Revista MVZ Córdoba
ISSN: 0122-0268
ISSN: 1909-0544
revistamvz@gmail.com
Universidad de Córdoba
Colombia

Genetic evaluation for weight traits in commercial Brahman cattle

Bedoya O, Christian; Alzate R, Jovany; Ángel C, Juan; Escobar R, Carlos; Calvo C, Samir
Genetic evaluation for weight traits in commercial Brahman cattle
Revista MVZ Córdoba, vol. 24, no. 2, 2019
Universidad de Córdoba, Colombia
Available in: http://www.redalyc.org/articulo.oa?id=69360025019
DOI: https://doi.org/10.21897/rmvz.1662

Artículos Originales

Genetic evaluation for weight traits in commercial Brahman cattle

Evaluación genética para características de peso en ganado Brahman comercial

Christian Bedoya O
Universidad Católica de Oriente, Colombia
cfbo09@gmail.com
http://orcid.org/0000-0002-2981-6287

Jovany Alzate R
Universidad Católica de Oriente, Colombia
cfbo09@gmail.com
http://orcid.org/0000-0003-3186-0778

Juan Ángel C
Universidad Católica de Oriente, Colombia
cangelca@gmail.com
http://orcid.org/0000-0001-5339-5913

Carlos Escobar R
Universidad de Antioquia, Colombia
carlos99992@gmail.com
http://orcid.org/0000-0002-3955-484X

Samir Calvo C
Universidad Católica de Oriente, Colombia
samirmejoramiento@gmail.com
http://orcid.org/0000-0003-3400-5208

DOI: https://doi.org/10.21897/rmvz.1662
Redalyc: http://www.redalyc.org/articulo.oa?id=69360025019

Received: 01 May 2018
Accepted: 01 November 2018
Published: 01 May 2019

Abstract:

Objective. Evaluate genetically the traits of birth weight and weaning weight in commercial Brahman cattle. **Materials and methods.** A total of 1.015 records of birth weight (BWT) and weaning weight adjusted to 270 days (WW270), were evaluated. Data correspond to the offspring born between 2002 and 2014 belonging to "La Envidia" farm, located in the municipality of Planeta Rica, Córdoba. A bi-character animal model that included, additive genetic effect, maternal effect and sex, month, year and age at weaning as fixed effects, was used. Genetic parameters were estimated using the MTDF-REML software. **Results.** The average and coefficient of variation (CV) of BWT was 29.62±3.13 kg and 10.59%, respectively. The mean and CV for WW270 was 216.71±26.97 kg and 12.45%, respectively. The estimates of direct heritability were 0.44±0.143 and 0.39±0.12 for BWT and WW270, respectively. Maternal heritability was 0.09±0.092 and 0.42±0.087 for BWT and WW270, respectively. The estimated genetic and phenotypic correlation between the evaluated characteristics was 0.11 and 0.13, respectively; with genetic progress per year of -2.02 kg for BWT and 7.81 kg for WW270. **Conclusions.** The estimations of heritability indicate the existence of direct additive genetic variability, evidencing the opportunity of genetic gain through selection. However, environment have a great influence on birth weight and weaning weight traits, which is why special attention should be paid to the handling and nutrition of females during pregnancy and of calves from birth to weaning.

Keywords: Animal model, beef cattle, genetic correlation, genetic progress, heritability .

Resumen:

Objetivo. Evaluar genéticamente las características de peso al nacimiento y peso al destete en una población de ganado Brahman comercial. **Materiales y métodos**. Se analizaron 1.015 registros de peso al nacimiento (PN) y peso al destete ajustado a los 270 días (PA270) de crías entre los años 2002 y 2014 pertenecientes a la hacienda La Envidia, ubicada en el municipio de Planeta Rica, Córdoba. Se utilizó un modelo animal bi-carácter que incluyó efectos fijos de sexo, mes, año y edad al destete, efecto genético aditivo y el efecto materno, estimando los parámetros genéticos con el software MTDF-REML. **Resultados.** Se encontró un promedio para PN de 29.62±3.13kg y coeficiente de variación (CV) del 10.6%. La media para PA270 fue de 216.713±26.97 kg y CV 12.5%. Los estimados de heredabilidad directa (h2d) fueron de 0.44±0.14 y 0.39±0.12 para PN y PA270, respectivamente. La heredabilidad materna (h2m) fue de 0.09±0.092 y 0.42±0.087 para PN y PA270, respectivamente. La correlación genética y fenotípica estimada entre las características evaluadas fue de 0.11 y 0.13, respectivamente; con progreso genético por año para PN de -2.02 kg y 7.81 kg para PA270. **Conclusiones.** Las estimaciones de heredabilidad indican la existencia de variabilidad genética aditiva directa, evidenciando la oportunidad de ganancia genética por medio de selección. Sin embargo, las características de peso al nacer y peso del destete presentan gran influencia del ambiente, por lo cual se debe poner especial atención al manejo y la nutrición de las hembras durante la gestación y de los terneros desde el nacimiento hasta el destete.

Palabras clave: Correlación genética, ganado de carne, heredabilidad, modelo animal, progreso genético .

INTRODUCTION

According to FAO, global meat production in 2018 may increase to 336 million tons in carcass weight equivalent, which is 1.7 percent (or 6 million tons) more than in 2017 (1). In Colombia, beef production in 2017 was approximately 905 thousand tons in carcass weight equivalent, 5 thousand tons less than in the previous year (2). Tropical agro-ecological conditions in Colombia are favorable for forage production throughout the year; being this, a positive condition in the bovine meat production (3). Specifically, the region of the Sinú valley has been characterized by having an average temperature of 27°C, a relative humidity of 83% and with a tropical dry forest habitat (4). Most of the farms located in these areas are dedicated to breeding, raising and finishing commercial Brhaman beef cattle but they do not have an oriented mating program or selection criteria (3).

In order to make beef cattle a more profitable business, it is mandatory to record the data of Birth and weaning weights and use it as a strategy to improve growth parameters from one generation to the next one. These weight characteristics are controlled by additive genetic factors from both father and mother, maternal additive genetic factors (milk production) and by direct environmental effects, such as nutritional management (5,6,7). The use of genetic evaluation, selection, mating and management of those weights characteristics in breeding programs generate heavier and profitable progenies (3).

The objective of this research was to estimate genetic, productive and selection parameters for the characteristics of birth weight and weaning weight adjusted to 270 days in a commercial Brahman herd in the Sinú valley-Colombia.

MATERIALS AND METHODS

Animals and agro-ecological conditions. Data collection of phenotypic and genealogical information of mothers, fathers and offspring was recorded on an unselected Brahman herd during the years 2002 until 2014. Records were taken from the database of the "La Envidia" farm located in the Sinu valley, department of Córdoba, Colombia. The farm is located at a height of 18 m above sea level, with an average temperature of 35°C and an average annual rainfall of 1.156 mm. It is located in a tropical dry forest habitat, with soils classified in the order of molisol rich in organic matter and with slopes of less than 5% (8).

Feeding and handling. "La Envidia" is a breeding farm constituted by cows of the commercial Brahman breed, managed under a natural mating system and since 2010 with artificial insemination. Animals were under a rotational grazing system with paddocks between 4 and 6 hectares, established with Braquipará (*Brachiaria plantaginea*), Pangola (*Digitaria decumbens*) and Angleton (*Dichantium aristatumbenth*) pastures, with a resting period of 45 to 90 days depending on the time of the year. Additionally, animals were supplied with proteinated salt, bypass fat and water at will.

Genealogical and phenotypic data. For the genetic evaluation, the following information was collected: animal identification, father and mother identification, sex, date of birth, weight at birth, weight and age at weaning. The number of records were 1,015 in total. The genealogical data were purified using the specialized pedigree viewer software (9) and the phenotypic data using the R-project version 3.5.1 (10).

From the data collected, the weaning weight adjusted to 270 days was calculated using the following formula:

$$WW270 = \left(\frac{\text{ACTUAL WEIGHT} - \text{BWT}}{\text{WEANING AGE IN DAYS}}\right) * 270 + BWT$$

FORMULA

Where, WW270 is weight adjusted to 270 days and BWT is birth weight.

Statistical model. The genetic evaluation was performed using the following bi-character animal model :

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} + \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} Z_1 & 0 \\ 0 & Z_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} W_1 & 0 \\ 0 & W_2 \end{bmatrix} \begin{bmatrix} m_1 \\ m_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \quad [m]$$

Where;

Y_1, Y_2: Traits observation vector (Y_1= BWT yY_2: WW270).

X_1, X_2: Incidence matrix that relate the observations to the fixed effects (sex, year of birth, month of birth, year of weaning, month of weaning).

B $_1$,ꞵ $_2$: Solutions for the fixed effects of birth weight and weaning weight.

Z_1, Z_2: Incidence matrix that relate the observations to the direct additive genetic effects.

a_1,a_2: Solutions for direct random effects (expected breeding value).

W_1, W_2: Incidence matrix that relate the maternal random effect.

m_1, m_2: Solutions for maternal effects.

e_1, e_2: Statistical error.

Correlation analysis. To estimate the phenotypic correlation between the traits BWT and WW270, the equation proposed by Falconer and Mackay (11) was:

$$rp_{1,2} = \left(rg_{1,2} * \sqrt{h_1^2} * \sqrt{h_2^2}\right) + \left(ra_{1,2} * \sqrt{1 - h_1^2} * \sqrt{1 - h_2^2}\right) \quad [\text{ecuación}]$$

Where,

rp1,2: Phenotypic correlation between trait 1 and 2

rg1,2: Genetic correlation between trait 1 and 2

ra1,2: Environmental correlation between trait 1 and 2

h21: Heritability of trait 1

h22: Heritability of trait 2

The estimation of the variance components and genetic parameters were performed using the restricted maximum likelihood method (REML) using the MTDF-REML software (12).

The genetic progress was estimated using the following formula (13):

$$\Delta G \Big/ year = \frac{h^2 * S}{IG}$$ [formula]

Where,
ΔG: Genetic progress
h2: Heritability of the characteristic
S: Selection differential
IG: Generation interval, as the weighted average of males and females of the evaluated population.

RESULTS

In the kinship matrix, 1.501 animals were distributed over three generations (83 fathers, 314 mothers and 795 progenies); 66 paternal families and 10 maternal families. The average inbreeding coefficient was 0.0 with 0 consanguineous animals in the genealogy.

The average for BWT was 29.62±3.13 kg with a CV of 10.6% and minimum and maximum values of 20 and 40 kg, respectively. The mean for WW270 was 216.71±26.97 kg and a CV of 12.5%; with a minimum and maximum weight value of 109.6 and 260.64 kg, respectively. Table 1 shows the descriptive statistics for the characteristics of birth weight and weaning weight in the evaluated Brahman population.

TABLE 1.
Table 1. Descriptive statistics for the characteristics of birth weight and weaning weight in commercial Brahman cattle.

Characteristics	N	X ± STD	C.V	Min	Max
BWT (kg)	1015	29.62 ±3.13	10.6	20	40
WW270(kg)	1015	216.71 ±26.97	12.5	109.6	260.6

N=Number of samples, X=Average, STD=Standard deviation, C.V=Coefficient of variation, Max=Maximum weight, Min=Minimum weight.

The variance components and the genetic and phenotypic parameters for BWT and WW traits found in commercial Brahman cattle can be observed in table 2 and figure 1. The direct and maternal heritability for birth weight was 0.23±0.086 and 0.05±0.05, respectively and for WW270 it was 0.39±0.127 and 0.39±0.091, respectively. The genetic correlation (0.11) and phenotypic correlation (0.13) between the traits BWT and WW270 in the Brahman population evaluated were positive and very low.

The genetic progress per year for BWT and WW270 was -2.02 kg and 7.81 kg, respectively. Table 3 shows the 10 best animals and the 10 best mothers for BWT and WW270 with respect to the genetic evaluation performed in the present study for commercial Brahman. The best animal for weight at birth was the female "1022" with an expected difference of progeny (EDP) of -3.12 kg and the best female for weaning weight was the "48" with an EDP of 38.34 kg. The best mother for birth weight was the "1020" with a maternal EDP of -1.48 kg and for weaning weight was the animal "326" with a maternal EDP of 23.35 kg.

TABLE 2

Table 2. Components of variance, genetic and phenotypic parameters for the characteristics of birth weight and weaning weight in commercial Brahman cattle.

Characteristics	σ^2a	σ^2m	σ^2e	σ^2p	h^2d ±SE	h^2m ±SE	ΔG/year
BWT	4.04	0.81	5.4	9.21	0.44 ±0.14	0.09 ±0.092	-2.02
WW270	348.9	376.72	224.27	657.79	0.39 ±0.12	0.42 ±0.087	7.81

σ^2a: Additive variance. σ^2m: Maternal variance. σ^2e: Environmental variance. σ^2p: Phenotypic variance. h^2d ± SE: Direct heritability ± standard error. h^2m ± SE: Maternal heritability ± standard error. ΔG/year: Genetic progress per year.

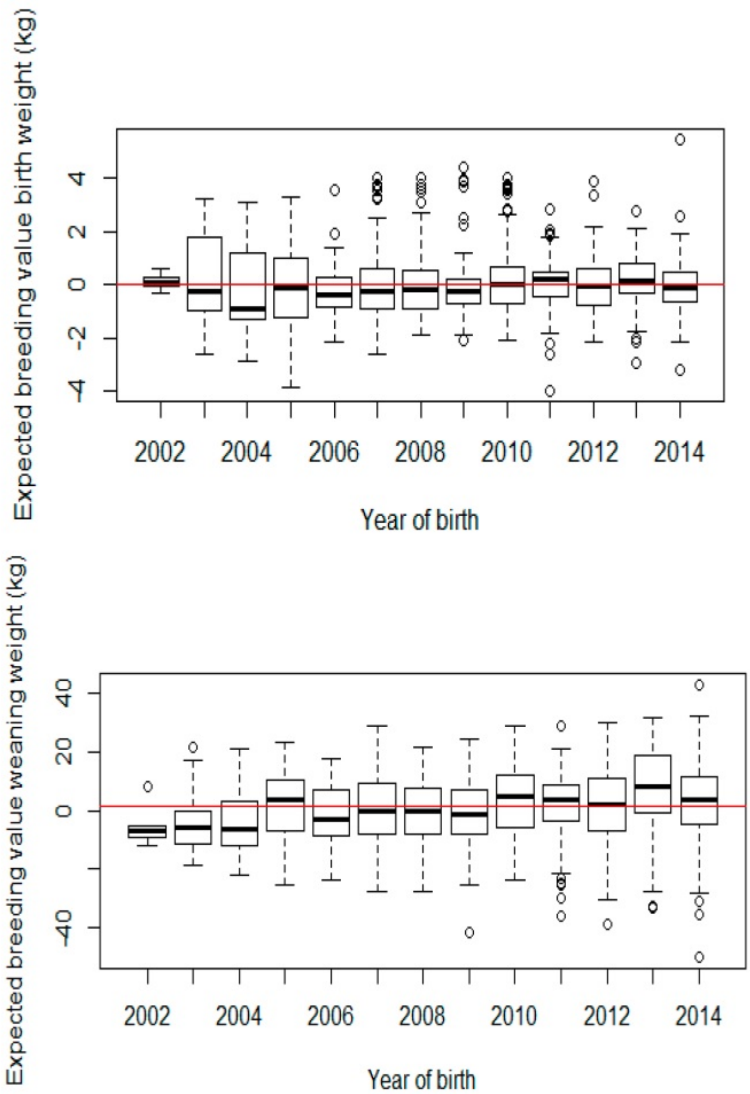

FIGURE 1

Figure 1. Behavior of the genetic values for birth weight and weaning weight per year in an unselected commercial Brahman stock.

TABLE 3

Table 3. Ranking of animals with the best direct and maternal genetic values for the characteristics of birth weight (BWT) and weaning weight (WW) in a commercial Brahman population.

BIRTH WEIGHT					WEANING WEIGHT				
ID	Sex	EDPdir	ID Mothers	EDPmat	ID	Sex	EDPdir	ID Mothers	EDPmat
1022	F	-3.12	1020	-1.48	48	H	38.34	326	23.35
399	F	-2.68	399	-1.27	1184	H	32.19	554	18.12
14	M	-2.68	91	-1.27	1194	M	31.04	510	17.77
91	F	-2.59	931	-1.23	1401	H	29.08	168	16.45
933	F	-2.35	1332	-1.11	69	H	28.62	356	15.91
1335	F	-2.14	407	-1.02	1424	H	27.51	655	15.75
342	M	-2.14	1417	-1.01	1055	M	27.31	129	15.71
407	F	-2.06	184	-0.98	73	H	27.30	213	15.70
883	M	-1.95	1054	-0.92	1144	H	26.18	365	15.58
1420	F	-1.94	375	-0.92	1091	H	25.40	368	15.19

ID: Animal identification. F: Female. M: Male. EDPdir: Direct expected difference of progeny.
EDPmat: Maternal Direct expected difference of progeny.

DISCUSION

Two studies in Colombia, using Brahman cattle under grazing conditions, have found weights at birth with an average of 35 ± 3 kg and 34.88 ± 3.9 kg, respectively (3,14). This shows that there are differences mainly in the management of cattle herds in Colombian tropics. The average weight of the population evaluated in the present study was lower. In Colombia, the management and feeding conditions in each commercial farm differ extensively and, in addition, the evaluated farm has an extensive management, without supplementation, and a very high number of animals per area.

The weights at birth obtained in this study were similar to those obtained by other authors in Brazil and Mexico. They evaluated commercial Nellore and Brahman cattle and found averages of 32.2±1.8 kg and 32.30±3.80 kg, respectively (15,16). In Colombia, evaluating this characteristic in populations of commercial creole cattle and in "Costeño con cuerno" breed, were found averages of 28.92 ± 3.2 kg in the department of Arauca (17) and 29 ± 3.71 kg (18), respectively. These results are within the ranges found in this study since for the characteristic weight at birth there is a lesser influence of the agroecological, nutritional and environmental management of the different farms.

The mean found for WW270 in the present study was 216.71±26.97 kg. This value was a normal average for heavy commercial zebu and is surpassed by those reported by Colombian authors whose values were 241±30 kg and 237.08±35.60 kg (3,14). Similar values of 210 kg for WW270 were found in Brahman (19); thus demonstrating a variability in the weight of the same breed by selection and management types in each herd, being able to reach weights between 210 and 250 kg under tropical Colombian conditions.

There are also studies that report weaning weights in Colombian Creole cattle that ranged between 169±24.7 kg and 137.65±28.04 kg (18.20). In Brazil, there was obtained weights for the Nellore breed of 185±29.40 kg (15) and in Mexico, using Brahman, they found an average of 180.7 ± 32.6 kg (16). These results were different from those of the present study, probably due to the different management and environmental conditions under which these populations of Brazil and Mexico were evaluated. When comparing these results, it can be inferred that there is great genetic and phenotypic variability among Zebu cattle populations in the different countries and that the weaning weights can be improved by selection in the population evaluated in the present study.

The direct and maternal heritability found in this study for birth weight was low (0.23) and almost nonexistent (0.05). In similar studies, low values in commercial Brahman of 0.33 and 0.08 (14) and 0.32 and 0.16 (21) were reported, respectively. In Romosinuano cattle were found values of 0.25 and 0.06, respectively (20). Other authors working with Romosinuano cattle raised in similar conditions to those of the present study, found values below 0.17 and 0.12 (22.23). In Brazil, using Nellore reported values of 0.25 and 0.25, respectively (15.24).

Maternal heritabilities for birth weight in almost all studies were very low, which means that the influence of the mother's genetics is very low during pregnancy and that the direct additive genetics and the uterine environment have a greater effect on this characteristic. Direct heritability was low, so special attention should be paid to improve feeding and management in the evaluated population. In addition, the selection pressure on the females must increase in order to improve the productive performance of the calves and the females of the forthcoming generations.

For WW270 a h^2d of 0.39 ±0.13 and a h^2m of 0.39 ± 0.091 was obtained, these values are means. The values found of h^2d for WW270 in the present study are above of those reported in Brahman, Nellore and Romosinuano of 0.22, 0.28 and 0.34 , respectively (21,22,24). From this, it can be inferred that the Brahman breed have greater potential of producing animals with better performance in their progeny if a good process of genetic selection and directed mating is carried out. Other authors in commercial Brahman found similar values (0.37) of h^2d (14) and higher (0.45 and 0.63) in Brangus and "Blanco Orejinegro" cattle (7,25).

The results obtained in the present study are important since an average heritability both direct and maternal, provides the opportunity to make selection and improvement of the productive characteristics in both the calves and mothers and thus increase the productive and reproductive efficiency of the herd. The Brahman breed has great potential for its adaptation to the tropics, but beef cattle farms do not perform genetic evaluation of bulls and cows and therefore have no criteria for the selection of future breeders. The production systems that have been selecting animals with great genetic potential for meat production tend to have a higher productivity of kilograms / hectare.

The genetic (Υg) and phenotypic (Υp) correlations for BTW and WW270 were low, possibly because there were no selection criteria in the evaluated population. In addition, the characteristic weight at birth tends to be less influenced by the agroecological, nutritional and environmental management and weaning weight has a greater influence of the maternal and nutritional environment. This makes that both characteristics do not correlate. However, in Colombia other authors report genetic correlation values of 0.64, 0.51 and -0.2 (19, 21, 14) in Brahman and in Brazil values of 0.36 and 0.27 (15.24) in Nellore cattle. The difference between the reported values and those found in literature is due to the selection of better animals for both characteristics in specialized herds. The phenotypic correlations found are similar in Creole breeds and those reported in other studies carried out in commercial Brahman, with values of 0.13, 0.14 and 0.16, respectively (14,18,23).

The genetic progress per year for BWT and WW270 was -2.02 kg and 7.81 kg, respectively. Figure 1 shows the genetic gain of WW270 during the years 2002 to 2014. This figure shows an increase in genetic progress between 2010 and 2014, mainly due to the inclusion of artificial insemination programs at fixed time, which forces the farmer to use tested bulls that have great genetic potential for weight characteristics.

In conclusion, estimates of heritability indicate the existence of direct additive genetic variability, showing the opportunity for genetic gain through selection. However, the characteristics of BTW and WW270 also have a great influence on the environment, which is why special attention should be paid to the management and nutrition of females during pregnancy and of calves from birth to weaning.

Artificial insemination is an effective strategy to introduce genetically superior genes into livestock herds, thus contributing to the genetic gain in future generations.

It is important to use the results of the genetic evaluation and the valuation of the animals as a strategy for future mattings that allow a genetic improvement of the weight characteristics in the commercial Brahaman population.

The implementation of genetic improvement programs and genetic evaluations in commercial farms can make more efficient the selection of animals with great genetic potential, which should be included in targeted mating programs. Consequently, improving the productive parameters from generation to generation and making beef cattle in Colombia more profitable.

Conflict of interest

The Authors expressly declare to the journal MVZ of the University of Córdoba Colombia, that the submitted manuscript has not been previously published, and that we have no conflict of interests of any kind.

Acknowledgements

We thank the farm "La Envidia" for the records and the research group in agronomy and Zootechnics-GIAZ of the Catholic University of Oriente, for the support during the investigation.

REFERENCES

1. Organización de las Naciones Unidas para la Alimentación y la Agricultura-FAO. Perspectivas alimentarias (Resumen de mercado). FAO [en línea] 2018 [fecha de acceso 26 de octubre de 2018]; 12. URL disponible en: http://www.fao.org/giews/reports/food-outlook/es/
2. DANE. La estructura de la producción de carne bovina en Colombia. Sipsa [en línea]. 2012 [fecha de acceso 26 de octubre de 2018]; 4:75. URL disponible en: https://www.dane.gov.co/files/investigaciones/agropecuario/sipsa/insumos_factores_de_produccion_octubre_2012.pdf
3. Montes D, Vergara O, Prieto E, Barragán W. Estimación de la repetibilidad y factores que afectan el peso al nacer y al destete en ganado bovino cebú brahmán. Rev Colombiana Cienc Anim. 2009; 1(1):19-36. https://doi.org/10.24188/recia.v1.n1.2009.405
4. Martínez R y Pérez E. Parámetros y tendencias genéticas para características de crecimiento en el ganado criollo colombiano Romosinuano. Corpoica Cienc Tecnol Agropecu. 2006; 7(1):25-32. https://doi.org/10.21930/rcta.vol7_num1_art:56
5. Osorio M, Segura C. Factores que afectan el peso al nacer y al destete de becerros de doble propósito en el trópico. Livest Res Rural Dev. 2008; 20(1):Article15. URL Disponible en: http://www.lrrd.org/lrrd20/1/osor20015.htm
6. Quintero J, Triana J, Quijano J, Arboleda E. Influencia de la inclusión del efecto materno en la estimación de parámetros genéticos del peso al destete en un hato de ganado de carne. Rev Col Cienc Pec. 2007; 20(2):117-123. https://aprendeenlinea.udea.edu.co/revistas/index.php/rccp/article/view/324128
7. Cañas J, Ramírez J, Arboleda O, Ochoa J, Vergara O, Cerón M. Estimación de parámetros genéticos para peso al destete en ganado Blanco Orejinegro (BON) en el noroccidente colombiano. Rev MVZ Córdoba. 2008; 13(1):1138-1145. https://doi.org/10.21897/rmvz.405
8. Castro D. Ensayo sobre tipología de suelos colombianos-Énfasis en génesis y aspectos ambientales. Rev Acad Colomb Cienc. 2003; 27(104):319-341. http://www.accefyn.com/revista/Vol_27/104/319-341.pdf
9. Kinghorn BP. An algorithm for efficient constrained mate selection. Genet Sel Evol. 2011; 43(1):4. DOI: https://doi.org/10.1186/1297-9686-43-4
10. R Development Core Team. R: a language and environment for statistical computing. [En linea] Version 3.5.1. Vienna: R Foundation for Statistical Computing. 2018. [fecha de acceso 26 de octubre de 2018]; URL disponible en: http://www.Rproject.org/

11. Falconer D, Mackay T. Introduction to Quantitative Genetics. Harlow, UK: Longman Group Ltd; 1996.

12. Boldman K, Kriese L, Van Vleck L, Van Tessell C, Kachman S. A manual for use of MTDFREML. A set of programs to obtain estimates of variances and covariances (Draft). USA; USDA-Agric Res Serv: 1995.

13. Daniel Gianola KH. Advances in Statistical Methods for Genetic Improvement of Livestock. vol 18. Lexington, KY: Springer; 1990.

14. Montes V, Vergara G, Prieto M, & Rodríguez P. Estimación de los parámetros genéticos para el peso al nacer y al destete en ganado bovino de la raza Brahman. Rev MVZ Córdoba. 2008; 13(1):1184-1191. https://doi.org/10.21897/rmvz.409

15. Chud T, Caetano S, Buzanskas M, Grossi D, Guidolin, D, Nascimento G, Munari D. Genetic analysis for gestation length, birth weight, weaning weight, and accumulated productivity in Nellore beef cattle. Livest Sci. 2014; 170:16-21. https://doi.org/10.1016/j.livsci.2014.09.024

16. Parra G, Martínez J, Cienfuegos E, García F, Ortega E. Parámetros genéticos de variables de crecimiento de ganado Brahman de registro en México. Veterinaria México. 2007; 38(2):217-229. https://doi.org/10.4067/s0301-732x2009000200004

17. Salamanca C, Quintero V, Benitez M. Características de crecimiento predestete en becerros del sistema doble propósito en el municipio de Arauca. Zoot Trop. 2011; 29(4):455-465. Disponible en http://www.scielo.org.ve/scielo.php?script=sci_arttext&pid=S0798-72692011000400007&lng=es&nrm=iso.

18. García E, Mitat A, Saraz A, Simanca C, Garay D. Componentes de covarianza y parámetros genéticos para características de crecimiento en una población de ganado Costeño con Cuernos en Colombia. Livest Res Rural Dev. 2015; 27(1):Article6. URL Disponible en: http://www.lrrd.org/lrrd27/1/pere27006.html

19. Plasse D, Verde O, Fossi H, Romero R, Hoogesteijn R, Bastidas P, Bastardo J. (Co) variance components, genetic parameters and annual trends for calf weights in a pedigree Brahman herd under selection for three decades. J Anim Breed Genet. 2002; 119(3):141-153. https://doi.org/10.1046/j.1439-0388.2002.00321.x

20. Ossa G, Pérez J, Suárez M. Valores genéticos de caracteres productivos y reproductivos en bovinos Romosinuano. Corpoica Cienc Tecnol Agropecu. 2008; 9(1):93-101. https://doi.org/10.21930/rcta.vol14_num2_art:503

21. Jiménez A, Manrique C, Martínez C. Parámetros y valores genéticos para características de composición corporal, área de ojo de lomo y grasa dorsal medidos mediante ultrasonido en la raza Brahman. Rev Med Vet Zoot 2010; 57(3):159-167. https://revistas.unal.edu.co/index.php/remevez/article/view/18236

22. Ossa G, Suárez M, Pérez E. Efecto del medio y la herencia sobre el peso al nacimiento, destete y a los 16 meses de edad en terneros de la raza Romosinuano. Corpoica Cienc Tecnol Agropecu. 2007; 8(2):81-92. https://doi.org/10.21930/rcta.vol8_num2_art:98

23. Boligon A, Albuquerque G, Mercadante E, Lôbo B. Herdabilidades e correlações entre pesos do nascimento à idade adulta emrebanhos da raça Nelore. R Bras Zootec. 2009; 38(12):2320-2326. https://doi.org/10.1590/s1516-35982009001200005

24. Vergara O, Martínez N, Almanza R, Patiño R, Calderón A. Parámetros y tendencias genéticas para característica de crecimiento predestete en una población bovina multirracial en Colombia. Rev Facult Cienc Vet, UCV. 2014; 55(2):68-77. Disponible en http://www.scielo.org.ve/scielo.php?script=sci_arttext&pid=S0258-65762014000200002&lng=es&nrm=iso.

Additional information

How to Cite: Bedoya Ospina, C., Alzate Ramirez, J., Ángel Cardona, J., Escobar R, C., & Calvo Cardona, S. (2019). Genetic evaluation for weight traits in commercial Brahman cattle. Journal MVZ Cordoba, 24(2), 7225-7230. https://doi.org/10.21897/rmvz.1662