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GENETIC AND PHENOTYPIC PARAMETERS OF BIRTH WEIGHT AND WEANING WEIGHT IN CANCHIM CATTLE

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ABSTRACT

The Canchim breed was formed by crossing Charolais females with 1/4 Charolais x 3/4 Zebu females on a farm belonging to the State Unit of Livestock Research of EMBRAPA, in São Carlos, State of São Paulo, Brazil. Data for 840 animals (418 females and 422 males) born between 1958 and 1973 and sired by 18 bulls were used for statistical analysis. Overall mean birth weight (BW) was 35.7 ± 0.2 kg, and the coefficient of variation was 17.2%. Mean weaning weight (WW) was 228 ± 2 kg for males, and 205 ± 2 kg for females, with an overall mean of 217 ± 1 kg. Average daily gain (ADG) from birth to weaning was 0.763 kg. Statistical analysis was by method of least squares analysis of variance. Significant effects of sex, birth order, calving season and year were detected. Heritability estimates, calculated from paternal half-sib correlations, were: 0.31 ± 0.13 for BW, 0.29 ± 0.13 for WW, and 0.26 ± 0.12 for ADG. Estimates of genetic and phenotypic correlation between BW and WW were 0.49 and 0.30; between BW and ADG, 0.31 and 0.11; and between WW and ADG, 0.98 and 0.98, respectively.

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INTRODUCTION

The study of birth and weaning weight in tropical breeds is needed in order to learn the genetic potential of calves, and it is also an indicator of the animal's growth during the nursing period. The influence of genetic and nongenetic factors on these economic traits in the major breeds from temperate climates is well documented. However, little has been published on synthesized *Bos taurus* x *Bos indicus* breeds in the Tropics. Objectives of the present study were to examine the effects of several genetic and nongenetic factors on birth weight, weaning weight and average daily gain from birth to weaning, as well as to obtain heritability estimates and genetic correlations.

MATERIALS AND METHODS

Climate and soil

The Canchim farm, belonging to the State Unit of Livestock Research of EMBRAPA, is located near the center of the State of São Paulo, 22°1' latitude South and 47°53' longitude West of Greenwich. Mean altitude is 826 m, with a quasi-temperate climate. Mean yearly precipitation is 1504.5 mm, distributed over two distinct seasons: October to March (1216 mm) and April to September (288.5 mm). Mean temperature is 20.3°C. The climatic data are shown in Table I. The soil consists of 50% red-yellow "latossolo", 30% red "latossolo" and 20% Bauru sandy soil. Forage consists of 70% "Batatais" grass (*Paspalum notatum*, Flügge) and 30% "pangola" grass (*Digitaria decumbens*, Stent).

Animals and management

The data for 840 animals (418 females and 422 males) born between 1958 and 1973 and sired by 18 bulls were analyzed. The animals were left on free pasture the whole year, and received common salt once a week. During the breeding season, which lasts 2 to 4 months, the bulls remained with the cows (an average of one bull to 20-30 cows). All common hygiene and identification measures were taken when the calves were born. Calves were weaned at 7 to 8 months of age during the rainy season. The herd was submitted to systematic vaccinations against aphtha, pneumoenteritis, symptomatic carbuncle and brucellosis. Ectoparasites such as botts were controlled by spraying at regular intervals and by baths every 15 or 20 days.

Table I - Mean monthly temperature, rainfall and relative humidity.

Month	Temperature (°C)			Total rainfall (mm)	Relative humidity (%)
	min.	max.	mean		
January	17.3	27.9	22.1	261.1	78.0
February	17.4	27.7	22.1	216.8	77.1
March	16.8	27.9	22.0	142.6	73.9
April	15.0	26.6	20.6	71.1	70.1
May	12.7	24.3	18.4	60.8	68.3
June	11.9	23.5	17.4	43.7	66.4
July	11.7	23.6	17.1	29.4	63.2
August	13.0	26.3	19.4	28.5	57.4
September	14.2	27.4	20.5	55.0	58.0
October	14.9	27.3	20.7	153.9	68.2
November	15.6	27.4	21.1	170.2	70.9
December	17.1	27.4	21.8	271.4	75.3
Overall Mean	14.8	26.4	20.3	1504.5	68.9

Source: Brazilian Department of Meteorology, Department of Agriculture.

Statistical analysis

Analysis was by method of least squares analyses of variance; object was to quantify the effects of various nongenetic factors and to estimate the components of variance needed to estimate heritability.

The following mathematical model was used

$$y_{ijklmn} = \mu + a_i + b_j + c_k + d_l + s_m + e_{ijklmn}$$

where:

y_{ijklmn} = an individual measure of birth weight, weaning weight, or average daily gain,
μ = least squares mean,
a_i = effect of the i^{th} sex (i = 1, 2),
b_j = effect of the j^{th} season (j = 1, 2),
c_k = effect of the k^{th} order of parturition (k = 1, 2, . . ., 6),
d_l = effect of the l^{th} year (l = 1, 2, . . . , 15),
s_m = effect of the m^{th} sire (m = 1, 2, . . . , 18), and
e_{ijklmn} = *residual within-animal error variance.*

The usual assumptions about the distribution of the e's were made. The effects of sex, season, order, and year were considered to be fixed. Sire effects were assumed to be random.

The following formula was used to estimate the heritability:

$h^2 = 4\sigma_s^2 \div \sigma_p^2$,

where σ_s^2 = sire component of variance, and σ_p^2 = phenotypic variance. The standard error (S.E.) of this estimate was obtained by the formula of Swiger *et al.* (1964).

RESULTS AND DISCUSSION

Birth weight

Mean birth weight was 35.7 ± 0.2 kg (C.V. = 17.20%), with males weighing 37.5 ± 0.3 kg and females weighing 34.2 ± 0.3 kg (Table II).

Several investigators have studied this trait in crossbred animals (*Bos indicus* x *Bos taurus*). Among them, Vianna *et al.* (1962) analyzed four types of crosses, one of which corresponds to the breed studied in the present investigation. The mean values reported by these authors were lower than those obtained for the 5/8 Zebu-Charolais straightbreds, 5/8 Charolais-Zebu and 5/8 Zebu-Charolais half-breds, and similar to those obtained for the 5/8 Charolais-Zebu straightbreds (Canchim). Miranda *et al.* (1970), in a study of Dutch-Guzerá crossbreds, reported lower values. Other authors, such as Solis and Varela-Alvarez (1973), in a study of Zebu crossbreds, also obtained lower values, whereas means reported by Poujardieu and Vissac (1968) for Charolais crossbreds and by Molinuevo (1971) for the Charolais and Limousine breeds were higher (Table II).

Table II - Means and variability of birth weight (BW), weaning weight (WW) and average daily gain from birth to weaning (ADG) by sex.

Sex	BW (kg)		WW (kg)		ADG (kg/day)	
	Mean ± SE[a]	CV (%)[b]	Mean ± SE	CV (%)	Mean ± SE	CV (%)
Male	37.3 ± 0.3	17.0	228 ± 2	17	0.806 ± 0.008	19
Female	34.2 ± 0.3	16.2	205 ± 2	16	0.721 ± 0.007	18
Overall mean	35.7 ± 0.2	17.2	217 ± 1	17	0.763 ± 0.005	20

[a]SE = standard error; [b]CV = coefficient of variation

The trait also was studied in the Santa Gertrudis breed, with wide variations in the results. Plasse and Koger (1967) and Willis and Wilson (1974) reported lower and higher mean values, respectively, than the means obtained in the present study. Mean birth weight usually is lower for Herefords, except for the results reported by Brinks *et al.* (1964) and by Pahnish *et al.* (1964).

Coefficients of variations reported in the literature were lower than that obtained in the present study: 12.69% (Krishna *et al.*, 1970), 12.77% (Venkateshwarlu *et al.*, 1972), 13.01% (Abreu, 1949), and 15.84% (Mortari, 1976). This might indicate that a considerable phenotypic variability still exists among Canchim animals, which offers better opportunities for improvement than other Zebu breeds, whose genetic constitution already is fixed. The Canchim breed has better birth weights than the Zebu breeds and their crossings.

Table III gives the analysis of variance and Table IV the least squares constants for effects included in the model. Males had a statistically significant 3 kg advantage over females. Similar results were obtained for non-Zebu breeds by Veiga *et al.* (1950), Burris and Blunn (1952), Carmo (1960), Lasley *et al.* (1961), Kumazaki and Matsuo (1968), Fahmy and Lalande (1973), who also reported significant sex effects. The difference in birth weight between sexes was higher than most values reported in the literature, which varied between 0.91 and 3.40 kg (Kohli and Suri, 1957; Molinuevo, 1971). A marked sex dimorphism was detected in the sample studied here, which was probably due mostly to the influence of the Charolais breed. Although the

specific causes for the difference between sexes have not been completely clarified, we believe that one of the basic causes may be the longer gestation period for males (Knapp *et al.*, 1940; Burris and Blunn, 1952) (Table III).

Table III - Least-squares analysis of variance for birth and weaning weight and average daily gain.

Source	d.f.	Mean Squares		
		BW	WW	ADG
Sex	1	1825*	77585*	1.020*
Season	1	173*	978	0.037
Order	5	72*	2441*	0.039*
Year	14	119*	12321*	0.195*
Sire	17	126*	3004*	0.046*
Error	710[a]	31	845	0.014

*$P < 0.05$; [a] Degree of freedom for birth weight was 801.

Birth season significantly influenced birth weight, with a tendency to lighter weights observed for calves born during the dry season (Tables III and IV). A high percentage of births (71.7%) occurred during the dry period, whereas the remainder occurred during the rainy season. Seasonal fluctuations in temperature, precipitation, relative humidity (Table I) and other climatic factors were possibly the most important causes of the influence of season of birth, since these variables determine the abundance or scarcity of forage available, which is directly related to the general physical condition of the dams during gestation, and thus perhaps reflect on birth weights of the calves.

The opposite situation was observed by Vianna *et al.* (1964) in Charolais cattle, however, whereby the calves born during the rainy season weighed less. However, Vianna *et al.* (1962) had detected no significant effects of season of birth on males or females of the Charolais breed and of the Charolais-Zebu cross.

Order of parturition had significant effects on birth weight. Least squares constants in Table IV suggest that biparous cows produced the heaviest animals (1.3 kg), whereas the cows at fourth or fifth parturition produced the lightest animals, with -0.5 and 0.7 kg, respectively. Since this factor is considerably influenced by dam age, the dam's weight is expected to be higher at each successive parturition until the animal reaches physiological maturity, thereby providing better maternal conditions for fetal development, with consequent increased calf weight at birth.

A survey of the literature shows that most investigators working with Zebu breeds obtained nonsignificant effects of dam age or order of parturition on birth weight (Kohli and Suri, 1957, and Singh and Tyagi, 1970, for the Hariana breed; Krishna *et al.*, 1970; for the Ongole breed; Torres, 1961, for the Gir, Nelore and Guzerá breeds, and Felicio, 1975, for the Nelore and Guzerá breeds). On the other hand, Torres (1961) demonstrated significant effects for the Indubrasil breed, as did Venkateshwarlu *et al.* (1972) for the Ongole breed, and Felicio (1975) for the Gir breed. Lasley *et al.* (1961), Kassab and Stengenga (1964), Vianna *et al.* (1964) and Fahmy and Lalande (1973) also reported significant effects for males and females of non-Zebu breeds, as did Plasse and Koger (1967) for the Santa Gertrudis breed.

Differences in birth weight attributed to year of birth were statistically significant (Table III). The least squares constants show that lighter animals were born from 1958 to 1964, and heavier animals from 1965 to 1973. Within these periods, the heaviest calves were born from 1971 to 1973 (3.8 to 4.0 kg above average) and the hightest animals were born in 1959, 1961 and 1964 (3.5 to 3.7 kg below average). Year effects on birth weight doubtless reflect climatic, feeding, sanitary and managing conditions of the dams during gestation, thus affecting calf birth weight. Therefore, the first period (1959, 1961 and 1964) was probably less favorable than the second (1971-1973) when these variables are considered.

Weaning weight

Mean weaning weight was 217 ± 1 kg and the coefficient of variation was 17%. Mean weaning age was 237 days. Males had a mean weaning weight of 228 ± 2 kg, and the females, 205 ± 2 kg (Table II). These values are higher than those reported by Swiger (1961), Pahnish *et al.* (1964) for Herefords, and by Mortari (1976) for Nelore, when the similarity in weaning age is considered, but are lower than those reported by Molinuevo (1971) for Charolais, at a lower weaning age.

Table IV - Least-squares constants for factors affecting birth weight, weaning weight and average daily gain.

Source of Variation		Constants		
		BW (kg)	WW (kg)	ADG (kg/day)
LS means		35.5	217	0.765
Sex	male	1.5	10	0.038
	female	-1.5	-10	- 0.038
Season	dry	-0.7	2	0.010
	rainy	0.7	- 2	- 0.010
Order of parturition				
	first	-0.2	- 6	- 0.025
	second	1.3	2	0.005
	third	0.5	3	0.012
	fourth	-0.5	4	0.019
	fifth	-0.7	3	0.014
	sixth or more	-0.4	- 6	- 0.025
Year	1958	-2.7	- 17	- 0.057
	1959	-3.5	- 14	- 0.044
	1960	-2.7	10	0.055
	1961	-3.7	- 8	- 0.014
	1962	-1.0	5	0.021
	1963	-1.6	- 37	- 0.152
	1964	-3.6	- 44	- 0.169
	1965	0.5	- 5	- 0.022
	1966	0.8	- 10	- 0.044
	1967	2.1	10	0.032
	1968	1.0	12	0.046
	1969	2.8	1	- 0.008
	1971	3.8	34	0.129
	1972	3.8	28	0.101
	1973	4.0	35	0.126

The apparent superiority in weaning weight for the Canchim breed when compared to data reported in the literature should be interpreted with caution in view of the great variability in weaning age. In addition, the different conditions prevailing at experimental stations or farms and management with or without supplementation could be among the probable sources of error when herds of different breeds and in different environments are compared.

The sex effect was statistically significant, as also reported by other investigators (Minyard and Dinkel, 1960; Pahnish *et al.*, 1961; Warren *et al.*, 1965; Plasse and Koger, 1967; Fahmy and Lalande, 1973).

The least squares constants showed a 20 kg difference in favor of males (Table IV). The sexual dimorphism observed in weaning weight could be partially explained by the action of sex hormones on the secondary sex characteristics (e.g. skeletal conformation and muscle size). In addition, owing to the longer gestational period, males are heavier at birth and carry this advantage throughout the nursing period, with higher weaning weights.

Season of birth had no significant influence on weaning weight (Table III). This suggests that the variations in temperature, precipitation and other environmental factors among seasons had little effect on the calves or on their dams at weaning. On this basis, we could suggest the advantage of mating at a certain time of year, so that the birth-weaning interval includes the largest number of days with the highest availability of forage, which in turn would determine plentiful feeding for the dams and thus more efficient nursing conditions.

Order of parturition had a significant effect on weaning weight, with a gradual increase in weight up to the fourth parturition. Significant results also were reported by Andrade (1973) for Guzerá, Lima (1974) for Gir, and Felício (1975) for Nelore, Guzerá and Gir. However, effects detected by Torres (1961) for the four Zebu breeds studied, by Solis and Varela-Alvarez (1973) for Zebu crossbreds, and by Lima (1974) for Nelore and Guzerá were not significant.

In view of the fact that order of parturition is a criterion for studying the influence of dam age, since age is associated with the calving sequence, calf growth from birth to weaning is influenced by the dam both in terms of the genes he receives from her and of the maternal environment she provides. Gene transmission does not depend on age, but the maternal environment could suffer alterations due to changes in weight and physiological functions that accompany dam aging. Thus, order of parturition has a direct effect on weaning weight and fully justifies the results obtained in the present study.

Year of birth significantly influenced weight, with a tendency towards increased weights occurring between 1958 and 1966. This significant effect seems to depend in relatively large part on favorable climatic conditions, with increased weaning weights observed during the years with good rainfall and consequent abundant forage, and on temperature, favorable environment and low incidence of disease.

Average daily gain from birth to weaning

Average daily gain was 0.806 kg for males and 0.721 for females, with an overall mean of 0.763 ± 0.005 and a coefficient of variation of 20% (Table II). These results are similar to those reported by Vianna *et al.* (1962) for 5/8 Zebu-Charolais animals, and lower than those obtained for 5/8 Charolais-Zebu animals. The effects of sex, order of parturition, year, and sire were significant.

The average daily gain from birth to weaning was 0.076 kg more for males than females. This difference is higher than most of those reported in the literature, which vary between 0.03 and 0.08 kg, and therefore is similar to the upper limit reported by Marlowe and Gaines (1957) for European breeds. The sexual dimorphism in preweaning gain shown by the Canchim breed could be partially explained by differences in birth weight. There is evidence that males and females with the same birth weight would have the same daily gain during the nursing period (Nelms and Bogard, 1956; Plasse and Koger, 1967).

Heritability estimates

The heritability estimates for birth weight, estimated by correlation among paternal half-sibs, were 0.37 ± 0.17 and 0.34 ± 0.18 for males and females, respectively. Joint heritability estimate was 0.31 ± 0.13. The higher estimate for males than for females, though not significant, agrees with results obtained by Pahnish *et al.* (1964) for Herefords and by Molinuevo (1971) for Charolais, but not with data reported by Koch *et al.* (1973) for Herefords.

Values obtained in the present study are in the 0.30 to 0.60 range, determined according to the literature, and are similar to those reported by Dawson *et al.* (1947), Koch and Clark (1955), Lombard (1963), Brinks *et al.* (1964), Pahnish *et al.* (1970) and Molinuevo (1971). These results indicate that birth weight can be considered to have average heritability and therefore

selection of Canchim bulls with higher birth weights to be used as sires is justified. Genetic improvement for birth weight also is possible, since the variability due to average gene effects is reasonable.

The heritability estimates for weaning weight were 0.46 ± 0.22 for males and 0.19 ± 0.15 for females (Table V). The higher coefficients obtained for males agreed with those reported by Molinuevo (1971) for Charolais. However, Pahnish *et al.* (1961, 1964) and Koch *et al.* (1973) obtained a difference in favor of females for the Hereford breed.

Table V - Estimates of heritability of BW, WW and ADG by sex.

Sex	BW		WW		ADG	
	h^2	S.E	h^2	S.E.	h^2	S.E.
Male	0.37	0.17	0.46	0.22	0.42	0.21
Female	0.34	0.18	0.19	0.15	0.14	0.13
Overall	0.31	0.13	0.29	0.13	0.26	0.12

The pooled estimate was 0.29 ± 0.13. This result favors a selection program oriented towards this trait, perhaps based on progeny testing, since selection by phenotype would not be very effective to improve weaning weight. In general, if we exclude estimates by Gregory *et al.* (1950), Torres (1962), Brinks *et al.* (1964) and Fahmy and Lalande (1973), results reported in the literature seem to indicate low heritability of weaning weight.

There was a large difference in heritability estimates for ADG between males (0.42) and females (0.14). Overall heritability estimate was 0.26, a lower value than reported for specialized breeds.

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RESUMO

A raça Canchim foi formada do cruzamento entre machos Charolês com fêmeas 1/4 Charolês x 3/4 Zebu, em uma fazenda da Unidade Estadual de Pesquisa Agropecuária da EMBRAPA, em São Carlos, São Paulo. Dados de 840 animais (418 fêmeas e 422 machos), nascidos no período de 1958 a 1973, filhos de 18 touros foram usados para as análises estatísticas. A média geral para o peso ao nascer (BW), foi de 35.7 ± 0.2 kg e coeficiente de variação de 17.2%. O peso médio ao desmame (WW) para machos foi 228 ± 2 kg, para fêmeas 205 ± 2 kg com média geral de 217 ± 1 kg. O ganho diário de peso do nascimento ao desmame (ADG) foi de 0.763 kg. A análise de variância pelo método dos quadrados mínimos mostrou a influência significativa de sexo, ordem, estação e ano do parto. Os coeficientes de herdabilidade calculados como correlação entre meio-irmãos paternos foram: BW 0,31 ± 0.13; WW 0.29 ± 0.13; ADG 0.26 ± 0.12. Estimativas de correlações genética e fenotípica entre BW e WW foram: 0.49 e 0.30; BW e ADG 0.31 e 0.11 e entre WW e ADG de 0,98 e 0,98, respectivamente.

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