

EFFECTS OF ENVIRONMENT AND HEREDITY ON THE RECTAL TEMPERATURE OF PITANGUEIRAS CATTLE

Álvaro de Matos Lemos¹ and Raysildo Barbosa Lôbo²

ABSTRACT

Objectives of the present study were to evaluate effects of environment and heredity on rectal temperatures of Pitangueiras cattle. Data were obtained from breeding files of the Três Barras Farm, located in the municipality of Pitangueiras, State of São Paulo, Brazil. Heat tolerance traits studied were: initial rectal temperature (IRT), final rectal temperature (FRT) and rectal temperature increase (RTI). Overall means and coefficients of variation for traits measured were 38.43°C and 1.0% for IRT, and 39.21°C and 1.1% for FRT, respectively. Time when temperature was taken had a significant effect on both IRT and FRT. FRT also was varied according to year when temperature was taken and coat color. Heritability estimated by paternal half-sib correlations in six different samples ranged from 0.15 ± 0.09 to 0.27 ± 0.12 for IRT, 0.17 ± 0.10 to 0.31 ± 0.13 for FRT, and 0.16 ± 0.16 to 0.27 ± 0.11 for RTI. Results indicated that greater accuracy could be obtained in selecting Pitangueiras cattle for heat tolerance by using a progeny test with seven or more daughters per sire.

INTRODUCTION

The high atmospheric temperature of tropical regions is one of the climatic factors that most affect the physical environment of cattle as a whole. Reduced milk yields caused by heat should not be attributed only to lower feed intake or to lower quality of tropical forages, but also to effects on physiological mechanisms related to lactation, such as low thyroxine levels in the bloodstream. Exposure to high ambient temperatures causes heat accumulation in the organism, favoring development of undesirable physicochemical processes. A 1°C increase in body temperature is sufficient to promote detectable changes in several physiological processes and to reduce

¹ CNP - Gado de Leite, EMBRAPA, 36155 Coronel Pacheco, MG, Brasil. Send correspondence to A.M.L.

² Departamento de Genética, Faculdade de Medicina de Ribeirão Preto, USP, 14049 Ribeirão Preto, SP, Brasil.

production (McDowell, 1972). The most accurate parameter for evaluating heat tolerance of an animal is measurement of its rectal temperature; an increase in rectal temperature should be considered a symptom of the animal's inability to promote reactions needed to maintain thermal equilibrium (Phillips, 1955; Shrode *et al.*, 1960; McDowell, 1967, 1972).

Relatively few studies on heritability of rectal temperature in cattle have been published. In Brazil, Silva (1973), working with Canchim cattle, obtained heritability estimates of 0.108 ± 0.164 for rectal temperature taken in the morning and 0.443 ± 0.275 for the increase in rectal temperature after exposure to sunlight.

In view of the importance of heat tolerance for cattle, objectives of the present study were to evaluate the nongenetic effects on rectal temperatures of Pitangueiras cows, to obtain adjustment factors for the traits studied and to estimate heritabilities needed for selection programs.

MATERIALS AND METHODS

The study was conducted on Pitangueiras cattle belonging to tre Três Barras Farm, municipality of Pitangueiras, State of São Paulo, Brazil. The farm is located at 503 m altitude, 21°00' latitude south and 48°11' longitude west of Greenwich. 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, 1,652 mm. 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 Mc 320 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 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 also were, classified for coat color using codes from 1 to 5, starting from light red (1) and ending with dark red (5).

The Pitangueiras herd studied consists of several generations resulting from planned matings and each generation was considered to be a different genetic group purposes of for statistical analysis. For determination of the effects of generation, we considered: $P_1 = 5/8$ Red Poll: $3/8$ Zebu, $P_2 = P_1 \times P_1$, $P_3 = P_1 \times P_2$, $P_4 = P_2 \times P_1$, and $P_5 = P_2 \times P_2$.

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

Month	Temperature (°C)			Rainfall (mm)
	Minimum	Maximum	Mean	
January	20.54	31.40	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/Total	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 traits considered were: initial rectal temperature (IRT) taken in the morning, final rectal temperature (FRT) taken in the afternoon, and rectal temperature increase (RTI). Data were analyzed 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 $(0, \sigma^2)$.

Fixed effects considered were: time of day and year when temperature was taken, genetic group, parturition number, and coat color. 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 heritability. Sires with less than four daughters were not included in the analysis. Heritability estimates (h^2) for heat tolerance were obtained by method of paternal half-sib correlation using the following formula: $h^2 = 4 \sigma_a^2 : (\sigma_a^2 + \sigma^2)$ where σ_a^2 = estimate of the sire variance component, and σ^2 = estimate of error variance component.

To measure associations between reproductive, productive and heat tolerance traits, different analyses of variance were performed because the samples

were different for each group of dependent variables depending on availability or lack of information (Lemos and Lôbo, in preparation). The program used for each analysis (Harvey, 1977) gave heritability estimates for the traits studied. Consequently, several heritability estimates were obtained for heat tolerance traits of different samples from the same herd.

RESULTS AND DISCUSSION

Overall mean for IRT was 38.43°C with a coefficient of variation of 1.0% and range of 37.00 and 38.89°C, respectively. These results are close to the temperature considered normal for cattle which, according to Dukes (1973), is 38.3°C for beef cattle and 38.6°C for dairy cattle. The low coefficient of variation obtained was expected since cows are homeotherms. Time when the temperature was taken significantly affected IRT, with lower values being obtained for animals whose temperature was measured earlier in the day (Tables IV and V). IRT tended to increase with time of day when the measurement was made, doubtless due to the increase in ambient temperature.

Table IV - Number of observations (N), mean (\bar{X}), coefficient of variation (C.V.%) and minimum and maximum values for initial rectal temperature (IRT) by time of day and year.

Variables	N	\bar{X} (°C)	C.V. (%)	Min. (°C)	Max. (°C)
Time categories					
1	273	38.34	0.8	37.50	39.28
2	272	38.41	1.0	37.11	39.60
3	275	38.41	0.9	37.40	39.50
4	274	38.50	1.0	37.00	39.89
5	125	38.52	0.9	37.50	39.39
Year					
1983	424	38.39	1.0	37.11	39.60
1984	795	38.45	0.9	37.00	39.89
Total/Overall mean	1219	38.43	1.0	37.00	39.89

Table V - Least squares analysis of variance of initial rectal temperature data for calculating the adjustment factors.

Sources of variation	d.f.	Mean squares	Probability
Sire	79	0.252	0.001
Time temp. taken	4	0.847	0.001
Residual	971	0.127	
Total	1055		

The adjusted factors estimated by least squares are presented in Table VI. Year when temperature was measured, number of parturition and genetic group had no detectable effects on IRT. Effect of coat color also was not significant, a result similar to that obtained by Silva (1973) for Canchim cattle. This may be due to the low incidence of sunlight on the animals at the time of data collection.

Table VI - Number of observations (N) and estimates of effects of initial rectal temperature (IRT) by time.

Time temp. taken (category)	N	Constants ($^{\circ}\text{C}$)
1	242	- 0.090
2	234	- 0.027
3	238	- 0.018
4	234	0.077
5	107	0.058
Total/Overall mean	1055	38.44

Mean FRT was 39.21°C with a coefficient of variation of 1.1% and minimum and maximum values of 38.00 and 41.20°C , respectively. There was a mean of 0.78°C increase in relation to the temperature taken in the morning (FRT-IRT). Mean FRT obtained in our study was close to those reported by others studies performed in Brazil for warmer times of day. For example, temperatures reported by Oliveira (1978) for animals of three genetic groups (39.06°C), Falco (1979) for Holsteins (39.04°C), and Cardoso *et al.* (1983) for Red and White Holsteins (39.12°C) and Black and White Holstein (39.39°C). Although cows are homeotherms, they may suffer a small increase in temperature when exposed to hot environments. It is known that the greater this increase, the lower the animal's reaction, with a 1°C increase in body temperature producing adverse reactions in the organism (McDowell, 1972).

Time when temperature was taken significantly affected FRT, with values tending to increase as the day progressed. This demonstrates the cumulative effects of heat on the animal even when the ambient temperature at the end of the afternoon is not the highest (Tables VII and VIII). It also can be thought of as a lag time. Year when temperature was taken also had a significant effect, with higher values being obtained in 1983 even though ambient temperature was higher in 1984 (Tables VII and VIII). However, it should be pointed out that ambient temperature is not the only factor affecting body temperature. Kibler and Brody (1953) observed that air humidity had a marked effect on body temperatures of European breeds when ambient temperature was above 24°C, and on the body temperature of Indian breeds when ambient temperature was above 29.4°C. Adjustment factors for time and year when temperature was taken are presented in Table IX. Coat color also had significant effects (Table VII), with darker animals having higher body temperatures greater heat absorption by darker coats. Our results are similar to those reported by Rhoad (1940), Riemerschmid and Elder (1945), Brody *et al.* (1954), Dowling (1956), Cena (1966) and Hafez (1973). Cows with lighter coats are known to be more efficient in reflecting radiation of longer wavelength. However, such codes do not reflect ultraviolet radiation, which, in turn, is retained by dark skin. Thus, to escape harmful effects of solar rays, cows raised in tropical regions should preferentially have a light coat and dark skin. Order to parturition and genetic group had no detectable effects on FRT.

Table VII - Number of observations (N), mean (\bar{X}), coefficient of variation (C.V.%) and minimum and maximum values for final rectal temperature (FRT) according to time of day and year.

Variables	N	\bar{X} (°C)	C.V. (%)	Min. (°C)	Max. (°C)
Time temp. taken (category)					
1	45	39.29	1.2	38.60	40.79
2	126	39.07	0.9	38.17	38.89
3	279	39.10	1.1	38.19	40.79
4	280	39.22	1.0	38.00	40.51
5	296	39.30	1.0	38.29	40.60
6	193	39.32	1.0	38.19	41.20
Year temp. taken					
1983	424	39.24	1.2	38.00	40.79
1984	795	39.20	1.0	38.19	41.20
Total/Overall mean	1219	39.21	1.1	38.00	41.20

Table VIII - Least squares analysis of variance of final rectal temperature for calculation of the adjustment factors.

Sources of variation	d.f.	Mean squares	Probability
Sire	79	0.276	0.000
Time temperature taken	5	1.923	0.000
Coat color	4	0.691	0.003
Year temperature taken	1	2.544	0.000
Residual	965	0.170	
Total	1055		

Table IX - Number of observations (N) and constants estimates of effects on final rectal temperature (FRT) according to time of day and year when temperature was taken and to coat color.

Variables	N	Constants (°C)
Time temp. taken (category)		
1	40	0.164
2	111	-0.174
3	251	-0.125
4	244	-0.032
5	263	0.057
6	146	0.109
Year temp. taken		
1983	403	0.058
1984	652	-0.058
Total/Overall mean	1055	39.286

Heritability estimates for IRT obtained from different samples showed a minimum of 0.15 ± 0.09 and a maximum of 0.27 ± 0.12 (Table X). These are similar to those obtained by Taneja (1966), 0.20, Silva (1973), 0.11 ± 0.16 , and Sethi and Nagarcenkar (1981), 0.24 ± 0.19 . The estimates we obtained are not of direct practical importance for the study of heat tolerance because they were obtained when am-

bient temperature does not provoke thermal stress in Pitangueiras cows. The minimum ambient temperature ranged from 17 to 22°C on the days of data collection. The thermal neutrality zone for European cattle is between 0 to 16°C, and for Indian cattle, between 10 and 27°C (Brody, 1948). Thus, for F₁ European x Zebu crossbreds, the thermal neutrality zone should be situated between these values and an ambient temperature of 22°C should not provoke thermal stress.

Table X - Heritabilities of rectal temperature estimated from different samples.

Samples	Number of cows	Number of sires	k	Heritability estimates ^a		
				IRT	FRT	RTI
1	566	63	8.81	0.24 ± 0.13	0.31 ± 0.13	0.26 ± 0.12
2	618	64	9.49	0.25 ± 0.11	0.31 ± 0.12	0.27 ± 0.11
3	570	62	9.04	0.27 ± 0.12	0.27 ± 0.12	0.16 ± 0.11
4	607	63	9.48	0.17 ± 0.10	0.30 ± 0.12	0.20 ± 0.11
5	683	68	9.88	0.15 ± 0.09	0.20 ± 0.10	0.16 ± 0.10
6	686	69	9.76	0.19 ± 0.10	0.17 ± 0.10	0.18 ± 0.10

^aHeritability ± SE; k, numerical coefficient associated with sire variance.

Heritability estimates for FRT ranged from 0.17 ± 0.10 to 0.31 ± 0.13 for the various samples studied (Table X). These estimates are near those obtained by Seath (1947), 0.15 and 0.31, Legates (1953), 0.22, Turner (1982), 0.25, and Turner (1984), 0.31 and 0.34. In contrast, Cartwright (1955), Okamoto *et al.* (1963) and Donegan and Franklin (1979) obtained lower estimates. For selection, with a heritability of 0.30, a progeny test with seven daughters per bull is superior to selection on individual performance (Briquet Jr., 1967). Thus, selection of Pitangueiras cows for increased heat tolerance under the present conditions would be more accurate if performed by a progeny test involving seven or more daughters per sire.

Heritability estimates for RTI ranged from 0.16 ± 0.11 to 0.27 ± 0.11 (Table X). In earlier reports, Taneja (1966) obtained a value of 0.21, whereas Silva (1973) and Chan (1974) obtained 0.44 and 0.76. High heritabilities indicate that additive gene action is important. Differences obtained for heritability estimates for a single trait illustrate the fact that, in addition to varying with breed, population and time, this parameter also varies according to the samples studied, especially when their size is

small. Because they are obtained from small data samples, these estimates are expected to be quite variable and to be associated with large standard errors. Thus, decisions based on these results should be made with caution.

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RESUMO

O objetivo do presente trabalho foi avaliar o efeito de fontes de variação não genéticas sobre a temperatura retal de vacas Pitangueiras, bem como obter fatores de ajustamento e ainda estimar coeficientes de herdabilidade a serem utilizados nas decisões sobre seleção. As características de tolerância ao calor consideradas foram: temperatura retal inicial (TRI), temperatura retal final (TRF) e aumento da temperatura retal (ATR). Utilizou-se o método da correlação entre meio-irmãos paternos para estimar os coeficientes de herdabilidade. As médias observadas e o coeficiente de variação para as características de tolerância ao calor foram: TRI 38,43°C, 1,0%; TRF 39,21°C, 1,1%. Observou-se efeito significativo da hora da tomada da temperatura sobre a TRI e TRF; para a TRF verificou-se também efeitos significativos de ano da tomada e tonalidade da pelagem. Em seis diferentes amostras as estimativas dos coeficientes de herdabilidade variaram de $0,15 \pm 0,09$ a $0,27 \pm 0,12$ para TRI, $0,17 \pm 0,10$ a $0,31 \pm 0,13$ para TRF e de $0,16 \pm 0,10$ a $0,27 \pm 0,11$ para ATR. Os resultados indicam que na seleção para tolerância ao calor em bovinos Pitangueiras, maior acurácia pode ser obtida com o uso do teste de progênie com sete ou mais filhos por reprodutor.

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