Rev. Brasil. Genet. 15, 3, 603-613 (1992)
(Brazil. J. Genetics)

CORRELATIONS BETWEEN HEAT TOLERANCE AND REPRODUCTIVE AND PRODUCTIVE TRAITS IN PITANGUEIRAS COWS

Álvaro de Matos Lemos[1] and Raysildo Barbosa Lôbo[2]

ABSTRACT

The relationship between heat tolerance and reproduction and production characteristics in Pitangueiras cows was studied. The data were collected from the Três Barras farm herd in Pitangueiras, São Paulo state. Heat tolerance was measured as rectal temperature increase (RTI), which is the increase in rectal temperature from the morning until the afternoon. Reproduction characteristics considered included: age at first calving (AFC), number of services per conception (NSC), days open (DO) and calving interval (CI). Production characteristics included: lactation length (LL), milk yield (MY), fat percentage (F%) and fat yield (FY). Genetic correlation coefficient estimates were obtained by the method of correlation between paternal half sisters. The correlations obtained were: RTI x AFC 0.11, -0.04, -0.02; RTI x NSC -0.29, 0.01, 0.11; RTI x DO 1.02, 0.07, 0.09; RTI x CI 0.09, 0.04, 0.03; RTI x LL 0.56, 0.13, -0.05; RTI x MY 0.18, 0.16, 0.29; RTI x F% -0.14, 0.13, -0.13; RTI x FY 0.16, 0.15, 0.18. We concluded that selection for heat tolerance in Pitangueiras cows is not recommended for Pitangueiras cows under the conditions of our study.

INTRODUCTION

The climate of tropical regions represents a serious problem for cattle raising. The various climatic components have direct effects on the cattle physiology, air temperature being the factor of highest relevance (Roman Ponce, 1977). High environmental temperatures usually decrease the reproductive efficiency of cattle by affecting different phases of reproduction (Thatcher, 1974; Mount, 1979; Collier *et al.*, 1982; Vercoe and Frisch, 1983). Milk yield is also affected directly and indirectly by

[1] CNP-Gado de Leite, EMBRAPA, 36155 Coronel Pacheco, MG, Brasil. Send correspondence to A.M.L.
[2] Departamento de Genética, FMRP-USP, 14049 Ribeirão Preto, SP, Brasil.

different climatic components (Ragsdale *et al.*, 1950, 1953; Payne and Hancock, 1957; Miescke *et al.*, 1979; Ordóñez Rodrigues, 1980; Collier *et al.*, 1982).

Some authors recommend cattle selection for tolerance to tropical conditions, thus avoiding the additional costs involved in the relief of stress (Frisch and Vercoe, 1978; Seifert, 1982). The results of a genetic breeding program depend on several factors, one of them being the choice of the traits to be selected and the emphasis placed on each (Henderson, 1982). A certain flexibility should be maintained when choosing the traits to be considered for selection until the possible desirable and undesirable correlations have been estimated (Seifert, 1982). In Brazil, although heat tolerance is an important point to be considered, there is virtually no information about the relevance of including this trait in the selection of dairy cattle (EMBRAPA/CNPGL, 1977). Silva (1973), in a study on Canchim beef cattle, obtained a genetic correlation of -0.89 ± 0.29 between increased rectal temperature and weight gain from weaning to 18 months of age. In Australia, Turner (1982, 1984), using data for halfbred animals, estimated a genetic correlation of -0.86 ± 0.17 and 0.17 ± 0.65 between rectal temperature and weight at 18 months for animals born in 1976 and 1977, respectively.

To determine the convenience of using heat tolerance in the elaboration of breeding programs for Pitangueiras cattle, in the present study we estimated the genetic, phenotypic and environmental correlation coefficients between increased rectal temperature and reproductive and productive traits.

MATERIALS AND METHODS

The data used were from 893 Pitangueiras cows, born from 1970 to 1981, belonging to the Três Barras Farm, municipality of Pitangueiras, State of São Paulo, Brazil. The farm is located at 503m altitude, 21°00' latitude South and 48°11' longitude West. The climate of the region is humid tropical, type Aw in the Köeppen classification. Temperature and rainfall of the region are characterized by a warm, rainy season from October to March and a dry, cool season from April to September. From 1977 to 1984, mean annual temperature was 23.86°C and rainfall, 1,652mm. Means for temperature and rainfall from data obtained at the Farm itself are shown in Table I. Minimum and maximum air temperatures recorded on the days when data were collected are presented in Table II.

Rectal temperatures of Pitangueiras cows were taken with a Suzuken Mc320 electronic thermometer. Data for animals with disease symptoms or in estrus were discarded. Rectal temperature measurements were made at two different times of day (from 4:00 to 8:00 a.m., and from 12:00 to 6:00 p.m.) and at different times of the year (twice in March 1983 and three times in January 1984). Times when individual rectal temperatures were taken were recorded and arranged in classes (Table III). At the time when the rectal temperatures were taken, animals were also classified for coat color using codes from 1 to 5, starting from light red (1) and ending with dark red (5).

Table I - Means for monthly temperature and rainfall at the Três Barras Farm, Pitangueiras, SP, from 1977 to 1984.

Month	Temperature (°C)			Rainfall
	Minimum	Maximum	Mean	(mm)
January	20.54	31.10	25.97	249.58
February	20.22	33.56	26.89	198.68
March	19.46	32.47	25.97	164.95
April	18.14	30.91	24.52	75.95
May	16.09	28.21	22.15	76.62
June	13.69	26.22	19.95	35.38
July	12.96	26.61	19.79	26.64
August	14.59	27.45	21.02	25.93
September	16.76	28.48	22.62	44.89
October	19.95	31.46	25.71	165.60
November	20.79	31.86	26.32	244.73
December	20.28	30.42	25.35	343.48
Overall Mean	17.79	29.92	23.86	1,652.43

Table II - Maximum and minimum air temperature on days when rectal temperatures were taken at the Três Barras Farm, municipality of Pitangueiras, SP.

Date	Air temperature (°C)	
	Maximum	Minimum
March 2, 1983	32	17
March 3, 1983	34	18
January 13, 1984	37	22
January 14, 1984	37	22
January 15, 1984	37	21

Table III - Times when rectal temperatures of Pitangueiras cows were taken.

Time categories	Time temperature taken	
	Morning	Afternoon
1	4:00 - 5:00	12:00 - 13:00
2	5:00 - 6:00	13:00 - 14:00
3	6:00 - 7:00	14:00 - 15:00
4	7:00 - 8:00	15:00 - 16:00
5	8:00 - 9:00	16:00 - 17:00
6		17:00 - 18:00

The herd is maintained on pasture the year around and at milking time cows receive a daily supplementation consisting of corn silage and barley chaff, at the rate of 1 kg per 3 kg milk produced. Milk production is checked monthly for every milking cow in the herd.

The Pitangueiras herd studied consists of several generations resulting from planned matings and each generation was considered to be a different genetic group for statistical analysis. For evaluation of the effects of generation, we considered: P1=5/8. Red Poll: 3/8 Zebu, P2=P1xP1, P3=P1xP2, P4=P2xP1, and P5=P2xP2.

The traits studied were: age at first calving (AFC), number of services per conception (NSC), days open (DO), calving interval (CI), lactation length (LL), milk yield (MY), fat percentage (F%), fat yield (FY), and rectal temperature increase (RTI), calculated by the difference between final and initial rectal temperature (FRT, IRT, respectively).

Data were analysed statistically using Model 2 of the Mixed Model Least Squares Maximum Likelihood Program (LSML76) of Harvey (1977), with the following general equation:

$$Y_{ijk} = \mu + a_i + F_j + \varepsilon_{ijk};$$

where Y_{ijk} = response for each dependent variable; μ = overall mean; a_i = sire effect (random); F_j = a set of fixed effects and ε_{ijk} = random error, assumed to be NID $(0, \sigma^2)$.

This model was used to obtain the least squares constants for fixed effects. For productive and reproductive traits the fixed effects (F_j) included in the model were: genetic group, month and year of parturition, age of dam, (except for AFC). For rectal temperatures (IRT and FRT), the effects were: time of day and year when temperature was taken, genetic group, age of dam, and coat color score. The non-significant fixed effects ($P > 0.05$) for traits studied were removed from the model, and the analysis of variance run again. After IRT and FRT were adjusted for significant nongenetic fixed effects, RTI was calculated and used as the measure indicating heat tolerance. Means of adjusted observations made over two consecutive years (1983 and 1984) were later calculated for each animal and an additional statistical analysis was performed to estimate genetic correlations.

With the reproductive and productive traits adjusted for fixed effects, the most probable producing ability (MPPA) for repeat traits were estimated, according to the Lush (1945) formula:

$$MPPA = \bar{H} + \frac{nt}{1+(n-1)t}(\bar{C} - \bar{H}), \quad \text{where}$$

$\bar{H}$ is the herd average, n is the number of parturition records of the dam, t is the repeatability of the trait, and $\bar{C}$ is the cow average. The values of repeatibility used for calculating the MPPA for reproduction and production traits are shown in Table IV.

Table IV - Estimates of repeatability used for calculating the most probable producing ability for reproduction and production traits.

Traits	Repeatability
Number of services per conception	0.120[a]
Days open	0.161[b]
Calving interval	0.145[b]
Lactation length	0.277[b]
Milk yield	0.395[b]
Fat percentage	0.090[b]
Fat yield	0.351

Source: Lôbo (1980)[b] and Reis (1983)[a].

The genetic, (r_a) phenotypic (r_p) and environmental (r_e) correlations were estimated using the following formulas:

$$r_a = \frac{\hat{Cov}_S}{(\hat{\sigma}^2_{si}\hat{\sigma}^2_{sj})^{0,5}}$$

$$r_p = \frac{\hat{Cov}_S + \hat{Cov}_W}{[(\hat{\sigma}^2_{si}+\hat{\sigma}^2_{wi})(\hat{\sigma}^2_{sj}+\hat{\sigma}^2_{wj})]^{0,5}}$$

$$r_e = \frac{\hat{Cov}_W - 3\hat{Cov}_S}{[(\hat{\sigma}^2_{wi}-3\hat{\sigma}^2_{sj})\,(\hat{\sigma}^2_{wj}-\hat{\sigma}^2_{sj})]^{0,5}} \quad , \text{ where}$$

$\hat{\sigma}^2_{si}$ and $\hat{\sigma}^2_{sj}$ = sire variance components for traits i and j.
$\hat{\sigma}^2_{wi}$ and $\hat{\sigma}^2_{wj}$ = residual variance components, for traits i and j.
$\hat{Cov}_W$ = residual covariance component for traits i and j.

RESULTS AND DISCUSSION

The correlations estimated between reproductive traits and heat tolerance are presented in Table V. The phenotypic correlations were low, demonstrating that in the present situation the phenotypic associations between these traits are low. Nagarcenkar and Sethi (1981) did not detect a significant correlation between heat tolerance and age at first conception and Turner (1982) obtained a -0.17 correlation between rectal temperature and fertility. Similarly, the environmental correlations were low, showing the small effect of environment and nonadditive genetic sources on the relationship between the traits under study.

Table V - Genetic, phenotypic and environmental correlations between rectal temperature increase and the most probable producing ability for reproduction traits.

Traits	Number of cows	Number of sires	Correlations		
			Genetic[a]	Phenotypic	Environmental
RTI x AFC	686	69	-0.11 ± 0.25	-0.04	-0.02
RTI x NSC	683	68	-0.29 ± 0.33	0.01	0.11
RTI x DO	607	63	1.02 ± 0.55	0.07	0.09
RTI x CI	570	62	0.09 ± 0.51	0.04	0.03

[a]: Genetic correlations ± standard error.

The genetic correlations of RTI with AFC, NSC and CI were -0.11 ± 0.25, -0.29 ± 0.30 and 0.09 ± 0.51, respectively. These estimates are relatively low, reflecting the small additive genetic association observed for the conditions in question. The genetic correlation between RTI and DO was estimated at 1.02 ± 0.55. In genetic terms, days open are higher in animals with the lowest heat tolerance. However, this result should be interpreted with caution because of the fact that an estimate higher than one was obtained, with a large standard error. Few authors have studied the genetic correlations between heat tolerance and reproduction in cattle. Turner (1982) estimated a genetic correlation of -0.76 ± 0.35 between rectal temperature and fertility in beef cattle. This author suggested the use of selection for greater heat tolerance for beef cattle in Australia and stated that improved heat tolerance may produce gains not only in terms of female fertility, but also in terms of production traits. The correlations estimated between RTI and DO in the present study support this idea despite the magnitude of the standard error.

The correlations estimated between production traits and increased rectal temperature are presented in Table VI. The phenotypic correlations between RTI and production traits were low, showing a small phenotypic association between these characteristics. The correlation between heat tolerance and MY was 0.16, a result in agreement with that obtained by Baccari Jr. *et al.* (1982), which was 0.21. However, it disagrees with the values reported by Erokhin (1976), -0.35, Johnson (1977), -0.25, Dalal (1979), -0.36 and Donegan and Franklin (1979), -0.24 and -0.01. The phenotypic correlation between RTI and F% was -0.13, which differs from the 0.37 value reported by Stepanov (1974).

The environmental correlations between RTI and production traits were relatively low, reflecting the small effect of the environment on the association between these traits.

Table VI - Genetic, phenotypic and environmental correlations between rectal temperature increase and the most probable producing ability for production traits.

Traits	Number of cows	Number of seres	Correlations		
			Genetic[a]	Phenotypic	Environmental
RTI x LL	618	64	0.56 ± 0.27	0.13	-0.05
RTI x MY	618	64	0.18 ± 0.23	0.16	0.29
RTI x F%	566	63	-0.14 ± 0.32	-0.13	-0.13
RTI x FY	566	63	0.16 ± 0.25	0.15	0.18

[a]: Genetic correlations ± standard error.

The genetic correlation between RTI and MY was 0.56 ± 0.27, a statistically significant estimate ($P < 0.05$). This result shows that, in genetic terms, the cows with the lowest heat tolerance were those which presented the longest lactations, probably due to the effect of the European genes. The genetic correlations between RTI and MY, F% and FY were relatively low, showing the small degree of genetic association between these traits. These low values may have been due to the fact that the environment in which the animals are managed represents only a small stress for this Pitangueiras herd. In the tropics, this stress is normally provoked by low nutritional levels, parasitic infestations and high environmental temperatures. In an environment of only moderate stress, the animals with the highest potential had the possibility of producing more and were those that presented the lowest heat tolerance, thus there were positive correlations between RTI and MY and FY, although the values were of small magnitude. On the other hand, if the environment produces rigorous stress, the animals with the highest heat tolerance may possibly be the most productive. Thus, a negative correlation would be obtained, which might increase in magnitude with increasing environmental adversities. Frisch (1981) reports that animals selected for growth under conditions of rigorous stress obtained a genetic gain due to the improved resistance to these environmental conditions.

The genetic differences with respect to heat tolerance are linked to thermoregulating attributes which control body temperature. These attributes include coat type and color, sweating, respiratory refrigeration, peripheral blood circulation and heat production. It is possible that different animals will obtain control of body temperature through different types of regulatory functions, with consequent different penalties in terms of productivity. For example, control through heat production is a function of food consumption and efficiency of energy metabolism. Thus, an animal with inherently reduced food consumption will be tolerant to heat but will have a low productivity level (Turner, 1984). One should consider the conflict existing between the need for heat tolerance and the high energy load associated with high food intake and metabolism (Seifert, 1984). On this basis, for increased production to occur in tropical regions, it is necessary to work on two fronts, one aiming at the attenuation of adverse environmental conditions and the other based on the selection of cattle more resistant to the circumstances existing in this environment. We can select for greater resistance to ticks, helminths and heat; however, when designing a selection program, it is necessary to estimate the genetic correlations between these traits and those of economic importance. On the basis of the results obtained in the present study, selection for heat tolerance would bring no advantage in terms of milk and fat yield, and therefore it is not indicated for inclusion in programs of selection of this Pitangueiras herd for the present conditions. However, these results are not definitive because of the very nature of the genetic parameters which may vary from year to year and because of the elevated standard errors encountered. For the present study the number of bulls was not a limiting factor;

however, it is recommended that the size of the families be increased and that the families be of more homogeneous distribution so that genetic correlations estimates may be obtained in a more precise manner.

ACKNOWLEDGMENTS

Publication supported by FAPESP.

RESUMO

Estudou-se as correlações entre a tolerância ao calor e características de reprodução e produção em vacas da raça Pitangueiras. Os dados foram coletados no rebanho da Fazenda Três Barras, localizada no Município de Pitangueiras, Estado de São Paulo. A característica de tolerância ao calor considerada foi o aumento da temperatura retal (ATR) que é a diferença entre a temperatura retal da manhã para a da tarde. Como características de reprodução considerou-se a capacidade mais provável de: idade ao primeiro parto (IDP_1), número de serviços por concepção (NSC), período de serviço (PSERV) e intervalo entre partos (IEP). As de produção foram: período de lactação (PLACT), produção de leite (PLEIT), porcentagem de gordura (%GORD) e produção de gordura (PGORD). As estimativas dos coeficientes de correlação genética foram obtidos pelo método da correlação entre meio-irmãs paternas. Obteve-se os seguintes resultados para as correlações genética, fenotípica e ambiente, respectivamente: ATR x IDP_1 -0,11, -0,04, -0,02; ATR x NSC -0,29, 0,01, 0,11; ATR x PSERV 1,02, 0,07, 0,09; ATR x IEP 0,09, 0,04, 0,03; ATR x PLACT 0,56, 0,13, -0,05; ATR x PLEIT 0,18, 0,16, 0,29; ATR x %GORD -0,14, -0,13, -0,13; ATR x PGORD 0,16, 0,15, 0,18. Baseado nos resultados encontrados, não seria recomendada a seleção para tolerância ao calor em vacas Pitangueiras, para a presente situação.

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(Received March 1, 1991)