Covariance components and genetic parameters in reproductive traits of Santa Gertrudis heifers

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Variance components and genetic parameters of the reproductive traits age at incorporation (AI), age at first service (AFS), age at first calving (AFC) weight at incorporation (WI) and weight for age (WFA) were estimated in 5896 Santa Gertrudis heifers born between 1975 and 2006 in the Cuban cattle breeding enterprises "Rancho Vallina", Turiguanó" and "Camilo Cienfuegos". An animal multi-trait model was used in which as fixed effect was considered the contemporary group, including the combination enterprise-year-birth season and as random the animal and the residual effect. The pedigree file comprised 11 966 animals, from 176 bulls and 3 448 dams. The highest heritability estimates were obtained for AI (0.16) and for WI (0.15). However, the lowest value was for AFC (0.07). The genetic correlations were significant with the highest estimate for AFS and AFC (0.99); while the AI and WFA (-0.86) showed a strong and negative correlation. The environment greatly influenced on all traits. The genetic correlations between traits demonstrated the improvement possibility through WFA which could be an important selection criterion for Santa Gertrudis heifers.

Key words: *heritability, genetic correlations, AI incorporation, Santa Gertrudis*

The improvement of beef producing bovine cattle is mainly focused on growth traits, because of being of high heritability (h^2). However, the reproductive regularity influences decisively on the production (Gutiérrez *et al.* 2002), since the reproductive traits are very important in beef producing bovine cattle (Bormann *et al.* 2006).

Traits traditionally used for the genetic evaluation of the fertility have low heritability. This could be due to the great influence of the management regarding the traits used in the majority of the improvement programs (Petersson *et al.* 2009). Even so, some criteria were proposed for the selection of beef cattle, as age at first calving and calving interval (Eler *et al.* 2002).

The reproductive traits of dairy cattle have been widely studied, but papers on beef cattle are scarce (van Raden *et al.* 2004). There are few studies realizing determinations of genetic parameters of reproductive traits in synthetic breeds living under tropical conditions. Regarding Santa Gertrudis cattle there are not many reports of this type of investigation and in Cuba there are no evidences at any time (Guerra *et al.* 2009).

The objective of this research was to estimate the covariance components and the genetic parameters of the reproductive traits of Santa Gertrudis heifers.

Materials and Methods

The records of 5 896 Santa Gertrudis heifers until fist calving, born between 1975 and 2006, in the cattle breeding enterprise "Rancho Vallina" of Santiago de Cuba and in the cattle breeding enterprises "Turiguanó" and "Camilo Cienfuegos" of Ciego de Ávila and Pinar del Río, respectively, were used. These are the main breed herds in Cuba and correspond to the Eastern, Central and Western regions of the country.

The feeding system was based on natural pastures (*Paspalum notatum*, *Dichantium curicosum*, *Hyparhenia rufa*) and forages (*Pennisetum purpureum* cv. Cuba CT-115, *Leucaena leucocephala* and *Glyricidia sepium*), with mineral salts and water *ad libitum*. These developing females received supplementation at a rate of 400 g d^{-1}. Calves were maintained with their dams until weaning at seven months of age. Later they were transferred to a development center. Animals planned to possible bull dams were gestated by artificial insemination; the rest was destined to mating. Monthly weighing was carried out to the non-incorporated heifers. To those weighing approximately 300 kg, weight and age data were recorded. The heat period was observed for their incorporation to reproduction maintaining them in the center until gestation.

The traits of age at incorporation (AI), age at first service (AFS), age at first calving (AFC), weight at incorporation (WI) and weight for age (WFA) at incorporation were analyzed.

A multi-trait model was used for the estimation of the variance components, where the contemporary group (168 groups) was considered, and including the enterprise-year-birth season (every four months) combination as fixed effect, and as random the animal and residual effects. The contemporary groups comprised five animals, as minimum. The four months period was considered as season, because of showing greater representativeness and distribution of the sample. The pedigree file was formed by up to great-grandparents and comprised 11 966 animals. From them, 179 were bulls and 3448 dams. Data were processed through the

Wombat program (Meyer 2007).

The model was expressed by matricial notation as $y_i = X_i b_i + Z_i a_i + e_i$, where:

y_i = vector of the observations for the i-th trait, from i = 1 to 5,

b_i = vector of the solutions of the fixed effects for the i-th trait.

a_i = vector of the solutions for the additive random effect of i-th trait.

X_i and Z_i = design matrices for the fixed and random effects of the i-th trait.

e_i = vector of the residual effects for the i-th trait.

It was assumed that: $E(y_i) = X_i b_i$, $E(a_i) = 0$; $E(e_i) = 0$ and var

$$\text{var}\begin{bmatrix} a_i \\ e_i \end{bmatrix} = \begin{bmatrix} G \otimes A & 0 \\ 0 & I \otimes R \end{bmatrix}$$

where:

G is the matrix for variances-covariances of the random additive effects of the five traits

R is the matrix for variances-covariances of the residual effects of the five traits

I is an identity matrix

A is the matrix of relationships between individuals in the genealogy.

Results and Discussion

The statistics for the reproductive traits of Santa Gertrudis heifers (table 1) demonstrated that, under the conditions of this study, the breed shows potentialities for beef production, although there are still indicators such as AI and thus, AFC that must be improved.

Average WI was higher than that reported by Mercadante *et al.* (200) for this breed under grazing, and to the results of Espinosa *et al.* (2007), who registered 301 kg in Cuban Zebu, under similar exploitation conditions. Also surpassed the estimates of Forni and Albuquerque (2005) in the Nelore breed under grazing in Brazil (313 kg), as well as those of Ceró (2007) in Chacuba (5/8 Charolaise x 3/8 Zebu) (313 kg) and those reported by González (2009) in Cuban Zebu (299 kg). Furthermore, they were above to the findings of Sánchez (2012) in Santa Gertrudis cattle, under exploitation conditions in the farm "Rancho Vallina".

WFA at incorporation was higher than that reported by González (2009) in Zebu cattle with 445.2 g d^{-1}. This trait resulted of great importance, since on being WI a pre-established indicator, its variability decreases having greater importance the WFA. This is an indicator of the growth and development rate of the animals. Therefore, the animals with higher WFA will reach earlier the WI, and will have greater reproductive performance in the future.

These differences could be mainly due to the genotype of the animals. In the study of Vallina (Sánchez 2012) could obey to the fact that the sample was smaller and also to the edaphoclimatic conditions of the rearing. Results showed that the Santa Gertrudis breed has favorable reproductive traits under Cuban conditions, regarding other beef breeds as the Zebu.

Age at first calving was higher to that reported by Pino *et al.* (2009) in Cuban Zebu, with 37.7 months and to that registered by Mejía *et al.* (2010) in México in Brahman, Nelore, Commercial Zebu and Brown Swiss breeds with values of 35.3 to 36.9 months. Also to that found by Martínez *et al.* (2012) in Blanco Orejinegro cattle, in Colombia, with 36.3 months. However, it was lower than that reported by Sánchez (2012) for this breed, with 47.6 months under the conditions of the cattle breeding farm "Rancho Vallina".

Considering what the coefficient of variation and the standard deviation of the studied traits indicate, it can be stated that these showed sufficient variability as to offer goodness, if work is searching for genetic improvement and if the relationship of the trait with the future reproductive development of the animals is considered. According to what was expressed by Menéndez (1989), the management in this stage is the key factor so the animals could express their potential.

The study of the variance components and the genetic parameters for the reproductive traits (table 2) showed moderate to low heritability. Excepting weight at incorporation, studied by Morales *et al.* (2012) in the Turiguanó herd, these indicators are shown for the first time in Cuba for Santa Gertrudis cattle. On establishing a weight for incorporation, could be considered as a test at fixed weight. This makes the WFA, the trait of greatest significance, since growth rate determines age at incorporation.

Heritability for AFS was higher than that obtained by Martínez *et al.* (2007), Guerra *et al.* (2008) and González (2009) in Cuban Zebu cattle. These authors estimated values of 0.04 ± 0.01, 0.07 ± 0.03 and of 0.05 ± 0.04). In the same way, they were higher to what was reported

Table 1. Descriptive statistics of reproductive traits of Santa Gertrudis heifers

Traits	$\overline{X}$	SD	VC (%)
AI (months)	23.1	6.1	26.9
AFS (months)	26.9	8.5	31.7
AFS (months)	38.1	9.5	24.9
WI (kg)	321	24.4	7.6
WFA (g.animal.day^{-1})	494.9	127.7	25.8

Table 2. Variance and heritability components (± SE) of reproductive traits in Santa Gertrudis heifers

Variance component	Reproductive traits				
	AI	AFS	AFC	WI	WFA
σ^2_a	3.16	3.94	3.22	58.53	144.98
σ^2_e	16.66	32.97	42.84	345.11	912.83
σ^2_p	19.82	36.91	46.05	403.60	1058.00
Heritability					
h^2	0.16 (±0.03)	0.11 (±0.03)	0.07 (±0.02)	0.15 (±0.03)	0.14 (±0.02)

by Forni and Albuquerque (2005) in Nelore cattle in Brazil (0.06 ± 0.05). These results could be due to the fact that a larger number of traits were studied, increasing the possibilities of applying the genetic relationship among them. Thus, the lowest heritability traits can be compensated, although all showed low heritability.

Heritability estimates for AFC in Santa Gertrudis were similar to those found by Forni and Albuquerque (2005) and González (2009), in the breeds Nelore of Brazil and Zebu of Cuba. Lower results than those of this study have been registered by Martínez *et al.* (2007) (0.04 ± 0.01) and Guerra *et al.* (2008) in Cuban Zebu (0.05 ± 0.03) and by Wasike *et al.* (2009) in Boran breed bovines (0.04). They were also below the figures reported by Grossi *et al.* (2009) in Nelore (0.02 ± 0.02 to 0.04 ± 0.02), and by Buzanskas *et al.* (2010) in Canchim (0.04 ± 0.02).

Suárez *et al.* (2006) and Ossa *et al.* (2008) reported in the Romosinuano breed higher values for AFC. Likewise, higher figures were also obtained by Martínez *et al.* (2012) for the Blanco Orejinegro breed. The cited authors developed their studies in Colombia with values of 0.16 ± 0.09; 0.16 ± 0.07 and 0.15 ± 0.03, respectively. A much higher value registered Estrada *et al.* (2008) in Mexican Brahman cattle (0.48 ± 0.10).

This situation could be due to greater adaptation to the environment shown by domestic breeds which brings about lower damage in the different traits. In the last case, it could also obey to the sample size which was very homogeneous for the trait. The low heritability of this trait could have been due to the fact that females are incorporated to reproduction after attaining pre-determined weights. In this way, they went in heat before reaching the weight, and in many instances they had no opportunity of showing their genetic potential for sexual precocity. This situation coincides with what Forni and Alburquerque (2005) stated.

This characteristic is of vital importance in economical terms, since as lower age at first service of the heifer is, greater will be the useful lifespan of the cow and consequently more calves will produce (Suárez *et al.* 2006).

Heritability estimate for WI showed a similar value to that reported by González (2009) in Cuban Zebu, and higher to that found by Ceró *et al.* (2011) in Chacuba cattle (0.12 ± 0.04). The heritability estimate for WFA was lower than that found by González (2009) in Cuban Zebu (0.20 ± 0.05).

Although in the literature low inheritance indices are shown for these traits, the importance of their genetic variability is not minimized. When this is wide, it can be taken into account for the genetic improvement of the herds (Menéndez 1994). This aspect confirms the statements of Buzanskas *et al.* (2010), who suggest that although the reproductive traits show low heritabilities, they should be included as selection criteria. In this way the conception rates are improved since reproduction is an economically important component in beef cattle systems.

Results could be due to the nutritional stress and unfavorable environmental conditions such as drought, extreme temperatures and other to which young females are more vulnerable in the developing stage. This situation is related to what Guerra *et al.* (2008) indicated.

The analysis of the genetic and phenotypic correlations between traits under study (table 3) demonstrated that the highest genetic correlation value was obtained between AFS and AFC (0.99). This confirms that the genetic basis of these traits is closely related. This result was similar to that reported by Espinosa *et al.* (2007), Guerra *et al* (2008) and Pino *et al.* (2009) in Cuban Zebu cattle. These authors obtained 0.98 ± 0.12, 0.99 ± 0.16 and 0.97 ± 0.15.

González (2009) noticed in Cuban Zebu higher genetic correlations (0.99) for WFA and WI. WI and WFA presented high and negative genetic correlation, similar to what was reported by Pino *et al.* (2009) in Zebu. A genetic antagonism between these two traits was demonstrated, to lower WFA lower WI. While the genetic correlation between WFA and WI was high and positive, demonstrating the large relationship in the genetic basis of these traits.

The rearing system could have affected the growth rate of heifers and the relationship weight for age at incorporation, where the highest incorporation age indicated lower growth rate and weight for age. This element is very important since heifer weight is a requirement for their incorporation to reproduction.

Table 3. Genetic correlations (above the diagonal and residual below) between reproductive traits of Santa Gertrudis heifers

Traits	AI	AFS	AFC	WI	WFA
WI	-	0.53 ± 0.11	0.56 ± 0.14	0.19 ± 0.14	-0.86 ± 0.03
AFS	0.30 ± 0.02	-	0.99 ± 0.01	-0.34 ± 0.16	-0.59 ± 0.11
AFC	0.23 ± 0.02	0.81 ± 0.01	-	-0.19 ± 0.19	-0.58 ± 0.13
WI	0.11 ± 0.02	0.01 ± 0.02	-0.01 ± 0.02	-	0.76 ± 0.12
WFA	-0.26 ± 0.01	-0.26 ± 0.02	-0.20 ± 0.02	0.29 ± 0.02	-

Other traits, such as AI and WI, showed low genetic correlations. This aspect denoted the scarce relationship that their genes exhibit. Thus, regardless the existence of pre-determined weight, age at incorporation will not influence on WI. The growth rate (WFA) will be the one determining the rate with which the animals attain the weight. McAndrews *et al.* (1993) and Abeygunawardena and Dematawewa (2004) also considered that age at puberty was not determined by a weight per se, but by an undetermined order of physiological and hormonal conditions inducing the onset of puberty.

It was concluded that WFA in Santa Gertrudis heifers, by its relationships with AI and heritability, although low, could be taken into account as selection criterion. AFC and AFS did not offer possibilities of genetic progress through selection, due to the high influence of management and environment on these traits. The improvement of the management practices for increasing the growth rate, together with the selection, could be the most rapid way of improving these attributes. The genetic correlations between the studied traits offer the possibility of improving simultaneously the WFA and the remaining traits.

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