GENETIC AND ENVIRONMENTAL VARIATION OF THE EFFECTIVE RADIATIVE PROPERTIES OF THE COAT IN HOLSTEIN CATTLE

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INTRODUCTION

The hair coat characteristics of cattle are important factors that affect the ability of an animal in supporting the tropical environment. Many reports have been published on the relationship between coat type and body temperature regulation, especially under the effects of solar radiation (Cena and Monteith, 1975; Hutchinson and Brown, 1969). Selection for production characteristics associated with that for physical characteristics of the coat would increase the fitness of Holstein cattle and may be considered as an interesting way for the genetic improvement of dairy cattle in tropical areas. This is the objective of the present study, in evaluating the genetic and environmental variation of the effective radiative and other properties of the coat in animals of that breed living in a tropical region.

MATERIAL AND METHODS

973 Holstein cows from a commercial herd in Descalvado, State of São Paulo, Brazil (21º01’42” S latitude, 47º50’28” W longitude and 860 meter high) were used. The animals, had 2 to 13 years of age, and were daughters of 793 dams and 205 sires. They were managed at intensive free-stall large-scale system, in housings with fans and sprinklers. Measurements of the coat thickness and color, and sampling of hair coat were carried out from November 2000 to April 2001. Coat color was defined as the percent black (MB) in relation to the body surface area, estimated by direct visual observation of both sides of each animal. Hair samples were taken according to Lee (1953) and coat morphological characteristics were measured according Silva (2001). The following coat traits were measured for both black and white coats: coat thickness, hair length, number of hairs per unit area and hair diameter. The radiative properties of coat and skin surfaces were obtained (Silva and LaScala, in preparation) : effective reflectivity (ρ^*_b for black and ρ^*_w for white), effective absorptivity (black α^*_b and white α^*_w), and effective transmissivity (black τ^*_b and white τ^*_w). These values were calculated with the formulas of Cena and Montheith (1975). The effective radiative properties of the coat were subdivided into three measurements according to the wavelength (300-420 nm, 420-780 nm and 780-850 nm).

The method of Restricted Maximum Likelihood (REML) was used to estimate variance and (co) variance components under the Animal Model. The program used was the MTDFREML (Multiple Trait Derivative Free Restricted Maximum Likelihood**,** Boldman *et al*. 1993), for which the initial value requested was estimated by the mixed model procedures of Statistical Analysis System (SAS, 1997). Variables departing from normality were transformed according to the method described by Box and Cox (1964). The animal model used to analyze the data was:

$$Y_{ijklm} = \alpha + g_i + m_j + a_k + o_l + b_1(T_{ijkl} - \overline{T}) + b_2(L_{ijkl} - \overline{L}) + b_3(N_{ijkl} - \overline{N}) + b_4(D_{ijkl} - \overline{D}) + \varepsilon_{ijklm}$$

where Y_{ijklm} were the average the effective radiative properties coat (ρ^*, α^* and τ^*) of the *m*th cow, g_i is the genetic merit of the *i*th animal m_j is the fixed effect of the *j*th month of sampling (j =1,…,6); a_k is the fixed effect of *k*th age class (k=1,…,6); o_l is the fixed effect of the *l*th origin of sire (l = 1,…,3); b_1 is the regression coefficient on coat thickness (T_{ijklm}), b_2 is the regression coefficient on hair length (L_{ijkl}), b_3 is the regression coefficient on the hair number (N_{ijklm}), b_4 is the regression coefficient on the hair diameter (D_{ijkl}), e_{ijklm} is the residual, including the random error, and α is the intercept.

RESULTS AND DISCUSSION

Table 1 shows the least-squares means for the black and the white spots of the coat. The means of the characteristics of the white coat were different from those of the black coat, the white coat having higher values, except for hair diameter. Similar results were presented by Udo (1978). It could be suggested that these differences would be associated to a better protection against solar radiation, needed in the areas covered by white coat. In Holsteins, the white coat always lays over a non-pigmented skin. Such a combination of white hairs and non-pigmented skin is the worst type of coat, regarding the effects of short wave radiation (Hutchinson and Brown 1969, Kovarik 1973, Silva *et al*. 2001).

Table 1. Least squares means of coat characteristics in Holstein cattle

	Proportion of black cover (%)	Coat thickness (mm):		Hair length (mm):		Number of hairs (cm^{-2}):		Hair diameter (μm):	
		black	White	black	White	black	White	black	White
Mean	71.13	2.35	2.75	12.05	14.26	932	1309	63.62	60.53
SE	0.920	0.0014	0.014	0.100	0.110	12	13	0.190	0.180

Table 2 shows the least squares means of the effective radiative properties of the coat, both black and white, according to the wavelength. It can be noted that the average effective reflectivity increased in the white and decreased in the black coat with the increased wavelength, a result similar to that presented by Cena and Monteith (1975). However, the absorptivity and the transmissivity of the black hairs did not change with the variation in the wavelength, perhaps due to the presence of high pigmentation in the coat as in the skin.

The higher effective transmission values of the black coat as compared to the white one was an unexpected finding. However, the values of τ used to calculate those properties and which were measured directly in the spectroradiometer were much higher in the white than in the black coat (Silva *et al.*2001), as it could be expected. A hypothesis we can present to explain that result could be the number of hairs per unit area of skin, which was lower in the black (932 hairs/cm^2) than in the white coat (1309 hairs/cm^2), because a higher hair population density can act as a shield against the incoming radiation. Davis and Birkebak (1974) and Gebremedhin *et al.*(1997) suggested the importance of the hair number for the protection given by the coat.

Table 2. Least squares means, Genetic (σ^2_g), Environmental (σ^2_e) and Phenotypic (σ^2_f) variances and heritabilities (h^2) of the effective radiative properties of the coat in Holstein cows, according to the wavelength

Properties	Wavelength (nm)	Mean	σ^2_f	σ^2_e	σ^2_g	h^2
Effective radiative transmissivity (τ*):						
Black	300-420	$0.018 \pm 1.5x10^{-3}$	0,108	0,105	0,0036	0,03±0,063
	420-780	$0.019 \pm 1.5x10^{-3}$	0,106	0,103	0,0035	0,03±0,063
	780-850	$0.019 \pm 1.5x10^{-3}$	0,106	0,101	0,0049	0,05±0,063
White	300-420	$0.005 \pm 9.6x10^{-4}$	0,128	0,119	0,0094	0,07±0,061
	420-780	$0.009 \pm 1.2x10^{-3}$	0,083	0,077	0,0063	0,08±0,061
	780-850	$0.011 \pm 1.4x10^{-3}$	0,069	0,064	0,0050	0,07±0,061
Effective radiative absorptivity (α*):						
Black	300-420	$0.930 \pm 1.4x10^{-3}$	7,163	6,896	0,266	0,04±0,064
	420-780	$0.940 \pm 1.4x10^{-3}$	49,637	47,208	2,429	0,05±0,066
	780-850	$0.940 \pm 1.5x10^{-3}$	52,618	50,002	2,615	0,05±0,066
White	300-420	$0.898 \pm 8.1x10^{-3}$	0,064	0,057	0,006	0,11±0,071
	420-780	$0.690 \pm 7.4x10^{-3}$	3,475	2,978	0,497	0,14±0,075
	780-850	$0.610 \pm 7.8x10^{-3}$	11,647	10,012	1,635	0,14±0,075
Effective radiative reflectivity (ρ*):						
Black	300-420	$0.052 \pm 5.0x10^{-7}$	0,8830	0,8830	0,00	0
	420-780	$0.042 \pm 2.0x10^{-5}$	31,815	31,815	0,00	0
	780-850	$0.041 \pm 3.0x10^{-5}$	52,742	52,742	0,00	0
White	300-420	$0.098 \pm 5.0x10^{-6}$	28,607	25,611	2,996	0,10±0,076
	420-780	$0.302 \pm 1.0x10^{-4}$	165,252	142,36	22,881	0,14±0,074
	780-850	$0.381 \pm 7.0x10^{-5}$	133,808	114,454	19,354	0,14±0,073
Proportion of black cover %		71.13± 0.920	774.17	191.97	582.20	0.75±0.076

The estimates of h^2 for the radiative properties (Table2) were not high and those for the effective reflectivity of black coat were zero, an expected result, as the variation of the characteristics of the black coat was of low magnitude. On the other hand, the h^2 estimate for the proportion of black coat was high, owing to its wide variation in the herd. The observed value of 0.75.

Positive genetic correlation of transmissivity with coat thikness, hair length and hair diameter (Table 3) is an evidence that the selection to a reduced transmissivity will reduce the coat thickness and the hair length, increasing the hair number, which is advantageous in a hot environment. However, the possible reduction of the hair diameter is not a desirable effect. The genetic correlations between reflectivity and morphological characteristics of the black coat were zero, as expected.

Table 3. Genetic (r_g) and environmental (r_e) correlation coefficients between the effective radiative properties and the coat characteristics of the black coat of Holstein cows, for wavelengths between 300 and 450 nm

Characteristics	Effective transmissivity correlation		Effective absorbtivity correlation		Effective reflectivity correlation	
	r_g	r_e	r_g	r_e	r_g	r_e
Coat thickness	0.38±0,692	0.067	1.00±2,883	-0.059	0	-0.026
Hair length	0.56±0,471	0.248	0.53±0,667	-0.108	0	-0.144
Hair number	-1.00±0,804	0.009	-0.56±0,56	-0.353	0	0.112
Hair diameter	0.41±0,381	0.034	-0.70±0,720	-0.255	0	-0.136

CONCLUSION

The morphological characteristics of the black coat were different from those of the white coat, especially for the hair number per unit area, which was greater in the white areas. For animals bred in tropical environments it is an advantageous feature, as this type of coat provides better protection against the shortwave radiation. Such a protection implies a dense, smooth coat, with long hairs. However, these features hinder heat dissipation by convection. Selection for predominantly black cows could be a good choice for the improvement of the resistance of Holstein cattle to the strong solar radiation in tropical regions, as it was suggested by Silva (2000). It could be easily performed considering the high heritability of the trait.

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