

Genetic parameters for growth traits in Mexican Nellore cattle

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Abstract The aim of this study was to estimate genetic parameters for growth traits in Mexican Nellore cattle. A univariate animal model was used to estimate (co)variance components and genetic parameters. The traits evaluated were birth weight (BW), weaning weight (WW), and yearling weight (YW). Models used included the fixed effects of contemporary groups (herd, sex, year, and season of birth) and age of dam (linear and quadratic) as a covariate. They also included the animal, dam, and residual as random effects. Phenotypic means (SD) for BW, WW, and YW were 31.4 (1.6), 175 (32), and 333 (70) kg, respectively. Direct heritability, maternal heritability, and the genetic correlation between additive direct and maternal effects were 0.59, 0.17, and -0.90 for BW; 0.29, 0.17, and -0.90 for WW;

and 0.24, 0.15, and -0.86 for YW, respectively. The results showed moderate direct and maternal heritabilities for the studied traits. The genetic correlations between direct and maternal effects were negative and high for all the traits indicating important tradeoffs between direct and maternal effects. There are significant possibilities for genetic progress for the growth traits studied if they are included in a breeding program considering these associations.

Keywords Genetic parameters · Growth traits · Beef cattle · Mexican tropics

Introduction

Beef and milk production are important economic activities in the tropical regions of Mexico (Tewolde 1993; Magaña et al. 2006; Rojo-Rubio et al. 2009). Around 28% of Mexican land is in the tropics, where weather conditions make livestock production difficult, particularly for *Bos taurus* breeds (Murillo et al. 2009). The Mexican livestock industry has gone through many changes across decades, including the introduction of different dairy breeds, which has allowed the presence of a diversity of genotypes for the dual purpose systems in the tropics. Nonetheless, meat and milk production in Mexico has not satisfied Mexican demand, so its market depends on imports (Magaña et al. 2006). The dual purpose systems are characterized by using the crosses from *B. taurus* x

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Bos indicus breeds and use of forages as main feed and single source for maintenance and milk production (Rojo-Rubio et al. 2009). In this system, calves remain with cows, during a variable period (7 to 10 months); milking is mainly manual and usually in the presence of the calf, to facilitate the milk let-down. Conversely, Cebu breeds (*B. indicus*) adapt better to the warm and humid tropical weather and hence are predominantly present in these environments producing in beef as well as in dual purpose production systems (Martins et al. 2000; De Souza et al. 2003; Rojo-Rubio et al. 2009). Ongole breed, known in the Western hemisphere as Nellore, was brought to Mexico from Brazil in 1923. This breed adapts well to several environments and weather conditions (Atencio 2000; Fonseca 2000), particularly to the adverse conditions of the tropical areas (AMCC 1997). Almost 60% of Brazilian beef cattle are Nellore, and there are an important number of studies regarding the genetic parameters of growth traits using data from this tropical Latin American country (Eler et al. 1995; De Souza et al. 2003; Ortiz et al. 2004). Nevertheless, since most of the Mexican farms lack production records, there are no genetic parameters estimates for growth traits in Mexican Nellore. In 1994, a program for monitoring production of Mexican Nellore started (AMCC 1996). The objective of this study was to estimate the additive direct and maternal genetic parameters for several growth traits measured from birth to 365 days of age.

Materials and methods

Data

Data records were provided by the Mexican Cebu Breeder Association (AMCC 1996). There were 9,772 records from Nellore animals born from 1993 to 2003 and performing in production systems that varied from grazing to feed lot, with reproduction occurring along the year and based mainly on controlled natural insemination with some artificial insemination cases (Martínez 1999). Data included records from six Mexican States (regions) from the dry and the humid tropical areas of this country. With the exception of Chiapas, these States (Tamaulipas, Veracruz, Tabasco, Campeche, and Yucatán) face the Gulf of Mexico.

Studied traits were birth weight (BW), adjusted weaning weight (WW; 205 days), and adjusted yearling weight (YW). Non-genetic correction factors recommended by the Beef Improvement Federation (BIF 2002) were used to adjust data. Incomplete records and those with missing or wrong animal or parent identification code were discarded. Body weight measures beyond three standard deviations from the respective mean were set to missing. The additive relationship matrix included 62,014 animals. Table 1 shows the number of herds and records included in the analysis for BW, WW, and YW.

Statistical analysis

An animal model was used in the analysis of every trait. The model included the fixed effects of herd, sex, and a contemporary group effect (year and season of birth). Seasons of birth were grouped as dry (January–June) and rainy (July–December). Age of the cow was included in the model as a covariate (linear and quadratic). Before the genetic analysis was performed, the genetic relationships between sires and contemporary groups were evaluated utilizing the MILC program (Fries 1998), from which the basis of related animals for each variable was derived. Contemporary groups with four or less records were discarded.

In matrix notation, the animal model used was:

$$\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{Z}\mathbf{a} + \mathbf{W}\mathbf{m} + \mathbf{e}$$

where \mathbf{Y} is the vector of observations (BW, WW, or YW); $\boldsymbol{\beta}$ is the unknown vector of fixed effects; \mathbf{a} is the unknown vector of additive direct genetic effects; \mathbf{m} is the unknown vector of additive maternal genetic effects; and \mathbf{e} is the vector of random residual effects. \mathbf{X} , \mathbf{Z} , and \mathbf{W} are incidence matrices that relate the fixed, animal genetic, and maternal genetic effects

Table 1 Number of herds and records analyzed for birth, weaning, and yearling weights in Mexican Nellore cattle

Trait					
BW		WW		YW	
Herds	Records	Herds	Records	Herds	Records
45	6,553	42	4,584	43	4,851

BW birth weight, WW weaning weight, YW yearling weight

with the observations, respectively. The model included the direct and maternal genetic effects as correlated. Expectations and covariance matrices of random vectors are described in the following equations:

$$E[y] = X\beta; E[a] = E[m] = E[e] = 0$$

$$\text{Var} \begin{bmatrix} a \\ m \\ e \end{bmatrix} = \begin{bmatrix} A\sigma_a^2 & A\sigma_{am} & 0 \\ A\sigma_{am} & A\sigma_m^2 & 0 \\ 0 & 0 & I_N\sigma_e^2 \end{bmatrix}$$

where N stands for the number of records, A is the numerator relationship matrix, and I is an identity matrix of proper order for each trait. Genetic and residual (co)variances were estimated by using the multiple-trait derivative-free REML algorithm implemented by Boldman et al. (1995) in MTDFREML software.

Results

Phenotypic means (SD) were 31.4 (1.6), 175 (32), and 333 (70) kg for BW, WW, and YW, respectively (Table 2).

Genetic analysis

(Co)variance components and genetic parameters are shown in Tables 3 and 4, respectively. The additive direct heritability for BW was rather high (0.59 ± 0.08) while maternal heritability was moderate (0.17 ± 0.08). The genetic correlation between direct and maternal effects was high and negative (-0.90). For WW, direct heritability (0.29 ± 0.07) and maternal heritability (0.17 ± 0.10) were both moderate, and the genetic

Table 2 Number of sires, sibs by sire, and sibs by cow used in the analysis and phenotypic mean and standard deviation for birth, weaning, and yearling weights in Mexican Nellore cattle

Trait	Sires	Sibs/sire	Sibs/cow	Mean \pm SD (kg)
BW	410	15.9	1.7	31.4 \pm 1.6
WW	398	16.7	1.7	175 \pm 32
YW	402	16.5	1.7	333 \pm 70

BW birth weight, WW weaning weight, YW yearling weight, SD standard deviation

Table 3 (Co)variance components for birth, weaning, and yearling weights in Mexican Nellore cattle

Trait	V_g	V_m	Cov_{gm}	V_e	V_p
BW	0.91	0.26	-0.44	0.79	1.52
WW	156.33	103.48	-114.89	385.84	530.78
YW	264.86	168.43	-181.93	839.91	1,091.27

BW birth weight, WW weaning weight, YW yearling weight, V_g additive direct genetic variance, V_m additive maternal genetic variance, Cov_{gm} covariance between additive direct and additive maternal genetic effects, V_e environmental variance, V_p phenotypic variance

correlation between direct and maternal effects was also high and negative (-0.90). Finally, for YW, direct heritability (0.24 ± 0.06) and maternal heritability (0.15 ± 0.09) were moderate also, and the genetic correlation between direct and maternal effects were high and negative as well (-0.86).

Discussion

Phenotypic values

The mean for BW in Mexican Nellore (31.4 kg) was similar to that published for Brazilian data (32.8 ± 3.4 kg; Martins et al. 2000) where breeding programs started more than 20 years ago (Holanda et al. 2004). In any case, Mexican Nellore population is directly descendent from Brazilian animals. The observed mean of WW (175 kg) was higher than that estimated by De Souza et al. (2003) in Brazil (153 kg), in production units where animals are raised mainly in grazing systems. Nevertheless, our WW mean was around 20 kg lower than the WW mean reported by Cabrera et al. (2001) and Garnero et al. (2001). The

Table 4 Genetic parameters for birth, weaning, and yearling weights in Mexican Nellore cattle

Variable	h_g^2	h_m^2	r_{gm}
BW	0.59 ± 0.08	0.17 ± 0.08	-0.90
WW	0.29 ± 0.07	0.17 ± 0.10	-0.90
YW	0.24 ± 0.06	0.15 ± 0.09	-0.86

BW birth weight, WW weaning weight, YW yearling weight, h_g^2 direct heritability, h_m^2 maternal heritability

YW mean (333 kg) was similar to that observed by Martínez (1999) for Mexican Nellore animals used in cattle shows across the country (320 kg). On the other hand, our YW mean was higher than that estimated by other authors in Brazilian populations (Eler et al. 1995; Cabrera et al. 2001), who observed YWs from 77 to 120 kg lower than our YW mean. This variation could be partially due to the fact that in Mexico, most of these Nellore producers provide grain supplementation after weaning. They do so, because a large number of these animals are intended to be sold to the Mexican government as breeding animals to be distributed for free or at very low prices in the national programs addressed to lower class producers across the tropical areas of Mexico (Núñez and Ramírez 1997).

Genetic parameters

Heritability for BW (0.59) was equal to that observed by Martins et al. (2000) in Brazilian Nellore. Nevertheless, it differed from values estimated by other authors (0.21 to 0.33) using Brazilian data (Eler et al. 1995; Nobre et al. 2003; Holanda et al. 2004). Likewise, Parra-Bracamonte et al. (2007) estimated additive direct and maternal heritabilities for BW in Brahman cattle in México as 0.21 and 0.005, respectively. In *B. taurus* breeds, Johnson et al. (1992) estimated additive direct heritability for BW as 0.42 and 0.58 for Angus and Hereford cattle, respectively.

Some studies in Mexico suggest that there has probably been some breeders selecting for lighter BW to reduce dystocia in beef cows (e.g., Martínez 1999), as it was also referred by Benett and Gregory (2001) from the US Meat Animal Research Center. The maternal heritability for BW in our study was moderate, in agreement with findings of Eler et al. (1995), who estimated it as 0.12, and lower than those estimates found by Nobre et al. (2003) who estimated it varying between 0.21 and 0.33 using Brazilian records and a multiple-trait model. In the case of *B. taurus* breeds, Johnson et al. (1992) estimated the maternal heritability for BW as 0.22, both in Angus and Hereford cattle.

The genetic correlation between additive direct and maternal effects for BW was -0.90 , which is higher than what has been observed in other studies averaging -0.53 (Eler et al. 1995; Parra-Bracamonte

et al. 2007; De Souza et al. 2008). Our results show that if BW is to be included in breeding programs, it is necessary to consider the additive genetic direct as well as the maternal genetic effects in the construction of selection indices, as it has been also suggested by other authors (Eler et al. 1995; Silveira et al. 2004).

Additive direct heritability for WW was moderate (0.29), in agreement with other authors' studies (Cabrera et al. 2001; Gunski et al. 2001; De Souza et al. 2003) who estimated it averaging 0.25 in Brazil and Paraguay. Nevertheless, our estimate differed from that reported by Silveira et al. (2004) who estimated a smaller value (0.17). Remarkably, in *B. taurus* animals, Johnson et al. (1992) estimated additive direct heritability for WW in Angus and Hereford breeds as high as 0.63 and 0.66, respectively.

Regarding maternal heritability for WW, our estimate (0.17) was similar to that observed by several authors (0.14 to 0.23; Eler et al. 1995; Cabrera et al. 2001; Silveira et al. 2004; Parra-Bracamonte et al. 2007), excepting Ribeiro et al. (2001) who estimated it as 0.36 and commented that WW seems to be the trait more maternally genetic influenced in beef cattle. Our maternal heritability observed for WW was similar to that we estimated for BW, and it is also similar to the one observed in Angus cattle (0.16) by Johnson et al. (1992). Nevertheless, the former author reported larger maternal genetic effects for WW with this heritability estimated as 0.43 in Hereford cattle.

The moderate maternal heritability estimated for WW is consistent with knowledge suggesting that maternal environment (mainly milk production) has important genetic components affecting growth in beef cattle. Similar to BW, the genetic correlation between direct and maternal effects for WW was high and negative. This negative association is consistent with findings of Gunski et al. (2001) who estimated it as -0.23 . Nevertheless, our estimate is higher than other authors' estimates (Cabrera et al. 2001; Gunski et al. 2001; Garnero et al. 2001). Our results indicate that if WW is included in Mexican Nellore breeding programs, its additive direct heritability, maternal heritability, and genetic correlation between direct and maternal effects should be considered for the appropriate construction of selection indices.

Direct heritability for YW was moderate (0.24) and clearly smaller than that observed by Martínez (1999) using also Mexican Nellore data (0.65). Our value

was slightly smaller than that observed by Cabrera et al. (2001) and Gunski et al. (2001) using Brazilian Nellore data who estimated it as 0.30 and 0.33, respectively, although it was larger than the value observed by Eler et al. (1995), who estimated it as 0.16 using also data from Brazil.

As expected, maternal heritability for YW (0.15) was lower than that estimated for BW and WW, but its magnitude it is still important, and in agreement with other authors' results (Cabrera et al. 2001; Gunski et al. 2001; Eler et al. 1995) which estimated it as 0.10. Eler et al. (1995) mentioned that in some production conditions, the time between weaning and yearling is not enough to clear up the maternal effects on growth, indicating that maternal genetic effects should also be considered when selection programs include YW.

Contrary to Eler et al. (1995) who estimated the genetic correlation between direct and maternal effects of YW as very small and positive (0.09), our estimate was high and negative (−0.86) indicating an important tradeoff between direct and maternal effects. Using Brazilian Nellore data, Cabrera et al. (2001) and Gunski et al. (2001) estimated this correlation as −0.43 and −0.38, respectively. These authors also suggested that maternal genetic effects on YW are of enough magnitude to be considered when selecting animals for YW.

Direct and maternal heritabilities observed for BW, WW, and YW allow their inclusion in Mexican Nellore breeding programs. Although with variable magnitudes, the observed negative genetic correlations between additive direct and maternal effects for body weight from birth to yearling are consistent with the findings of Nobre et al. (2003) with Brazilian data and random regression models. These correlations evidence an important tradeoff between these effects for these growth traits. Hence, it would be necessary to consider both effects and their genetic associations in the construction of selection indices for the Mexican Nellore population.

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