

GENETIC PARAMETERS OF GIROLANDO CROSSBRED COWS IN DAIRY HERDS IN THE STATE OF ACRE, BRAZIL

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ABSTRACT: This study aimed at estimating genetic parameters for milk production and conformation characteristics in Girolando crossbred dairy cows reared in the High and Low Acre region using the restricted maximum likelihood methodology, under an animal model. We estimated the variance components and genetic parameters using the REML/BLUP procedure (Restricted Maximum Likelihood Methodology/Best Linear Unbiased Prediction). The estimated average for milk production for 305 days of lactation (P305) was of 1523.25 ± 481.11 kg, with a heritability of 0.38 for this characteristic. The conformation characteristics showed no significant correlation with milk production. The phenotypical correlations between the linear characteristics of type were, in general, positive and moderate. The P305 obtained in this study can be considered low and indicates that there is a possibility of increasing milk production through selection in herds along with the use of tested and proven bulls. The heritability estimate found (0.38) indicates that there is genetic variability for milk production, demonstrating that selection for this characteristic would result in genetic progress.

KEYWORDS: Dairy cattle. Heritability. Phenotypic correlation. Variance components

PARÂMETROS GENÉTICOS DE VACAS MESTIÇAS GIROLANDO EM REBANHOS LEITEIROS NO ESTADO DO ACRE, BRASIL

RESUMO: Este estudo teve como objetivo estimar parâmetros genéticos para produção de leite e características de conformação em vacas leiteiras mestiças Girolando criadas na região do Alto e Baixo Acre, utilizando a metodologia da máxima verossimilhança restrita, sob modelo animal. As estimativas dos componentes de variância e dos parâmetros genéticos foram realizadas pelo procedimento REML/BLUP (Máxima verossimilhança restrita/Melhor predição linear não viesada). A média estimada para produção de leite aos 305 dias de lactação (P305) foi de $1.523,25 \pm 481$ kg e a herdabilidade para esta característica foi de 0,38. As características de conformação não apresentaram correlação significativa com a produção de leite. As correlações fenotípicas entre as características lineares de tipo foram em geral positivas e de magnitude moderada. A P305 obtida neste estudo pode ser considerada baixa e indica que existe a possibilidade de aumento da produção de leite através de seleção nos rebanhos, juntamente com a utilização de touros testados e provados. A estimativa de herdabilidade encontrada (0,38) indica que há variabilidade genética para produção de leite, demonstrando que a seleção para esta característica resultaria em progresso genético.

PALAVRAS-CHAVE: Bovino de leite. Herdabilidade. Correlação fenotípica. Componentes de variância.

PARÁMETROS GENÉTICOS DE VACAS CRUZADAS GIROLANDO EN GANADOS LECHEROS EN EL ESTADO DE ACRE, BRASIL

RESUMEN: El objetivo del estudio fue estimar los parámetros genéticos para la producción de leche y las características de conformación en vacas lecheras cruzadas Girolando criadas en la región de Alto y Bajo Acre utilizando el método de máxima verosimilitud restringida, con un modelo animal. Estimamos los componentes de la varianza y los parámetros genéticos mediante el procedimiento REML / BLUP (metodología de máxima verosimilitud restringida / mejor predicción lineal insesgada). El promedio estimado para la producción de leche para los 305 días de lactancia (P305) fue de 1523.25 ± 481.11 kg, con una heredabilidad de 0.38 para esta característica. Las características de conformación no mostraron correlación significativa con la producción de leche. Las correlaciones fenotípicas entre las características lineales de tipo fueron, en general, positivas y moderadas. El P305 obtenido en este estudio puede considerarse bajo y muestra que existe la posibilidad de incrementar la producción de leche a través de la selección en rebaños, junto con el uso de toros probados y comprobados. La estimación de heredabilidad encontrada (0,38) indica que existe variabilidad genética para la producción de leche, lo que demuestra que la selección de esta característica daría lugar a un progreso genético.

PALABRAS CLAVE: Vacas lecheras. Heredabilidad. Correlación fenotípica. Componentes de la varianza.

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Introduction

One of the great challenges of animal genetic improvement lies in the fact that the characteristics of economic importance in animals of zootechnical interest are polygenic or quantitative (FALCONER, 1989). It is also known that the phenotypic value (P), which corresponds to the observable and measurable expression of the characteristics, is the result of the interaction between the genotype of the animal (G), which corresponds to the gene pool that influences the characteristic, and the environment (E) to which the individual is submitted (ROSA et al., 2013).

In other words, only part of the differences observed in the animals' performance is likely to be transferred from one generation to the next, being the choice of the best individuals for the reproductive process an important step in the improvement of a herd (COLE; VANRADEN, 2018).

The northern region of Brazil has the most significant territorial extension of the country with approximately 38.5 million km², occupying close to 45% of the national territory. The effective cattle of Acre ranks fourth in the region, surpassing the number of three million in livestock in 2018, most of which is made up of animals for meat production (IBGE, 2018).

The state of Acre is ranked fifth regarding the number of milked cows when compared to the other states in the North Region, presenting more than 55 thousand animals milked in 2018. The distance from the large grain production centers associated with the low price of milk paid to the farmers, which has suffered a down price along the years from 1990 to 2000 (BEZERRA et al., 2019), and according to more recent data is approximately 0.89 cents of Brazilian currency (IBGE, 2018), lead to the discouragement for investment in production and stimulates the early drying of the animals. However, as a result of the low investment in inputs, water availability, and land prices, the demand for this activity still raises interests.

In Acre, despite the continuous growth of milk production resumed in 2011 a 2016 (IBGE, 2018), the dairy cattle herd still maintains very low production ratios mainly due to the low technological standard employed in the region, resulting from the production system adopted by most producers and characterized by a significant conservatism and extractivism, sometimes based on subsistence (CARNEIRO JÚNIOR et al., 2009; BRAGA, 2016).

Despite the challenges, when there is an investment in business management, especially knowledge of production costs and technical improvement of the activity, the producers can guarantee a profit. Because of this, dairy farming has aroused the interest of rural producers with greater business perspectives for its potential and profitability (SÁ, 2008), and is among the main economic activities developed by family farmers in the state of Acre (BAYMA, 2016). However, studies that better define the paths for consolidating the dairy chain in Acre are needed.

Efforts in animal breeding, essential for the growth of the productivity of the dairy production chain, have been scarce (CAVALCANTE et al., 2014). The percentage of producers who adopt the dairy control practice in the state is still very low, hindering the implementation of selection programs (BAYMA, 2016; CARNEIRO JÚNIOR et al.,

2016).

Information on genetic parameters for milk production and conformation characteristics regarding the state herd are limited (SATRAPA et al., 2012, ASSIS et al., 2014, SANTOS et al., 2015). These parameters are essential for choosing the selection method of state producers, whose objective is not always the same as in other regions of the country if one considers regional peculiarities. Thus, the need for researches in the field of breeding with the local population is evident.

The objective of this study was to estimate genetic parameters for milk production and conformation characteristics in crossbred dairy cows reared in the High and Low Acre regions using the REML/BLUP procedure, under an animal model.

Material and Methods

The information used in this study was collected from thirteen dairy farms located in the High and Low regions of Acre. The herds were comprised of Girolando crossbred animals, presenting the genetic composition from 3/8Holstein and 5/8Gir, with an average, 25 lactating cows per herd, and totalizing approximately 50 dairy matrices per farm.

We weighed the milk obtained from each cow every 30 days, at the milk day of control, to obtain the monthly milk control. The product was obtained by manual or mechanical milking depending on the availability or not of the equipment in each property and, soon after, it was weighed using a hook scale. It was used the Girolando Linear Evaluation System - SALG to evaluate the Linear and Conformation characteristics (SILVA et al., 2015).

The database obtained in the study period consisted of 1,323 records of milk production on the day of control, in different lactations of 540 crossbred cows, resulting in a small set of data due to the low adherence of the rural producers of the region to the practice of dairy control. However, the sample was consistent with the methodology used for the genetic evaluation. To structure the data, we eliminated the data from the animals with less than three dairy controls registered during the collection months and had no recorded delivery date.

There were no restrictions on the duration of the lactation since one of the leading causes of a short lactation period in tropical dairy cattle is the genetic origin (MADALENA, 1988). After the eliminations, we calculated the milk production of up to 305 days of lactation according to the official method regulated by the Ministry of Agriculture and Supply (BRASIL, 1986), using the following expression:

$$PL305 = C1 \times E1 \sum_{i=2}^n \left[\frac{CI + C_{i-1}}{2} \right] \times Ei + Cn \times En$$

In which: PL305 = Milk production at 305 days; CI = Milk production obtained in the nth milk control; n = Number of controls performed; E1 = Interval between the delivery dates and first control (in days); Ei = Interval between two consecutive controls (in days). The chemical composition of the milk was not an object of this study.

Subsequently, the milk production was grouped

into four control periods, in the year of 2015, where period 01 (rainy season) included the months from December to March, period 02 (rain-dry transition) consisted of April to May, period 03 (drought season) ranged from June to September, and period 04 (dry-rain transition) was from October to November.

The contemporary group (CG) used in the analyzes was formed by the herd, month, and control period. It was used the restriction that each Contemporary Group presented, at least, three observations.

After analyzing the data consistency, a descriptive statistical analysis to describe and summarize the data was performed. Subsequently, the data were subjected to the analysis of variance by the Generalized Least Squares method using the General Linear Models Procedure - PROC GLM of the SAS - Statistical Analysis System (SAS, 2005) to identify the fixed effects that significantly affected the PL305. The estimates of the variance components were obtained by the Restricted Maximum Likelihood Methodology (REML), using the MTDFREML program (BOLDMAN *et al.*, 1995).

The uni character animal model used to estimate the variance components, and heritability for milk production in the analyzes was:

$$Y_{ij} = \mu + GC_i + a_{ij} + e_{ij}$$

In which: γ_{ij} = milk production accumulated in 305 days (PL305) observed in the animal j belonging to the contemporary group i ; μ = general mean; GC_i = contemporary group effect i , formed by the combination of herd, month of birth, and control period; a_{ij} = direct additive genetic effect of the animal j belonging to the contemporary group i ; e_{ij} = residual effect.

In the matrix form, the model used for data analysis

is represented by:

$$Y = X\beta + A\alpha + e$$

In which: γ = vector of the milk production observations in the animals (PL305); β = vector of the unknown fixed effects; α = vector of the random effects of additive genetic values of unknown animals; e = vector of the random errors; X and Z = the matrices corresponding to the observations, for fixed effects, and additive random genetic effects of the animals.

Results and Discussion

The estimated mean for milk production at 305 days of lactation (PL305) and its respective standard deviation in the studied period were of $1,523.25 \pm 481.11$ SD, which is expected for a population of mostly primiparous cows, daughters of unproved crossbred bulls with low milk yield. This mean value is inferior to that described by Mcmanus *et al.* (2008) for Girolando cattle 3/8Holstein 5/8Gir in the central region of the country, of which mean production was of $2,795.5 \pm 1,131.5$ SD.

The means estimated for milk production up to 305 days ranged between the minimum of 561.32 ± 685.91 SD kg and the maximum of $2,875.32 \pm 950.46$ SD kg, revealing the existence of management differences and genetic potential within the group of herds analyzed. The results of the analysis of variance of milk production (Table 1) indicate that the effects of herd, month of birth, and control period were significant ($P < 0.01$), which was also detected by other authors (BARBOSA *et al.*, 2008; HERRERA *et al.*, 2008) who studied Zebu cattle, demonstrating that the fixed effects directly interfered on milk production.

Table 1. Summary of the analysis of variance for milk production (kg) at 305 days (P305) in Girolando cows using monthly milking control.

Variables	P305 DF	Mean Squares
Contemporary Group	24	781,359.12*
Herd	08	2,103,068.21*
Month of birth	08	1,106,907.0*
Period	03	1,720,644.00*
Residue	580	1,278,108.14

*($P < 0.01$); DF: Degrees of Freedom

It was verified through the descriptive analysis that the cows presented lower production in the rainy-dry transition periods and in the dry season, respectively, which is probably due to the quantity and quality of the pastures and supplementation available at this time which contributes to the decrease in milk production.

Regarding the estimates of genetic parameters in milk production, an estimated heritability for milk production of 0.38 at 305 days was observed. Facó *et al.* (2007) reported a similar heritability estimate, 0.31, when studying the covariance heterogeneity for milk production in Girolando breeders. Canaza-Cayo *et al.* (2017) reported a heritability value of 0.27 ± 0.03 SD in the first lactation and of 0.28 ± 0.04 SD in the second when estimating the genetic parameter

for milk production of Girolando cows. The heritability estimate of milk production observed in this study indicates a genetic variability of this population, showing that the selection for this characteristic can result in genetic progress, making possible the implantation of breeding programs based on the technical disposal of dairy cows and replacement by heifers of greater genetic merit.

Regarding the conformation and management characteristics, the mean values and respective standard deviations found for the crossbred cows studied are demonstrated in Table 2.

Table 2. Means (\bar{X}) and respective standard deviations (SD) of conformation and management characteristics of Girolando crossbred cows by the Girolando Linear Evaluation System (SALG).

	Characteristic	$\bar{X} \pm SD$
Body Capacity Measurements	Croup Height (cm)	134.7 \pm 5.5
	Body Depth (cm)	68.7 \pm 4.6
	Body Length (cm)	108.4 \pm 8.3
	Thorax Perimeter (cm)	177.7 \pm 11.9
	Chest Width (1-9)	4.8 \pm 0.6
Croup	Croup Length (cm)	45.6 \pm 3.7
	Ischia Width (cm)	18.8 \pm 2.0
	Iliac Height (cm)	132.0 \pm 5.4
	Ischia Height (cm)	122.9 \pm 7.2
Legs and Feet	Legs lateral view (1-9)	5.0 \pm 0.4
	Legs back view (1-9)	4.5 \pm 0.6
	Hoof angle(1-9)	4.7 \pm 0.8
Posterior Udder	Posterior height (cm)	14.4 \pm 3.9
	Posterior width (cm)	5.3 \pm 1.4
	Teat placements (1-9)	4.2 \pm 0.9
Anterior Udder	Teat length (cm)	4.8 \pm 1.4
	Teat placement (1-9)	4.9 \pm 0.9
	Ligament (1-9)	4.9 \pm 0.7
	Teat diameter	2.2 \pm 1.0
Mammary System	Udder depth (cm)	11.9 \pm 3.1
	Central ligament (1-9)	5.1 \pm 0.4
Milk Characterization	Angularity (1-9)	5.0 \pm 1.0
Auxiliary Characteristics	Temperament (1-9)	6.2 \pm 1.6
	Ease in milking (1-9)	7.0 \pm 1.2
	Ease in birth (1-9)	7.2 \pm 1.1

In the present study, phenotypic correlations between linear type characteristics and milk production at 305 days (PL305) were generally low and close to zero, with some exceptions that presented moderate values.

Unfavorable correlations were observed (Table 3) between P305 and linear measurements of the udder and the mammary system, such as the teat placement (-0.05) and udder depth (-0.31), revealing that cows with higher milk production tend to present irregular teats and deeper udders, which must be taken into account during selection, because badly placed teats hinder mechanical milking and very deep udders are more subject to trauma and contamination, reducing the longevity of the animal in the production system (SILVA *et al.*, 2018). Negative correlations between milk production and udder depth were also observed to a lesser extent (-0.10) by Esteves *et al.* (2004) in the Holstein breed, and in higher extent (-0.50) by Lagrotta *et al.* (2010) in the Gir breed.

In general, the other correlations between PL305 and the conformation measures analyzed were positive and of low to moderate magnitude, such as the group of characteristics in the section of measures of body capacity

and croup, which varied from -0.34 WBII to 0.26 BD. As for the legs and feet session, which ranged from 0.11 HA to 0.19 LBV. For udder characteristics, the values varied from -0.05 TP to 0.04 LIG. The mammary system showed moderate values, varying between -0.31 UD and 0.36 CL, and the auxiliary characteristics ranged from 0.18 TEM to 0.24 EB.

These results were similar to those obtained by Teodoro *et al.* (2000) and Wenceslau *et al.* (2000) in the Gir breed, as for Freitas *et al.* (2003); Esteves *et al.* (2004) and Lagrotta *et al.* (2010) in the Holstein breed, which in general also found relatively low (close to zero) a moderate phenotypic correlations between the linear characteristics and milk production.

Table 3 presents the phenotypic correlations found and shows that most correlations between the linear type characteristics presented non-significant values ($P < 0.05$).

Table 3. Phenotypic correlations (Pearson) obtained between the linear type characteristics of Girolando crossbred cows measured by the Girolando Linear Evaluation System (SALG).

	PL305	CH	BD	BL	TP	CL	WBI	WBII	IH	LBV	HA	PW	TP	LIG	UD	CL	TEM	EM	EB
PL305	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CH	-0,26*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BD	0,26*	0,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BL	0,02	0,00	0,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TP	0,07	0,52*	0,56*	0,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CL	0,03	0,52*	0,00	0,00	0,00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WBI	0,21*	0,00	0,00	0,00	0,00	0,00	-	-	-	-	-	-	-	-	-	-	-	-	-
WBII	-0,34*	0,49*	0,00	0,00	0,00	0,00	0,00	-	-	-	-	-	-	-	-	-	-	-	-
IH	0,08	0,61*	0,00	0,00	0,00	0,49*	0,00	0,00	-	-	-	-	-	-	-	-	-	-	-
LBV	0,19	0,00	0,00	0,54*	0,00	0,57*	0,00	0,00	0,52*	-	-	-	-	-	-	-	-	-	-
HA	0,11	0,53*	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-	-	-	-	-	-	-	-	-
PW	0,01	0,00	0,00	0,00	0,00	0,00	0,56*	0,00	0,00	0,00	0,00	-	-	-	-	-	-	-	-
TP	-0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,68*	0,00	0,00	-	-	-	-	-	-	-
LIG	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,53*	0,00	0,00	-	-	-	-	-	-
UD	-0,31*	0,76*	0,00	0,00	0,00	0,00	0,00	0,00	0,53*	0,50*	0,00	0,00	0,00	0,00	-	-	-	-	-
CL	0,36*	0,00	0,53*	-0,52*	0,73*	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-	-	-	-
TEM	0,18	0,00	0,48*	0,00	0,00	0,00	0,56*	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-	-	-
EM	0,23*	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,48*	0,00	0,00	0,00	0,00	0,00	0,00	-	-
EB	0,24*	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,64*	0,00	0,00	0,00	0,55*	0,61*	-

PL305= Milk production by the 305 days; CH=Croup Height; BD=Body Depth; BL=Body Length; TP=Thoracic Perimeter; CL=Croup Length; WBI=Width between Ischia; WBII=Width between Iliia; IH=Ischia Height; LBV=Legs back view; HA=Hoof Angle; PW=Posterior Width; TP= Teat Placement; LIG= Ligament; UD=Udder Depth; CL= Central Ligament; TEM= Temperament; EM= Ease in Milking; EB= Ease in Birth. *: there was a significant correlation (P<0.05).

It is observed that, among the group of characteristics called body capacity, TP presented relatively high correlations with CH (0.52) and BD (0.56), demonstrating that, cows with greater cardiac and respiratory capacity, tend to present taller rumps and greater digestive capacity. These values are similar to the results (0.60 CH; 0.35BD) found by Esteves *et al.* (2004) studying genetic and phenotypic correlations between type characteristics and milk production in the Holstein breed.

Still in the set of measures of body capacity, it was observed that CH presented expressive correlations with different groups of characteristics, such as measures of legs and feet (0.53 HA), croup (0.61 IH) and the mammary system (0.76 UD) indicating that the height of the animal's croup has an influence on its locomotion and on the quality, support and longevity of the mammary system.

The characters belonging to the set of legs and feet correlated significantly with the group of characteristics of the udder and the mammary system, highlighting the correlations between HA and LIG (0.52), as well as LBV and TP (0.68), revealing that the positioning of the hind limbs influences locomotion, as well as the space available for the positioning and insertion of the udder and teats.

On the other hand, no direct association was observed between the body capacity characteristics and udder characteristics, agreeing with the results verified by Esteves *et al.* (2004). Regarding the group of characteristics of Croup and Udder, the correlations were also not significant, apart from the WBI which presented a considerable correlation

(0.56) with the PW, suggesting that cows with larger croups tend to have a wider posterior udder.

In the case of Auxiliary Characteristics, EB showed high correction with TEM (0.55) and with EM (0.61), which was already expected, as animals with a more docile temperament tend to present better productive and reproductive performance (SILVA *et al.*, 2018).

It is worth noting that the body capacity measurements were the characteristics that most resulted in phenotypic correlations, and presented, in general, positive correlations with the other characteristics evaluated, apart from BL, which presented negative correlation (0.52) with the CL. Rennó *et al.* (2003) regarding the Brown Swiss breed and Lagrotta *et al.* (2010) regarding the Gir breed, also observed positive correlations between the characteristics of the body measurements section, which indicates that the selection of one of these characteristics would lead to the improvement of others correlated to it.

Although, in general, the morphological characteristics did not present high correlations with P305, the selection to increase milk production, in an isolated way, can lead to worsening of the conformation of cows, directly interfering in longevity and increasing the rate of involuntary disposal, consequently reducing the profitability of the production system, being recommended to select for both characteristics, in order to obtain a more productive and long-lived cow.

Conclusion

The estimated mean of milk production (PL305) for crossbred cows is considered low and indicates that there is a possibility of increasing milk production through selection in herds along with the use of tested and proven bulls.

The environmental effects of herd-period and month of birth should be considered in the genetic evaluation of dairy herds in Acre since they have a direct effect on milk production. The estimated heritability obtained in this study (0.38) indicates a genetic variability for milk production in this population, demonstrating that the selection for this characteristic would result in genetic progress.

In general, the phenotypic values obtained for the linear conformation characteristics are inferior to the ideal values for the Girolando breed, which demands that these characteristics be included in the breeding plans of the dairy properties.

Complementary studies including reproductive characteristics and more lactation are required to obtain reproductive genetic parameters.

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