Evidence of genotype-environment interaction for final live weight in the performance test of the Cuban Zebu

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The response of 203 Cuban Zebu sires was evaluated from the final live weight in the performance test of their offspring, born in the period 1981-2009, in six Cuban cattle breeding enterprises. The breeding value of the sires was compared, depending on the environment where their offspring realized the test (high or low). These two levels were defined from the mean value of the gain in test to the corresponding group of contemporaries. For each one of the two data file an animal model was analyzed including the random effect of the animal, final age of the test, as linear covariable, and the fixed effect of the contemporary group (enterprise-year-birth trimester). In both groups the Spearman and Pearson correlations were determined to the breeding values of the sires. Heritability values from moderate to low were obtained in both cases ($h^2 = 0.22 \pm 0.04$ in the high environmental group and $h^2 = 0.15 \pm 0.03$ in the low). The values of Spearman and Pearson correlations (0.39 and 0.46, respectively) indicate that there is genotype x environmental group interaction between these extreme environments. Thus, the male offspring from sires of high breeding value do not perform in the same way when the environmental or management conditions change. In the national genetic improvement plan of Cuban Zebu, it is recommended to consider the selective use of sires according to the characteristics where their progeny will be developed.

Key words: *Cuban Zebu, genotype-environment interaction, growth, robust, plastic*

The performance test under grazing is the procedure used in Cuba for the genetic improvement program of the Cuban Zebu cattle. The growth capacity of each animal is evaluated during a constant period of 12 months and results are expressed by the relative deviation of growth of each animal regarding its contemporaries. The methodology currently applied to estimate the breeding value and later sire selection is the use of a uni-variate animal model.

This model estimates the breeding value of all the animals in test and allows selecting bulls with higher daily gains or higher live weights at the end of the test. However, the genetic potential of the animals is expressed as the environmental conditions allow. In many instances, the best genotype in an environment does not perform in the same way in a different context.

The genotype-environment interaction is one of the problems in the selection process. Young sire candidates for the next generation must be evaluated and selected under the same conditions where their progeny will be exploited. In many occasions this condition is not fulfilled, though the genetic progress of the desired trait is reduced. Artificial insemination offers the possibility of comparing the performance of the descendants of a same bull under different environmental conditions (countries, geographic regions, management and feeding conditions). Cardoso *et al*. (2010) stated that the multi-trait models are appropriate when there is a limited amount of environmental sub-classes, as in the case of different countries in international evaluations or different geographic areas in evaluations in a same country. In these cases, if the genetic correlation of a same trait, measured under different environments, is significantly different from the unit, it is inferred that there is genotype x environment interaction. The possible explanation (Falconer and Mackay 1996) is that the same trait can be partially controlled by a group of genes in each environment, thus, the genetic merit is specific for each environmental sub-class.

Taking into account that in the selection tests of the best bulls of the Cuban Zebu the possible genotype-environment interaction is not considered, this paper is aimed at evaluating the response of the progeny of Cuban Zebu sires according to the final live weight of the test in different environmental groups (high and low).

Materials and Methods

Final live weight records in performance test of 10 867 males, were used. Animals were descendants of 223 white Cuban Zebu sires born between 1981 and 2009, in the cattle breeding enterprises "Camilo Cienfuegos" (Pinar del Río), "San Juan" (Matanzas), "San Lino" (Cienfuegos), "Abra Güinía (Villa Clara), "Rescate de Sanguilí" (Camagüey) and "Manuel Fajardo" (Granma). Animals with less than 10 descendants and contemporary groups with less than five individuals were discarded. The environmental describer was created from the average gain value in test of each contemporary group. These mean values were standardized to distribution with mean 0 and standard deviation 1, to determine the deviations of each contemporary group regarding the mean gain of the population (491.8 g/d ± 126.76). The standardized value was multiplied by five to work with whole numbers and the environmental groups were created: low o with extreme negative values (gradient from -8 to -3), medium (gradient from -1 to 2) and high (gradient from 3 to 9). Finally, the information was divided in two data sets, since the medium environmental

Table 1. Description of each data sub-set

Environment	n	Mean (kg)	SD	Min (kg)	Max (kg)	No. of contemporary groups	No. of sires	No. of dams
Low	5355	297	37	216	440	231	203	4571
High	5136	368	42	220	456	222	203	4395

Number of observation (n), mean, standard deviation (SD), maximum final live weight values (Max) and minimum (Min), number of contemporary groups, number of dams and sires in each data set (low or high environment)

group was discarded (385 observations) to contrast only the extreme values. Table 1 shows a description of each data sub-set.

The genetic parameters (heritabilities and breeding value) were obtained from the Wombat program (Meyer 2006) through the application of a uni-variate animal model, which dot-matrix equation is the following:

$y = Xb + Za + e$

where:

y = is the vector of the observations (final live weight)

b: is a vector of the fixed effects containing the effect of the contemporary group (herd-year-birth trimester) and final age of the test as linear covariable.

a: vector of the random effects of the animal

e: vector of the random residual effects

X, Z incidence matrices relating the data to the fixed and random effects, respectively

Pearson and Spearman correlations by the procedure Corr of SAS (V9.1.2 of 2007) were determined to the breeding values obtained from the 203 sires common to both environments.

Additionally an animal model was analyzed considering all the information (the three levels together, which is commonly made to evaluate sires of this breed) for comparing the result of the breeding values of the sires when the genotype-environment interaction is rejected.

Results and Discussion

Heritabilities for final live weight in both environmental groups were moderate to low and slightly higher in the high environment (table 2). In this case it was higher than the value found by Espinoza-Villavicencio *et al*. (2008) in this same breed, for this same trait and through a uni-trait model (0.19). However, higher values were found by Menéndez-Buxadera *et al*. (2006) for live weight at different ages in the Cuban Zebu and using a multi-trait model (0.21 – 0.34). In this case, the authors analyzed in performance trait a total of 1 091 males belonging to only one enterprise and considering jointly the White, Red and Sardo.Lower values to those of this paper were reported by Plasse *et al*. (2002) for Brahman cattle of Venezuela (0.13) for live weight at 18 months. However, high heritability values were obtained by Silva *et al*. (2008) in Nellore breed of Brazil, for weight at 550 d (0.35 ± 0.03 to 0.51 ± 0.05) in different southern regions of Brazil. Also, these authors found genotype-environment interaction.

Pearson and Spearman correlations between the breeding values of the sires evaluated in both groups and environments were low. This suggests the presence of genotype-environment presence. This suggests a change in the magnitude of the differences in the genetic merit of the individuals.

Table 2. Heritability estimates (h^2 ± SE, represented in the diagonal), Spearman correlation (above the diagonal) and Pearson correlation (below the diagonal) for final live weight in the Cuban Zebu in two environmental groups

Environmental group	High	Low
High	0.22 ± 0.04	0.39
Low	0.46	0.15 ± 0.03

In figure 1 is corroborated that in high environment sires show greater variability regarding the breeding values, with greater range in the extreme values in both senses (positive and negative). However, there is less variability in low environment.

Figures 2 and 3 present the best and worst 5% of the sires in high and low environmental groups, respectively. The male offspring from sires with greater breeding values in high environment maintain their favorable breeding values in low environment. Only changes drastically the 5319B which is placed in the tenth place in high environment and falls to the place 69 in low environment. Similarly, the 5873A drops from the 8th place in the high environment to the 117 in the low. The rest of the bulls in this percentage (5%) can be classified as robust sires.

Nonetheless, those exhibiting greater breeding values in low environment not always maintain them so favorable in high environment. Besides changing the merit rank, the breeding values decrease to negative values. This could be due to the fact that in extreme low environment average daily gains are extremely low, which can provoke bias in the information or mistakes by the representativeness of the data. In the same way is manifested for the negative breeding values. In both cases, male offspring from sires in a low environmental group do not always show unfavorable results on changing the management environment, though they

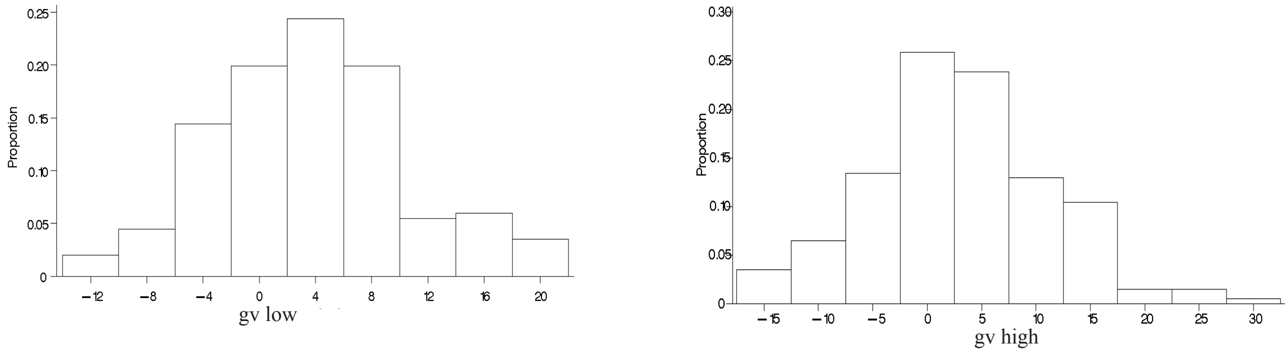

Figure 1 Distribution of the breeding values of the 203 sires in both environmental groups (high and low)

can be classified as plastic sires.

Results of genotype-environment interaction, inferred from the low genetic correlations were obtained by Suárez *et al*. (2009) in the Siboney de Cuba breed (0.49 and 0.08) in the periods before and after the economical crisis in Cuba (before and after 1991), for dairy and reproductive traits, respectively.

Table 3 presents a comparison between the breeding values calculated for the total database (without considering the influence of the environmental group) and those obtained in both environmental groups. This demonstrates that if the effect of the genotype-environment interaction is not considered, animal showing a different performance could be promoted to best sires, depending on the management conditions in which their progeny carry out the performance test. In this way an important source of variation would be rejected and therefore a greater genetic progress for final live weight will be hindered.

The selection of the environment where the progeny will live is important, since depending on the available environmental conditions, the type of sire that will be used is selected. The maximum genetic progress is manifested when the environment with greater conditions is chosen

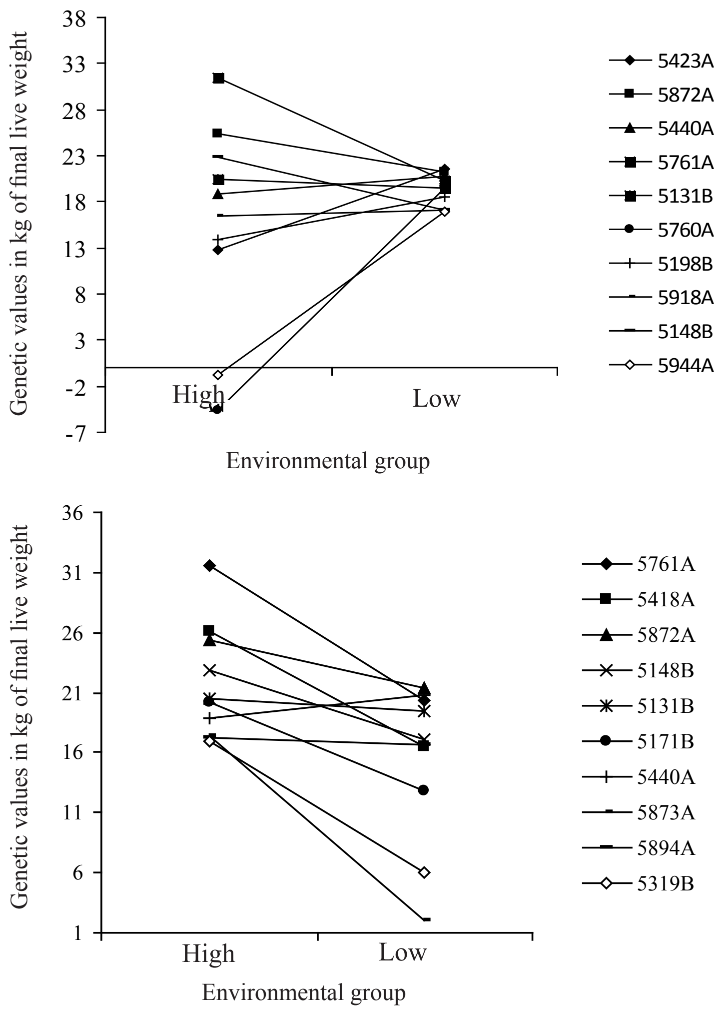

Figure 2. Breeding values of the best 5% of the sires in low environment (above) and high environment (below), in both cases are shown comparatively the breeding value of these same sires in the opposite environmental group

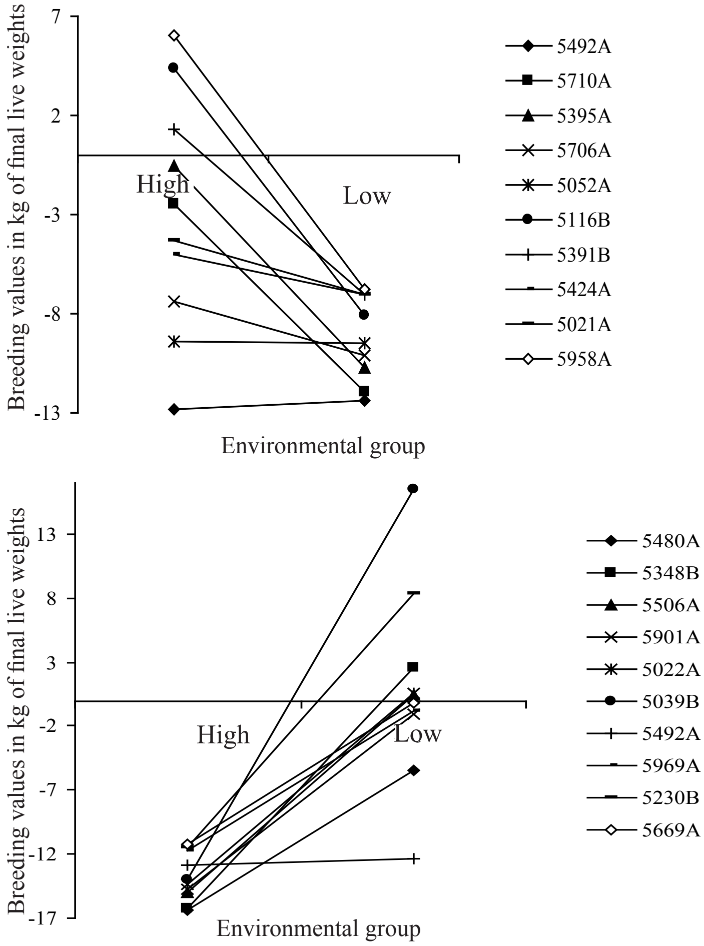

Figure 3. Breeding values of the worst 5% of the sires in low environment (above) and in high environment (below), in both cases are shown comparatively the breeding value of these same sires in the opposite environmental group

Table 3. Comparison between the breeding values (BV) of the best 10% when an animal model is considered with all the information and taking into account the high and low environmental groups. In parenthesis is shown the merit rank of the sires

Sire	Total BV	BV low environment	BV high environment
5240B	30.4 (1)	14.8 (38)	10.7 (18)
5171B	26.6 (2)	12.7 (6)	20.1 (20)
5678A	21.9 (3)	6.2 (129)	0.3 (67)
5360A	21.9 (4)	11.1 (12)	16.7 (25)
5319B	20.9 (5)	6.0 (10)	16.9 (69)
5198B	19.6 (6)	18.5 (18)	13.9 (7)
5124B	19.4 (7)	7.6 (9)	16.8 (47)
5872A	18.2 (8)	21.3 (3)	25.3 (2)
5127B	17.8 (9)	6.7 (174)	-5.8 (63)
5961A	16.7 (10)	6.5 (110)	2.1 (17)
5998A	16.5 (11)	15.5 (24)	13.2 (13)
5068B	16.3 (12)	16.5 (62)	6.0 (99)
5991A	15.8 (13)	3.1 (148)	-1.9 (39)
5065B	15.8 (14)	9.5 (21)	13.6 (37)
5913A	15.3 (15)	9.5 (31)	11.7 (65)
5077B	15.1 (16)	6.6 (29)	12.3 (30)
5123B	14.9 (17)	10.9 (86)	9.9 (27)
5056B	14.8 (18)	10.2 (43)	3.7 (84)
5321B	14.8 (19)	4.6 (164)	-4.2 (11)
5894A	14.7 (20)	16.7 (9)	17.3 (62)

for the expression of the trait, since heritabilities are higher and the interval between generations is reduced. In beef cattle it must be considered that on choosing for growth in a high feeding plane, animal reaching higher live weights will be those with greater appetite, on that account greater sizes will be attained, a question that could be undesirable for our tropical conditions. The best animals in a low plane will be the most efficient, since they possess the lowest maintenance requirements (Frisch and Vercoe 1969).

In this study, on considering the same trait, measured as different trait in different environments, the correlated response to selection must be taken into account. This depends on the selection intensity, the heritability trait in the two environments, the genetic correlation and the additive genetic deviation of the trait. In the specific case of Cuba, the selection intensity is only one, at national level for this breed. As heritabilities obtained in both environments are similar, it can not be expected that indirect selection would be superior to the direct, since the genetic correlation between both traits was low.

It is concluded that it is possible to realize a selection process for final live weight in the present population of Cuban Zebu, where the high heritability values in both environmental groups are considered. In the present plan of genetic improvement can not be disregarded the existence of changes in the sire rank, according to the management group where their progeny realize the performance test.

These results allow recommending the selective use of sires according to the conditions in which its progeny is going to live. The most appropriate sires are those capable of showing an adequate performance in both management groups. Otherwise, if all nutritional and management resources (high environment) are guaranteed, it could be more adequate the use of animals with the highest breeding values for this type of environment. This allows increasing the genetic progress for live weight in this breed. It is evidenced the importance of improving the feeding basis in the units where the performance test is conducted, which makes feasible that the progeny of sires with phenotypic plasticity could express their true genetic potential.

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