães. Para classificar os animais com desempenhos similares em função das ordens de parto (idade) das vacas, utilizou-se a análise multivariada de agrupamento, por meio do método hierárquico de ligação completa. O melhor desempenho é observado em bezerros filhos das vacas de até sexto parto. Para as bezerras o maior desempenho é verificado em filhas das matrizes de até oito partos. Vacas de no máximo oito partos devem ser descartadas.

**Palavras-chave:** análise de agrupamento, ganho médio diário, idade da vaca, número de dias para atingir 160 kg, peso ao desmame.

## Introduction

According to Boligon, Albuquerque, Mercadante and Lôbo (2009), increased weight gain in the pre-weaning phase has a positive effect on slaughter age reduction. The most commonly used ways to assess the performance of animals in this phase are average daily gain (ADG), adjusted weight at a pre-established age, and number of days to reach a certain weight (Pilau & Lobato, 2009; Souza et al., 2010; Lopes, Santos, Marques, Silva, & Ferreira, 2012).

Performance from birth to weaning is one of the first indications of genetic potential for an animal to gain weight. However, the expression of this quantitative phenotypic characteristic is not only due to its genes, but also influenced by month of birth, the cow's gestational age, the calf's weaning age, the matrix's maturity weight, the mother's racial composition, the calf's sex, and correlations between these variables (Castro-Pereira, Alencar, & Barbosa, 2007; Bocchi, Oliveira, Ferraz, & Eler, 2008; Queiroz, Costa, Oliveira, & Fries, 2009; Barichello, Alencar, Torres Jr., & Silva, 2011; Fialho et al., 2015).

There are several ways of analyzing animal production data. With the advent of computers, more complex analyses have emerged that can present solutions to problems in a more consistent way, with highlight to multivariate statistical methods, which are exploratory analyses that allow generating hypotheses on the object studied, using several variables simultaneously (Ferreira, 2008; Silva et al., 2011).

Cluster analysis is one of these techniques. This method allows the identification/formation of similar groups, through which it is possible to verify correlations between sample units, that is, how similar or dissimilar they are (Souza et al., 2010). However, they need to be tested and confirmed in other studies, given the small number of investigations (Val et al., 2008).

The objective of this study was to assess the performance of Nellore calves and heifers as a function of the cows' age of dam (calving order), using as criteria the ADG, W205 and D160 variables, through cluster analysis.

## Material and methods

Data from the records of 1,122 calves and 1,009 heifers and their respective mothers were analyzed. The animals were obtained from a commercial Nellore herd collected from four breeding stations (2006 to 2010) at Barra do Prata Agropecuária S/A, located in the Southwestern mesoregion of the State of Mato Grosso, in the municipality of Pontes e Lacerda, at latitude 15°19'1.61"S and longitude 59°13'11.87"W, inserted in the transition zone between the Amazon Forest and the Cerrado.

The property counts with several breeds and crossings. To eliminate the effect of the progenitors' racial composition, the NABC classification system (Nellore, Adapted, British and Continental, respectively) was used and, subsequently, only cows with Nellore blood level above 81.25% (13/16 Nellore) were selected. This technique was employed because data were extracted from software used for zootechnical control.

The cows were arranged in a certain pasture as per the reproductive management. Each picket had animals of all ages; pasture composition had no effect on a certain calving order and, consequently, did not favor the performance of calves and heifers born to cows of different calving orders. The same occurs with the effect of the calves' and heifers' weaning age, which ranged from six to eight months; however, there were cows of all ages weaning younger or older animals in each picket.

The parameters/variables measured to assess the performance of the calves and heifers were average daily weight gain (ADG) from birth to weaning, number of days to reach 160 kg (D160) and standardized weaning weight at 205 days of age (W205). ADG was calculated with the ratio of the difference between the obtained weaning and birth weight by the weaning age in days, expressed by:

$$ADG = \frac{WW - BW}{WA}$$

where:

WW = weaning weight;

BW = birth weight;

WA = weaning age.

The D160 variable was obtained by dividing 160 by ADG (Gusmão Malhado, Carneiro, & Martins Filho, 2009; Tanaka, Carvalheiro, Fries, & Queiroz, 2009), expressed by:

$$D160 = \frac{160\,kg}{ADG}$$

Where: ADG = average daily gain.

To obtain the W205 variable, ADG was multiplied by 205, and birth weight was added (Lopes, Rorato, Weber, Boligon, Comin, & Dornelles, 2008; Silva, Pedrosa, & Fraga, 2008), as expressed below:

$$P205 = ADG \times 205 + BW$$

Birth weight (BW) was obtained with an electronic scale, until a maximum of 24 hours after birth, while birth information was recorded (date, mother number, calf number and birth weight) (Cardoso, Cardellino, & Campos, 2000). Weaning weight was obtained at weaning time (calf's, heifer's and cow's weight).

For each calf and heifer, the cows' age at calving was identified by applying the multivariate cluster analysis to verify similar calving orders in relation to the weight performance of the offspring, according to the aforementioned variables. Due to sexual dimorphism, data were analyzed separately for males and females (Oliveira et al., 2007; Barichello et al., 2011).

Data analysis used the System for Statistical and Genetic Analysis [*Sistema para Análises Estatísticas e Genéticas*] (SAEG), described by Ribeiro Jr. and Melo (2008), applying the cluster analysis multivariate statistical technique. All animals from the four breeding seasons were considered. Cluster patterns were obtained between calving orders based on the ADG, W205, D160 variables, adopting the farthest-neighbor hierarchical cluster method. Due to the simultaneous use of three variables (ADG, W205 and D160) in the cluster analysis, the mean Euclidean distance was used, expressed by

$$\Delta_{ii'} = \frac{1}{\sqrt{p}} \sqrt{\sum_{j=1}^{p} \left(x_{ij} - x_{i'j}\right)^2}$$

where:

$X_{ij}$ represents the observation in the i-th sample unit (calving order) for the j-th variable (ADG, W205 and D160);

$X_{i'}j$ represents the observation in the i-th sample unit (calving order) for the j-th variable (ADG, W205 and D160);

p represents the number of variables to be analyzed (ADG, W205 and D160).

## Results and Discussion

The means and standard deviations of the average daily gain (ADG), weight at 205 days (P205) and days to reach 160 kg (D160) variables of the calves and heifers were estimated as a function of the matrices' calving orders. For the ADG and W205 variables, the best performance was found in the offspring of sixth-calving cows, while the poorest was observed in the offspring of 14$^{th}$-calving cows for both males and females (Tables 1 and 2).

The performance of the calves found in this study are close to those recommended by Gusmão et al. (2009), as they suggest that the ideal would be to produce a calf weighing 190 kg at 205 days of age, guaranteeing that it reaches the slaughter weight of 450 kg at 24 months of age. When assessing the cow age effect using the W205 variable of Nellore calves from the Northeast, Midwest, Southeast and South regions, Bocchi et al. (2008) verified better performance in the calves of 9-year-old cows (sixth calving).

For all variables used, males presented better performance than females did. This behavior was also observed by Oliveira et al. (2007) and Barichello et al. (2011). Although males show higher performance potential than females do, the former are more affected by declining milk production as the cows age (Bocchi et al., 2008).

With the application of the complete linkage cluster hierarchical method to classify calving orders using the ADG, W205 and D160 variables of the calves, the cutoff point was obtained at a height of 20%, with this height being defined for representing the best performance behavior of the calves and heifers as a function of the cows' age (Figure 1A) .

**Table 1.** Means and standard deviations of the average daily gain (ADG), weight at 205 days (P205) and days to reach 160 kg (D160) variables of the calves.

| [1]CO | ADG (g) | W205 (kg) | D160 (days) | No of animals |
|---|---|---|---|---|
| 01 | 747.6074 ± 13.2 | 186.9895 ± 31.5 | 214.0161 ± 49.7 | 300 |
| 02 | 731.5882 ± 12.5 | 186.8723 ± 31.0 | 218.7023 ± 48.5 | 155 |
| 03 | 767.3429 ± 11.3 | 194.2312 ± 35.3 | 208.5117 ± 37.9 | 135 |
| 04 | 769.9853 ± 11.5 | 194.6142 ± 26.6 | 207.7962 ± 30.6 | 116 |
| 05 | 763.2000 ± 10.1 | 192.9520 ± 28.7 | 209.6436 ± 33.3 | 81 |
| 06 | 773.9664 ±1 1.4 | 194.6177 ± 32.8 | 206.7273 ± 48.6 | 66 |
| 07 | 738.6873 ± 10.0 | 187.2302 ± 26.5 | 216.6015 ± 42.9 | 50 |
| 08 | 740.0200 ± 07.2 | 188.0727 ± 22.0 | 216.2162 ± 23.0 | 30 |
| 09 | 724.7000 ± 08.4 | 184.9994 ± 19.4 | 220.7800 ± 28.4 | 39 |
| 10 | 719.2687 ± 11.3 | 182.7659 ± 39.1 | 222.4482 ± 63.1 | 38 |
| 11 | 690.5325 ± 10.9 | 178.6655 ± 32.0 | 231.7052 ± 47.2 | 47 |
| 12 | 663.5633 ± 13.5 | 171.2952 ± 32.4 | 241.1224 ± 76.3 | 34 |
| 13 | 621.5236 ± 14.7 | 164.7808 ± 37.5 | 257.4319 ± 55.5 | 19 |
| 14 | 538.3891 ± 15.7 | 145.2586 ± 33.3 | 297.1829 ± 10.6 | 09 |
| 15 | 543.3962 ± 10.1 | 147.7296 ± 09.1 | 294.4444 ± 54.0 | 03 |
| Mean | 702.2511 ± 12.3 | 180.0717 ± 25.3 | 230.8887 ± 46.4 | 1122 |

[1]Calving Order.

**Table 2.** Means and standard deviations of the average daily gain (ADG), weight at 205 days (W205) and days to reach 160 kg (D160) variables of the heifers.

| [1]CO | ADG (g) | W205 (kg) | D160 (days) | No of animals |
|---|---|---|---|---|
| 01 | 682.9659 ± 99.9 | 171.4698 ± 21.2 | 240.2778 ± 43.4 | 275 |
| 02 | 674.3708 ± 95.6 | 171.9205 ± 20.6 | 242.7895 ± 41.8 | 169 |
| 03 | 685.6824 ± 92.1 | 175.6844 ± 18.7 | 237.9667 ± 35.9 | 92 |
| 04 | 688.5285 ± 104.4 | 175.6048 ± 38.9 | 238.7504 ± 45.6 | 92 |
| 05 | 691.3646 ± 111.1 | 176.0630±30.4 | 238.2818±44.0 | 75 |
| 06 | 691.8581 ± 110.2 | 177.4191 ± 24.1 | 237.9006 ± 43.8 | 51 |
| 07 | 678.9351 ± 105.8 | 173.3731 ± 23.4 | 241.8558 ± 40.4 | 47 |
| 08 | 690.9059 ± 82.0 | 176.6844 ± 17.7 | 235.4257 ± 32.5 | 41 |
| 09 | 684.2243 ± 106.7 | 174.6870 ± 23.4 | 241.1350 ± 48.3 | 38 |
| 10 | 673.2214 ± 75.2 | 172.2812 ± 16.0 | 240.8202 ± 28.7 | 48 |
| 11 | 676.5464 ± 79.9 | 171.7545 ± 18.2 | 240.0475 ± 30.8 | 32 |
| 12 | 633.9019 ± 73.6 | 165.1098 ± 14.1 | 256.6345 ± 37.1 | 25 |
| 13 | 649.6438 ± 91.2 | 166.5103 ± 20.0 | 251.5505 ± 40.0 | 18 |
| 14 | 540.4212 ± 97.4 | 145.4530 + 19.6 | 307.0284 ± 61.0 | 06 |
| Mean | 667.3264 ± 109.2 | 171.0011 ± 23.2 | 246.4618 ± 41.7 | 1009 |

[1]Calving Order.

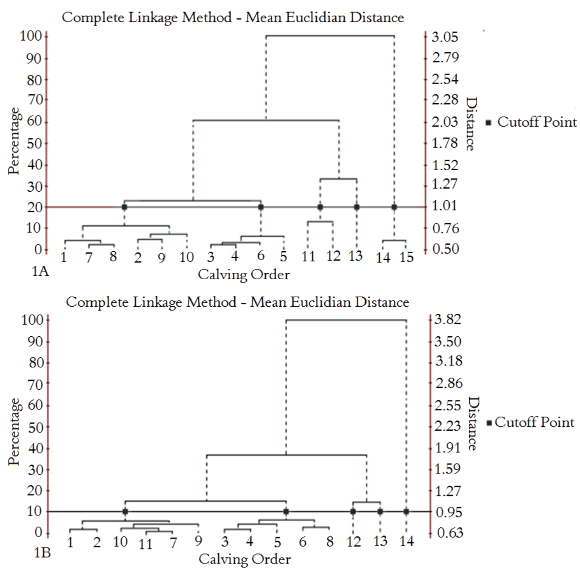


**Figure 1.** Dendrogram of calving orders through the complete linkage method using the average daily gain (ADG), weight at 205 days (W205) and days to reach 160 kg (D160) variables of the calves (1A) and the heifers (1B), Respectively.

Adopting this method, five groups were formed for the calves (Figure 1A). The first one was composed of the offspring of first, second, seventh, eighth, ninth and tenth calving cows. The second group consisted of the offspring of third, fourth, fifth and sixth calving cows. The third group was formed by the offspring of 11 and 12th-calving matrices. The fourth group was represented by the calves born to 13th-calving cows, and the last group was made up of calves born to 14 and 15th-calving cows.

The cluster analysis technique does not indicate which group of animals has the best performance. However, based on the estimated parameters, it is possible to observe the average performance of the animals (Tables 1 and 2). The group with better performance was formed by calves born to 3rd-6th calving cows.

Assessing Nellore animals, Bocchi et al. (2008) observed similar behavior, with better performance in the offspring of cows aged up to nine years (6th calving), and, from that age, the animals' performance decreases. According to Oliveira et al. (2007), studying Nellore animals they found an inferior performance of animals born to very young or old cows, with this being a non-genetic effect with direct consequences on weaning weight.

It is possible to notice that from the sixth calving order (9 years), there is a decrease in the performance of the calves. However, according to Queiroz et al. (2009), when assessing ADG, the visual scores of conformation, precocity and weaning muscle of Brangus animals, verified that cows that weaned calves with better performance were those aged between eight and 12 years old, and, from that age, there was a decrease in the performance of the calves. This fact is due to a decrease in maternal ability and low milk production as the cow ages.

Assessing 2nd - 6th calving Guzerah cows, Rangel, Guedes, Albuquerque, Novais and Lima Jr. (2009) concluded that shorter intervals between calving and service periods occur in 4 and 5th-calving cows, and at this age better productive and reproductive rates are observed.

Applying the complete linkage cluster hierarchical method to calving orders, using the ADG, W205 and D160 variables of the heifers, the cutoff point stood at the height of 10%, because this height is the one that best represents the behavior of the characteristics studied (Figure 1B).

For the heifers (Figure 1B), five groups were formed. The first one consisted of those born to first, second, seventh, ninth, tenth and 11th-calving cows. The second group consisted of heifers born to third, fourth, fifth, sixth, and eighth-calving cows. The heifers of 12th-calving cows formed the third one. The fourth being formed by heifers of 13th-calving cows, and the fifth group being composed of heifers born to 14th-calving cows.

Similar behavior was observed between females and males, as the clustered animals with better performance were born to third, fourth, fifth, sixth and eighth-calving cows, suggesting that, for the females, decrease in performance starts from the eighth calving. The difference between the two sexes is because, for the females, the offspring of eighth-calving cows were gathered in the most productive group. This may be because larger animals cause a greater organic exhaustion of their mothers due to a more intense milk sucking (Viu et al., 2008).

Thus, the females' performance is less affected by the drop in the milk production of cows with age (Bocchi et al., 2008). However, to describe this behavior perfectly, the heifers of seventh-calving cows should also be associated with this group.

Results similar to those of the present study were also found by Pereira, Yokoo, Bignardi, Sezana and Albuquerque (2010), who studied Nellore animals – pasture-raised and fed mineral supplementation at will – and verified that the best performance and the greatest hip heights occurred in heifers of cows aged eight to nine years. It is concluded that the females' performance curve as a function of the cows' age is more plane, showing that their performance is less impaired by the aging of the matrix.

Despite this behavior observed in the heifers, and the cluster formed including animals in the eighth calving at most, the best ADG and W205 were observed in the heifers of sixth-calving cows (Table 2). Because the values were very close, other studies should be conducted with heifers to better describe these characteristics. Just as Bocchi, Teixeira and Albuquerque (2004) suggest replacing old cows with genetically better heifers to raise productivity.

Queiroz et al. (2009) found similar values when working with Brangus animals raised in the South, Midwest and Southeast regions. The cows that calved at the age of eight and nine years were those that weaned calves and heifers with the best performance from birth to weaning, and this is probably due to the higher milk production of eight-year-old cows.

Researching Canchim cattle and using data on 12,344 animals born during the whole year from 1999 to 2005, Barichello et al. (2011) concluded that, with the aging of the cows, the performance of their offspring increases to a certain point, from which it begins to decrease. That this is due to a decrease in milk production and in the maternal ability of the cows.

## Conclusion

The effect of a cow's calving order on the variables of calves and heifers, assessed through cluster analysis process, indicated that the best performance is observed in the calves born to sixth-calving cows at most, while for heifers, the best performance is observed in those born to eighth-calving cows at most. Cows in their eighth calving should be discarded, because, as of that age, they begin to wean their offspring with a lower performance compared to that of first-calving matrices.

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*Received on December 12, 2016.*
*Accepted on June 28, 2017 .*