Rev. Brasil. Genet. VI, 1, 81-92 (1983)
(Brazil. J. Genetics)

GENETIC ANALYSIS OF PERFORMANCE TRAITS IN CANCHIM CATTLE. II. WEIGHT GAIN*

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ABSTRACT

The objective of this study was to estimate heritability and genetic, phenotypic and environmental correlations for weight gain in Canchim (5/8 Charolais x 3/8 Zebu) cattle. Data were collected over a period of 16 years, from 1958 to 1973, for 1290 animals, 579 males and 711 females sired by 55 bulls. The following parameters were studied: average daily gain from birth to 6 (G_1), 12 (G_2), 18 (G_3) and 24 (G_4) months; from 6 to 12 months (G_5), from 12 to 18 months (G_6), and from 18 to 24 months (G_7). Heritability estimates were calculated from paternal half-sib correlations for males and females separately and combined. Estimates for males and females combined were: 0.376 for G_1, 0.468 for G_2, 0.371 for G_3, 0.261 for G_4, 0.274 for G_5, 0.092 for G_6, and 0.091 for G_7. Genetic correlations between G_1, G_2, G_3 and G_4 were positive and high both for males and females (0.730 to 0.985), whereas the value for the remaining gains varied between extremes of -1.180 to 0.776. These results are similar to those reported in the literature for the main beef cattle breeds raised in temperate climates.

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* Part of J.A.D.O.'s Doctoral Thesis.

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INTRODUCTION

Weight gain at different times of life is one of the most important productivity traits of beef cattle. Since variation among animals is caused by genetic and environmental factors, the importance and magnitude of each of these factors should be determined. Estimates of genetic parameters represent a fundamental aid for the development of an effective selection program. Heritability indicates the response potential expected from mass selection, whereas genetic correlation demonstrates whether genetic alterations in a given trait might be accompanied by alterations in another. Such information for Canchim cattle is limited. Objectives of this study were to determine heritabilities and genetic, phenotypic and environmental correlations between average daily gain from birth to 6, 12, 18 and 24 months of age; *from 6 to 12 months, from 12 to 18 months, and from 18 to 24 months* of age for Canchim cattle.

MATERIAL AND METHODS

Data were obtained for 1290 Canchim animals, 579 males and 711 females, raised on the Canchim farm in São Carlos, State of São Paulo, from 1958 to 1973, and sired by 55 bulls. The climate in this region is tropical, with a mean annual temperature of 20.3°C. Yearly rainfall during this period was 1505 mm, 81% of which occurred from October to March. Animals were maintained on pasture throughout the year. The farm attempted to establish a specific breeding season each year, but births occurred every month during the course of the study. Details of climate and management program have been reported earlier (Oliveira *et al.*, 1982a).

The dependent variables studied were: average daily gain from birth to 6 months (G_1), average daily gain from birth to 12 months (G_2), average daily gain from birth to 18 months (G_3), average daily gain from birth to 24 months (G_4), average daily gain from 6 to 12 months (G_5), average daily gain from 12 to 18 months (G_6), and average daily gain from 18 to 24 months (G_7).

Statistical analysis

Data were analyzed by mixed model, least-squares procedures (Harvey, 1972). The following model was used:

$$Y_{ijklno} = \mu + m_i + a_j + v_k + s_l + t_n + \epsilon_{ijklno}$$

where Y_{ijklno} is a specified weight gain, μ is the least-squares mean, m_i is the fixed effect of month i, a_j is the fixed effect of year j, v_k is the fixed effect of age k, s_l is the fixed effect of sex l, t_n is the random effect of sire n and ϵ_{ijklno} is the residual within-animal error variance. Paternal half-sib estimates of heritability were calculated according to the following formula $h^2 = 4\sigma_s^2/(\sigma_s^2 + \sigma_e^2)$, where σ_s^2 and σ_e^2 are the component of variance estimates for sire and error. Standard errors for these estimates were obtained by the formula of Swiger *et al.* (1964).

Phenotypic, genetic and environmental correlations between the two traits were estimated from sire components of variance and covariance, as shown previously (Oliveira *et al.*, 1982b).

RESULTS AND DISCUSSION

Heritability estimates

Variance and covariance components between sires and error were estimated from mean squares and products for sire and error, using the following values for coefficient k (within-sire component): 8.56 for males, 10.66 for females, and 19.77 for both sexes combined.

Table I shows the number of observations and least-squares means for weight gain by sex. Estimates of variance components and heritability for weight gain with their respective standard errors are presented in Table II. Heritability for G_1 was consistently higher for males than females. This result is similar to those reported by Marlowe and Vogt (1965) and Oliveira (1977) in studies on average daily gain from birth to weaning. The study by Oliveira (1977) was also on Canchim Cattle, though only on first-generation animals. However, there is evidence in the literature of considerably lower heritability

Table I - Number of observations and least-squares means for weight gain (g)

Sex	Number of observations	Gain 1	Gain 2	Gain 3	Gain 4	Gain 5	Gain 6	Gain 7
Male (M)	579	775.23	608.80	539.94	502.61	442.84	403.11	390.93
Female (F)	711	713.68	520.72	460.45	429.54	331.36	340.75	337.81
M and F combined	1290	735.65	558.96	492.46	460.99	384.72	360.34	367.37

Table II - Components of variance and heritabilities for the weight gains.

Trait	Components of variance		
	Sire	Error	$h^2 \pm SE$
Gain 1			
(1)	3293	17160	0.64 ± 0.16
(2)	1023	15105	0.25 ± 0.11
(3)	1727	16654	0.38 ± 0.09
Gain 2			
(1)	1671	8193	0.68 ± 0.17
(2)	509	5165	0.36 ± 0.12
(3)	957	7233	0.47 ± 0.11
Gain 3			
(1)	1036	6930	0.52 ± 0.15
(2)	433	3228	0.47 ± 0.13
(3)	578	5662	0.37 ± 0.09
Gain 4			
(1)	572	6434	0.33 ± 0.13
(2)	228	1954	0.42 ± 0.13
(3)	326	4659	0.26 ± 0.08
Gain 5			
(1)	2440	18576	0.46 ± 0.15
(2)	581	11105	0.20 ± 0.10
(3)	1206	16364	0.27 ± 0.08
Gain 6			
(1)	1115	22658	0.19 ± 0.11
(2)	499	10449	0.18 ± 0.10
(3)	465	19787	0.09 ± 0.05
Gain 7			
(1)	267	27293	0.04 ± 0.09
(2)	123	10317	0.05 ± 0.08
(3)	499	21320	0.09 ± 0.05

(1) Male; (2) Female; (3) Male and Female combined.

of growth from birth to weaning for males than for females (Pahnish *et al.*, 1964; Koch *et.al.*, 1973). When the heritabilities of average preweaning daily gain reported in the review by Petty and Cartwright (1966) are compared with the G_1 estimates obtained in the present study, we have 17% vs. 64% for males and 64% vs. 25% for females. Many reports on heritability of preweaning average daily gain were based on data for both sexes combined. Among them, a study by Packer (1977) on Canchim cattle reported heritability of 0.44. The 0.38 reported in the present study for G_1, although lower than that reported by Packer (1977), was higher than the 0.30 mean reported by Petty and Cartwright (1966).

A probable explanation for the differences between sexes in paternal half-sib heritability estimates may be, as proposed by Al-Mallah and Shrode (1975), a slight interaction between sire and progeny sex occurring for some traits, in such a way that between-sire and within-sire progeny variances might contain some effects of the differences between sexes. Probable reasons for higher heritability of weaning traits in females than in males have been suggested by Carter and Kincaid (1959) and Pahnish *et al.* (1961).

When heritabilities of the remaining gains were compared for males and females, higher values were once again observed for males, except for G_4 and G_6. Heritabilities of the gains studied for both sexes combined were between 0.09 and 0.47, which were the extremes for G_7 and G_2, respectively. These values are generally lower than those reported in the literature, which varied between 0.41 and 0.60 for G_3, between 0.39 and 0.67 for gain from weaning to 12 months, and between 0.22 and 0.25 for G_7 (Koch and Clark, 1955; Kumazaki *et al.*, 1962; Françoise *et al.*, 1973; Figueiredo, 1977; Rosa, 1977).

Since heritability depends on ratios of additive genetic and total phenotypic variances, different values for the same trait in separate herds are expected, especially if the herds are located in different environments and were submitted to selection of different intensity. These arguments, however, seldom explain extreme values, which may be due, as reported in the literature, to estimates with large sampling errors or, in certain cases, to inappropriate estimating methods. Furthermore, since heritability is a function of additive genetic variance, changes in gene frequency can alter its values. Thus, it is possible that estimates change with time, the rate of change depending on factors such as gene action, selection intensity, genetic drift etc. For this reason, heritability of economically important traits should be reestimated periodically, especially for herds submitted to artificial selection.

The heritabilities of G_1, G_2, G_3 *and* G_4 *estimated in the present* study suggest that the Canchim herd has sufficiently high additive genetic variability to respond to mass selection based on these weight gains. On the other hand, the remaining gains, with the exception of G_5 for males, had relatively low heritability.

Genetic correlations

Genetic, phenotypic and environmental correlations between continuous variables are presented in Tables III through V for each sex separately and for both combined.

Correlations between G_1, G_2, G_3 and G_4 were positive and high. However, it can be seen that, in general, correlations decreased as intervals between gains increased. This is expected, since a part-whole relationship exists between each pair of traits, and does not necessarily imply positive association between growth rates at the various stages.

As far as the remaining gains are concerned, genetic correlations were variable, with extreme values of -1.18 and 0.78, whereas phenotypic and environmental correlations were low and at times negative. In general there was no agreement between the corresponding correlations obtained for males and females separately. A remarkable divergence occurred in the genetic correlations between G_5, G_6 and G_7, since the values, although high, had opposite signs. The occurrence of genetic correlations exceeding the theoretical limit of one among females is not surprising. Possibly the partition of variances and covariances did not isolate exactly the genetic part from the non-genetic part.

The presence of negative values, especially for G_7, in the genetic correlations may be explained as a consequence of weight loss during this period. However, if this assumption were valid, negative values would be expected for both sexes, and this was not the case.

Limited information is available on genetic, phenotypic and environmental correlation between weight gains for beef cattle. Thus, the correlations shown in Tables III through V provide additional estimates. Even though the standard errors of genetic correlations were very high in some cases, the results of the present study seem noteworthy. The present estimates were of similar magnitude to those observed by Brinks *et al.* (1964) for females; their genetic, phenotypic and environmental correlations between average daily gain from birth to weaning at 12 months and from 12 to 18 months

Table III - Phenotypic, genetic and environmental correlations among weight gains for males.

	G_1	G_2	G_3	G_4	G_5	G_6	G_7
G_1		0.799 ± 0.089	0.816 ± 0.098	0.730 ± 0.153	0.164 ± 0.239	0.390 ± 0.239	-0.564 ± 0.876
G_2	0.686 0.467		0.942 ± 0.042	0.964 ± 0.069			
G_3	0.627 0.375	0.819 0.660		0.985 ± 0.038			
G_4	0.522 0.382	0.747 0.629	0.872 0.820				
G_5	-0.044 -0.306					-0.001 ± 0.350	0.760 ± 0.950
G_6	0.206 0.130				-0.027 -0.041		-0.568 ± 1.124
G_7	0.040 0.211				0.225 0.171	0.011 0.067	

Above the diagonal: genetic correlation;

Below the diagonal: phenotypic and environmental correlations.

Table IV - Phenotypic, genetic and environmental correlations among weight gains for females.

	G_1	G_2	G_3	G_4	G_5	G_6	G_7
G_1		0.841 ± 0.108	0.893 ± 0.098	0.901 ± 0.116	0.216 ± 0.371	0.776 ± 0.315	-0.146 ± 0.670
G_2	0.722 0.677		0.961 ± 0.043	0.866 ± 0.075			
G_3	0.679 0.589	0.813 0.717		0.984 ± 0.29			
G_4	0.593 0.454	0.786 0.737	0.848 0.741				
G_5	-0.167 -0.279					0.288 ± 0.424	-1.180 ± 0.959
G_6	0.138 -0.037				-0.214 -0.319		0.693 ± 1.124
G_7	-0.123 -0.127				0.157 0.310	-0.378 -0.501	

Above the diagonal: genetic correlation;

Below the diagonal: phenotypic and environmental correlations.

Table V - Phenotypic, genetic and environmental correlations among weight gains for males and females.

	G_1	G_2	G_3	G_4	G_5	G_6	G_7
G_1		0.839 ± 0.067	0.901 ± 0.060	0.817 ± 0.099	0.292 ± 0.210	0.593 ± 0.255	-0.280 ± 0.294
G_2	0.689 0.586		0.959 ± 0.029	0.854 ± 0.069			
G_3	0.632 0.471	0.797 0.687		0.952 ± 0.032			
G_4	0.520 0.388	0.721 0.674	0.853 0.816				
G_5	-0.080 -0.258					-0.102 ± 0.319	-0.308 ± 0.297
G_6	0.175 0.086				-0.113 -0.119		0.441 ± 0.451
G_7	-0.022 0.040				0.170 0.269	-0.086 -0.139	

Above the diagonal: genetic correlation;

Below the diagonal: phenotypic and environmental correlations.

varied between -0.23 and 0.49, -0.19 to 0.13 and -0.16 to -0.08, respectively. Figueiredo (1977) reported positive correlation between average daily gain from weaning to 365 days, from 365 to 550 days and from 550 days to 730 days of age. The genetic correlation obtained by this investigator was equal to 1.00, and the phenotypic correlation varied between 0.66 and 0.96.

In addition to the results presented here, genetic, phenotypic and environmental correlations between weights at 6, 12, 18 and 24 months and gains G_1, G_2, G_3 and G_4, respectively, and between birth weight and all weight gains considered, also were obtained. In the first case, correlation was near one, with a standard error of less than 0.03. This demonstrates that, for selection purposes, these traits can be considered essentially to be identical. In the second, (males and females combined), genetic correlations varied from 0.10 to -0.26, phenotypic correlations from 0.04 to 0.10, and environmental correlations from 0.04 to 0.19, suggesting that birth weight is not an efficient indicator of weight gain for Canchim cattle.

ACKNOWLEDGMENTS

The authors are indebted to CNPq, FAPESP and OAS for financial support, and to EMBRAPA, as represented by Drs. Mario Santiago and Antonio J. Tambasco, for supplying the data. We are also indebted to Miss Maria Bernadete Malerbo for reviewing the references.

RESUMO

Os objetivos do presente estudo foram estimar a herdabilidade e as correlações genéticas, fenotípicas e ambientais para ganho em peso de animais da raça Canchim (5/8 Charolês x 3/8 Zebu). Dados referentes a 1290 animais (579 machos e 711 fêmeas filhos de 55 touros) foram coletados durante um período de 16 anos, de 1958 a 1973. Foram estudadas as seguintes variáveis: ganho médio diário do nascimento até 6 (G_1), 12 (G_2), 18 (G_3) e 24 (G_4) meses de idade; de 6 a 12 meses (G_5), de 12 a 18 meses (G_6), de 18 a 24 meses (G_7). As estimativas de herdabilidade foram obtidas pela correlação entre meio-irmãos paternos para machos e fêmeas isoladamente e em conjunto. As estimativas para machos e fêmeas em conjunto foram: 0,376 para G_1; 0,468 para G_2; 0,371 para G_3; 0,261 para G_4; 0,274 para G_5; 0,092 para G_6 e 0,091 para G_7. As correlações genéticas entre G_1, G_2, G_3 e G_4 foram altas e positivas tanto para os machos como as fêmeas (0,730 a 0,985), enquanto que os valores para os demais ganhos variaram entre limites extremos de -1,180 e 0,776. Estes resultados são semelhantes aos encontrados na literatura para as principais raças de corte em clima temperado.

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(Received March 23, 1982)