Genetic variation of the hair coat properties and the milk yield of Holstein cows managed under shade in a tropical environment

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Abstract

Present study is aimed at an evaluation of the genetic and environmental effects of the coat colour and physical characteristics on the first lactation yield in Holstein cows managed under shade. Data from 449 cows were analyzed by the least-squares method and Restricted Maximum Likelihood (REML) was used to estimate (co)variance components under the Animal Model. The results showed that predominantly white Holstein cows tended to present higher milk yield than those predominantly black, when managed in large stalls with fans and sprinklers in a tropical environment. The physical characteristics have negative association with milk yield, except for the hair diameter. This association favours the heat transfer through the coat and is widely favourable in hot environments. High heritability estimates together with the high genetic correlations of milk yield and the hair properties is an evidence of the possibility of a selection for increased milk yield together with the selection towards a less dense coat with thick, short, settled hairs.

Key-words:
Coat colour.
Genetic parameters.
Hair properties.
Holstein.
Milk yield.

Introduction

The ability of an animal to eliminate excessive body heat to its surrounding environment depends on the morphological characteristics of the hair coat (colour, thickness, hair characteristics) and on environmental variables (wind, radiation, air temperature and humidity). Coat colour has been directly related to the amount of absorbed or reflected radiation[1,2] while those physical properties of the coat (number of hairs per unit area, hair length, hair diameter and coat thickness) are an important part of the thermal insulation of mammals[3], influencing the sensible and latent heat losses from the surface of skin to the coat surface[1,4,5,6,7,8].

Animals (cattle, sheep and others) having very dense coats with long, thin hairs present lower thermal conductance than those with less dense coats with short, thick hair[3,7,8]. Their heat loss efficiency is low, due to the air trapped among the hair[5]. Such features are desirable in a temperate climate, but in a tropical environment with high levels of air temperature and solar radiation it is needed an increased dissipation of heat from animals to the environment in order to favour the production[9,10] and reproduction traits[11].

The purpose of the present study was to evaluate the genetic and environmental effects of the coat colour and the physical characteristics of the hair coat on the first lactation of Holstein cows managed in a tropical environment.

Materials and Methods

Records of the first lactation of 449 Holstein cows from a commercial herd in

Descalvado, State of São Paulo, Brazil (22º01' S latitude, 47º53' W longitude and 856m altitude) were used. These animals were managed under intensive free-stall large-scale system in housings with fans and sprinklers.

Milk yield records were adjusted for 305 days, according to correction factors of Torres et al.[12]. Coat colour was defined as the percentage of black spots in relation to the body surface area[13].

As the hairs in the different colour spots of Holsteins have different physical properties[13], these characteristics were considered separately for the black and white areas. Hair properties were determined as follows:

Coat thickness (T):

$$T = \beta T_b + \omega T_w \quad \text{(mm)}$$

Hair length (L):

$$L = \beta L_b + \omega L_w \quad \text{(mm)}$$

Number of hairs per unit area (N):

$$N = NT_b \; N \; \omega T_w \quad \text{(hairs/cm}^2\text{)}$$

Hair diameter (D):

$$D = \Delta T_b + \omega D_w \quad (\mu\text{m})$$

The coefficients β and ω refer to the amount of black and white areas respectively, in relation to the total body surface area. The subscripts b and w refer to black and white coats respectively. Coat thickness was measured by using a thin metal rule. Hair length was determined as the average of the ten longest hairs of each sample measured with a digital calliper. The number of hairs was established by direct count, and the diameter was the average of those of the ten longest hairs, measured with a Mitutoyo micrometer.

Hair samples were taken during the period of November 2000 to March 2001, from a site located 20cm below the dorsal line in the centre of the thorax, for the black and the white coat separately, by using adapted pliers according to Lee[14] and the methods described by Silva[15].

The proportion of black spot area (b) showed lack of normality in the error distribution, and therefore was transformed to β_t=arcsin$(\beta+1)^{0.5}$ before the analysis was performed.

Mathematical Model and Statistical Analysis

The data were analyzed by the least-square method[16] available in the GLM software of the Statistical Analyses System[17]. The mathematical model used for milk yield was:

$$Y_{ijklm}=\alpha+o_i+a_j+c_k+s_{il}+b_1(T_{ijkl})+b_2(L_{ijkl}) +b_3(N_{ijkl})+b_4(D_{ijkl})+\varepsilon_{ijklm} \quad ...[1]$$

Where Y_{ijklm} was the milk yield of the *m*th cow; o_i is the fixed effect of the *i*th sire origin (i = 1,…,3); a*j* is the fixed effect of *j*th the class age at first calving (j = 1,…,4); c_k is the fixed effect of the *k*th class percentage of black spots (k = 1,...,3); s_{il} is the random effect of the *l*th sire within of the *i*th origin; b_1 is the regression coefficient on coat thickness (T_{ijkl}), b_2 is the regression coefficient on hair length (L_{ijkl}), b_3 is the regression coefficient on the hair number (N_{ijkl}), b_4 is the regression coefficient on hair diameter (D_{ijkl}), ε_{ijklm} is the residual, including the random error, and is the intercept. The overall mean was given by:

$$\hat{\mu} = \hat{\alpha} + \hat{b}_1\overline{T} + \hat{b}_2\overline{L} + \hat{b}_3\overline{N} + \hat{b}_4\overline{D}$$

where $\overline{T}, \overline{L}, \overline{N}$ and $\overline{D}$ are the average values of the coat thickness, hair length, number of hair per unit area and hair diameter, respectively.

The method of Restricted Maximum

Likelihood (REML) was used in the univariate and bivariate analyses to estimate variance and covariance components under the Animal Model. The program used was the MTDFREML (Multiple Trait Derivative Free Restricted Maximum Likelihood)[18]. The animal model used to analyze the data was:

$$Y = 1\mu + X\beta + Za + e \qquad [2]$$

where Y is a nx1 vector of observations for each trait, μ is the overall mean, 1 is an nx1 vector for which entries are all ones, X is the nxp incidence matrix of fixed effects, including observations for covariates; β is an px1 vector of fixed effects and covariates; Z is the nxg incidence matrix for animal effects; a is the gx1 vector of random animal effects and e is the nx1 vector of random residual effects. Others definitions:

n = total number of cows with measurements = 449;

g = number of animals in the additive relationship matrix = 1374; and

p = number of levels of fixed effects and covariates.

For model 2 the mixed model equations are

$$\begin{bmatrix} 1'1 & 1'X & 1'Z \\ X'1 & X'X & X'Z \\ Z'1 & Z'X & Z'Z + A^{-1}\alpha \end{bmatrix} \begin{bmatrix} \mu \\ \beta \\ a \end{bmatrix} = \begin{bmatrix} 1'Y \\ X'Y \\ Z'Y \end{bmatrix}$$

with $\alpha = \sigma^2_e / \sigma^2_a$, where A is the additive relationship matrix, σ^2_a is the additive variance, and σ^2_e is the residual variance.

Thus, for the analysis of milk yield the fixed effects considered were the same as for model 1. For the physical characteristics of the coat (T, L, N and D) the fixed effects considered were: month of sampling (1,...,5), age class (1,...,5), sire origin (1,...,3). For the proportion of black spots (β) the only fixed effect considered was the sire origin (1,...,3). Animal was the random effect for all traits.

Results and Discussion

The arithmetic mean (SE) 305-d for milk yield (8682.31 71.36kg) of the cows analyzed is in table 1. It was greater than the values 3415.80kg; 1264.22kg; 6939.08kg; 8222kg and 3741kg reported by Vale and Nali[19]; Rorato et al.[20], Torres et al.[12], Pinheiro[21] and Morais[22], respectively for Holstein cows in Brazil. Management practices were probably the cause of this greater yield observed. The cows were milked three times daily, fed with a balanced total ration all the year, and housed in large stalls with fans and sprinklers. Goodwin et al.[10] and Roman-Ponce, Cabello-Frias and Wilcox[23] observed that cows with access to shade and spray had higher milk yield than cows with no shade available.

The means of the physical characteristics of coat and proportion of black spots are given in table 1. It is interesting to note the diameter of the hair observed in the present study, which was higher than that reported in temperate climates for Holsteins. In general, cattle hair is thicker in inter-tropical areas than in the temperate ones, as it can be deduced from the literature values of 39.3 and 37.7 μm for black and white hairs, receptively Udo[24] and 29.11 μm, Rawia et al.[25].

The coat layer thickness, hair density (number of hair per unit area) and hair length even exceed 8 mm, 1400 hair.cm^{-2} and 24 mm, respectively for animals bred in temperate regions[24,25]. However, those animals of the same breed but acclimated to tropical climates present very thin coats and less dense with short hair, even less than 3 mm to thickness[26,27]; its hair density is about 1000 hair.cm^{-2} [21,28] and the hair length about 14 mm[22,28].

The results obtained in the present study agree to which was expected. In fact, the above mentioned differences among climates in the hair coat are not coincidental, for a coat with thick, short, packed, well settled hairs presents a very low resistance for the heat flux from the skin to the coat

Table 1 - Averages (± SE), standard deviation and median of milk yield, percentage of black spots and coat physical characteristics in 449 Holstein cows

Traits	Mean	Standard deviation	Median
Milk yield (kg):	8682.31±71.364	1517.23	8780.765
Percentage of black spots:	69.78±13.60	29.04	83.00
Physical characteristics of coat			
Coat thickness (mm):	2.48±0.022	0.471	2.50
Hair length (mm):	12.39±0.143	3.080	12.05
Number of hairs (hairs/cm²):	1004±18	391	952
Hair diameter (μm):	62.18±0.249	5.27	62.45

surface[5,6,7,8].

The ANOVA applied to milk yield (Table 2) showed significance for the effect of sire origin, but not for other fixed effects. With respect to the covariates, the number of hairs per unit area was only nearly significant (P>0.06).

The regression coefficients for coat thickness, hair length and hair density were negative, while those for the hair diameter was positive. Other papers reported similar results for hair length[29] and for coat thickness[25]. These results agree with those described by theoretical physics of heat transfer in hair coats[1,5,6,7,8,30] where coat with thick, short, packed, well settled hair presents high latent and sensible flux from the skin to the coat surface.

Milk yield was greater in the cows sired by bulls from USA than in the cows sired by bulls of Brazilian origin (table 3). This result might be attributed to the genetic superiority of those bulls for milk yield.

Milk yield in predominantly white cows also tended to be greater than that of predominantly black cows. These results relating the percentage of black spots are in agreement with the observations of Hansen[9], Becerril et al.[31], and Goodwin et al.[10]. On average, daily milk yield in shaded environments was 23.1kg for black cows and 25.2kg for white cows[9]. Goodwin et al.[10] showed that milk yield was 1.64 l/day greater for predominantly white animals (P<0.05), relatively to those predominantly black (>60% black spots).

The lower milk yield in predominantly black cows could be due to the greater thermal balance by radiation in black coat[2,29,32]. Greater absorption of thermal radiation contributes to increased coat surface and rectal temperatures[1,9,33,34], which consequently reduces the ability of the animal to dissipate heat. Thus, contributes to the increase of the thermal stress and decreased milk yield[9,10]. Predominantly white cows do not present such problems, due to the lower absorption and higher reflection of solar radiation[32].

The heritability estimate for milk yield is in table 4. It is in the range of those typically

Table 2 - Analysis of variance for milk yield in Holstein cows

Source of variation			D.F.	Mean squares	*P*>F
Sire origin			2	14504935.3	0.0011
Class age at first calving			3	4888359.6	0.0728
Sire within origin			140	2392546.8	0.1635
Class percentage of black spots			2	3637713.6	0.1762
Regression	Coefficients	*P*>*t*			
Coat thickness	-161.878	0.4811	1	1096194.5	0.4687
Hair length	-12.653	0.7238	1	229940.7	0.7399
Number of hairs	-0.454	0.0535	1	7917150.9	0.0522
Hair diameter	13.651	0.4859	1	795660.8	0.5370
Residual			297	2082786.0	

Table 3 - Least squares means for milk yield, according to the class of percentage of black spots, origin of sire and age class at first calving

% black spots	Number of cows	Milk yield (kg)
0 – 30	65	8666.48[a]
30 – 70	102	8186.38[a]
70 – 100	285	8201.21[a]
Origin of sire		
Brazil	51	7682.456[b]
Canada	79	8619.590[ab]
USA	322	8752.039[a]
Class age at first calving (months)		
20 – 27	304	8170.084[a]
27 – 29	91	8328.046[a]
29 – 31	40	8936.940[a]
31 – 60	14	7970.376[a]

[a, b] different superscripts within columns are significantly different by test Tukey ($P < 0.01$)

reported in the literature[21,31,35] while those heritability estimates to physical characteristics of the coat were moderately high, except for the number of hair per unit area. Silva et al.[36] estimated heritabilities of 0.23±0.12 and 0.08±0.08 for coat thickness and hair length, respectively, in Jersey cows. Pinheiro[21] found values of 0.00 and 0.20 for the same traits in Holstein cows.

The phenotypic and genetic correlations showed negative associations between milk yield, proportion of black spots and physical characteristics of the coat (table 5) except hair diameter. Low phenotypic correlations are in agreement with Pinheiro[21]. Is interesting to note the genetic correlations, which were higher than the phenotypic ones. Searle[37] observed similar results. It is an astonishing result, as the phenotype includes genotype and one might anticipate the correlation between phenotypes to be larger than that between genotypes. However, Searle[38] found such problem in his study and later he explained that the phenotypic correlation is lower than the genetic correlation when the ratio of the environmental to the genetic correlation $(R = r_e / r_g)$ is lower than the value of $K = (1 - \sqrt{h_1 h_2}) / \sqrt{(1 - h_1)(1 - h_2)}$, where h_1 and h_2 are the h^2 estimates for traits 1 and 2, respectively. This just occurred in the present study. A phenotypic correlation lower than its genetic counterpart, together with a small positive environmental correlation, occurs where the environments pertaining to the expression of these traits have a low correlation[38] . The low environmental correlation observed in the present study might be due to the greater control of the environments by of the alleviating of the heat load, thus favouring a better expression of the genotypes.

The genetic correlations show negative but strong associations between milk yield and the other traits studied. These genetic correlations show that selection to increase milk yield in a tropical environment went with an indirect negative selection for physical characteristics of the coat, except for diameter. Of course, that selection to increased milk yield, aiming to a selection of Holstein cows with less dense coat and short, settled hairs is highly desirable in tropical environments, but it will contribute to decrease the percentage of black spots. This last effect would not be a problem for animals under permanent shade.

Conclusion

Predominantly white Holstein cows tended to present higher milk yield than the predominantly black ones, when managed in large stalls with fans and sprinklers ever in

Table 4 - Additive genetic (σ^2_a), environmental (σ^2_e) and phenotypic (σ^2_p) variances and heritabilities (h^2) for milk yield, proportion of black spots and physical characteristics of coat in 449 Holstein cows

Traits	σ^2_p	σ^2_e	σ^2_a	h^2
Milk yield	2252173.005	1490004.04	762168.95	0.34±0.000
Proportion of black spots*	-	-	-	0.75±0.076
Coat thickness	0.20987	0.17106	0.03881	0.18±0.120
Hair length	8.53569	5.26534	3.27036	0.38±0.143
Number of hairs	133231.4267	125665.776	7565.6502	0.06±0.056
Hair diameter	25.39840	15.56313	9.83527	0.39±0.144

*Source Maia et al., (2003)

Table 5 - Genetic (r_a), environmental (r_e) and phenotypic (r_p) correlation coefficients between milk yield and percentage of black spots and physical characteristics of coat in Holstein cows

Traits	Milk yield		
	r_g	r_e	r_p
Percentage of black spots	-0.18±0.000	-0.03±0.000	-0.09
Coat thickness	-0.99±0.365	0.03±0.115	-0.21
Hair length	-0.52±0.266	0.06±0.149	-0.15
Number of hairs	-0.82±0.258	0.02±0.000	-0.13
Hair diameter	0.07±0.293	0.01±0.150	0.03

tropical environments.

The proportion of black spots and the physical characteristics of the coat present negative associations with milk yield, except for hair diameter.

High heritability estimates together with the high genetic correlations between milk yield and hair properties show that it is possible to make a selection for increased milk yield and adaptation traits together, aiming to a less dense coat with thick, short, settled hairs which are the most desirable in

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Variação genética das características do pelame e da produção de leite em vacas Holandesas manejadas à sombra em ambiente tropical

Resumo

O presente estudo realizou uma avaliação genética e ambiental dos efeitos da cor e das características físicas do pelame sobre a produção de leite na primeira lactação de vacas Holandesas manejadas sobre sombra. Os dados são pertencentes a 449 vacas Holandesas e foram analisados pelo método de quadrados mínimos. O método da Máxima Verossimilhança Restrita (REML) foi utilizada para estimar os componentes de variância e covariância sob o modelo Animal. Os resultados mostraram que vacas Holandesas predominantemente brancas tendem a apresentar maior produção de leite do que aquelas predominantemente negras em um ambiente tropical, quando manejadas em free-stall providos de ventilação e aspersão. As características físicas do pelame apresentaram uma associação negativa com a produção de leite, exceto o diâmetro dos pêlos. Essa associação favorece a transferencia de calor através do pelame e, é amplamente favorável em ambientes quentes. As altas estimativas de herdabilidade

Palavras-chave:
Cor Pelame.
Parâmetros Genéticos.
Propriedades Pêlos.
Holandesas.
Produção de Leite.

juntamente com as altas correlações genéticas da produção de leite com aquelas propriedades físicas do pelame é uma evidencia da possibilidade de realizar uma seleção genética para aumento da produção de leite juntamente com uma seleção na direção de um pelame menos denso com pêlos grossos, curtos e assentados.

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Likelihood (REML) was used in the univariate and bivariate analyses to estimate variance and covariance components under the Animal Model. The program used was the MTDFREML (Multiple Trait Derivative Free Restricted Maximum Likelihood)[18]. The animal model used to analyze the data was:

$$Y = 1\mu + X\beta + Za + e \quad [2]$$

where Y is a nx1 vector of observations for each trait, μ is the overall mean, 1 is an nx1 vector for which entries are all ones, X is the nxp incidence matrix of fixed effects, including observations for covariates; β is an px1 vector of fixed effects and covariates; Z is the nxg incidence matrix for animal effects; a is the gx1 vector of random animal effects and e is the nx1 vector of random residual effects. Others definitions:

n = total number of cows with measurements = 449;

g = number of animals in the additive relationship matrix = 1374; and

p = number of levels of fixed effects and covariates.

For model 2 the mixed model equations are

$$\begin{bmatrix} 1'1 & 1'X & 1'Z \\ X'1 & X'X & X'Z \\ Z'1 & Z'X & Z'Z + A^{-1}\alpha \end{bmatrix} \begin{bmatrix} \mu \\ \beta \\ a \end{bmatrix} = \begin{bmatrix} 1'Y \\ X'Y \\ Z'Y \end{bmatrix}$$

with $\alpha = \sigma^2_e / \sigma^2_a$, where A is the additive relationship matrix, σ^2_a is the additive variance, and σ^2_e is the residual variance.

Thus, for the analysis of milk yield the fixed effects considered were the same as for model 1. For the physical characteristics of the coat (T, L, N and D) the fixed effects considered were: month of sampling (1,...,5), age class (1,...,5), sire origin (1,...,3). For the proportion of black spots (β) the only fixed effect considered was the sire origin (1,...,3). Animal was the random effect for all traits.

Results and Discussion

The arithmetic mean (SE) 305-d for milk yield (8682.31 71.36kg) of the cows analyzed is in table 1. It was greater than the values 3415.80kg; 1264.22kg; 6939.08kg; 8222kg and 3741kg reported by Vale and Nali[19]; Rorato et al.[20], Torres et al.[12], Pinheiro[21] and Morais[22], respectively for Holstein cows in Brazil. Management practices were probably the cause of this greater yield observed. The cows were milked three times daily, fed with a balanced total ration all the year, and housed in large stalls with fans and sprinklers. Goodwin et al.[10] and Roman-Ponce, Cabello-Frias and Wilcox[23] observed that cows with access to shade and spray had higher milk yield than cows with no shade available.

The means of the physical characteristics of coat and proportion of black spots are given in table 1. It is interesting to note the diameter of the hair observed in the present study, which was higher than that reported in temperate climates for Holsteins. In general, cattle hair is thicker in inter-tropical areas than in the temperate ones, as it can be deduced from the literature values of 39.3 and 37.7 μm for black and white hairs, receptively Udo[24] and 29.11 μm, Rawia et al.[25].

The coat layer thickness, hair density (number of hair per unit area) and hair length even exceed 8 mm, 1400 hair.cm^{-2} and 24 mm, respectively for animals bred in temperate regions[24,25]. However, those animals of the same breed but acclimated to tropical climates present very thin coats and less dense with short hair, even less than 3 mm to thickness[26,27]; its hair density is about 1000 hair.cm^{-2} [21,28] and the hair length about 14 mm[22,28].

The results obtained in the present study agree to which was expected. In fact, the above mentioned differences among climates in the hair coat are not coincidental, for a coat with thick, short, packed, well settled hairs presents a very low resistance for the heat flux from the skin to the coat

Table 1 - Averages (± SE), standard deviation and median of milk yield, percentage of black spots and coat physical characteristics in 449 Holstein cows

Traits	Mean	Standard deviation	Median
Milk yield (kg):	8682.31±71.364	1517.23	8780.765
Percentage of black spots:	69.78±13.60	29.04	83.00
Physical characteristics of coat			
Coat thickness (mm):	2.48±0.022	0.471	2.50
Hair length (mm):	12.39±0.143	3.080	12.05
Number of hairs (hairs/cm^2):	1004±18	391	952
Hair diameter (μm):	62.18±0.249	5.27	62.45

surface[5,6,7,8].

The ANOVA applied to milk yield (Table 2) showed significance for the effect of sire origin, but not for other fixed effects. With respect to the covariates, the number of hairs per unit area was only nearly significant (P>0.06).

The regression coefficients for coat thickness, hair length and hair density were negative, while those for the hair diameter was positive. Other papers reported similar results for hair length[29] and for coat thickness[25]. These results agree with those described by theoretical physics of heat transfer in hair coats[1,5,6,7,8,30] where coat with thick, short, packed, well settled hair presents high latent and sensible flux from the skin to the coat surface.

Milk yield was greater in the cows sired by bulls from USA than in the cows sired by bulls of Brazilian origin (table 3). This result might be attributed to the genetic superiority of those bulls for milk yield.

Milk yield in predominantly white cows also tended to be greater than that of predominantly black cows. These results relating the percentage of black spots are in agreement with the observations of Hansen[9], Becerril et al.[31], and Goodwin et al.[10]. On average, daily milk yield in shaded environments was 23.1kg for black cows and 25.2kg for white cows[9]. Goodwin et al.[10] showed that milk yield was 1.64 l/day greater for predominantly white animals (P<0.05), relatively to those predominantly black (>60% black spots).

The lower milk yield in predominantly black cows could be due to the greater thermal balance by radiation in black coat[2,29,32]. Greater absorption of thermal radiation contributes to increased coat surface and rectal temperatures[1,9,33,34], which consequently reduces the ability of the animal to dissipate heat. Thus, contributes to the increase of the thermal stress and decreased milk yield[9,10]. Predominantly white cows do not present such problems, due to the lower absorption and higher reflection of solar radiation[32].

The heritability estimate for milk yield is in table 4. It is in the range of those typically

Table 2 - Analysis of variance for milk yield in Holstein cows

Source of variation			D.F.	Mean squares	*P*>F
Sire origin			2	14504935.3	0.0011
Class age at first calving			3	4888359.6	0.0728
Sire within origin			140	2392546.8	0.1635
Class percentage of black spots			2	3637713.6	0.1762
Regression	Coefficients	*P*>*t*			
Coat thickness	-161.878	0.4811	1	1096194.5	0.4687
Hair length	-12.653	0.7238	1	229940.7	0.7399
Number of hairs	-0.454	0.0535	1	7917150.9	0.0522
Hair diameter	13.651	0.4859	1	795660.8	0.5370
Residual			297	2082786.0	

Table 3 - Least squares means for milk yield, according to the class of percentage of black spots, origin of sire and age class at first calving

% black spots	Number of cows	Milk yield (kg)
0 – 30	65	8666.48[a]
30 – 70	102	8186.38[a]
70 – 100	285	8201.21[a]
Origin of sire		
Brazil	51	7682.456[b]
Canada	79	8619.590[ab]
USA	322	8752.039[a]
Class age at first calving (months)		
20 – 27	304	8170.084[a]
27 – 29	91	8328.046[a]
29 – 31	40	8936.940[a]
31 – 60	14	7970.376[a]

[a, b] different superscripts within columns are significantly different by test Tukey (P < 0.01)

reported in the literature[21,31,35] while those heritability estimates to physical characteristics of the coat were moderately high, except for the number of hair per unit area. Silva et al.[36] estimated heritabilities of 0.23±0.12 and 0.08±0.08 for coat thickness and hair length, respectively, in Jersey cows. Pinheiro[21] found values of 0.00 and 0.20 for the same traits in Holstein cows.

The phenotypic and genetic correlations showed negative associations between milk yield, proportion of black spots and physical characteristics of the coat (table 5) except hair diameter. Low phenotypic correlations are in agreement with Pinheiro[21]. Is interesting to note the genetic correlations, which were higher than the phenotypic ones. Searle[37] observed similar results. It is an astonishing result, as the phenotype includes genotype and one might anticipate the correlation between phenotypes to be larger than that between genotypes. However, Searle[38] found such problem in his study and later he explained that the phenotypic correlation is lower than the genetic correlation when the ratio of the environmental to the genetic correlation $(R = r_e / r_g)$ is lower than the value of $K = (1-\sqrt{h_1 h_2})/\sqrt{(1-h_1)(1-h_2)}$, where h_1 and h_2 are the h^2 estimates for traits 1 and 2, respectively. This just occurred in the present study. A phenotypic correlation lower than its genetic counterpart, together with a small positive environmental correlation, occurs where the environments pertaining to the expression of these traits have a low correlation[38] . The low environmental correlation observed in the present study might be due to the greater control of the environments by of the alleviating of the heat load, thus favouring a better expression of the genotypes.

The genetic correlations show negative but strong associations between milk yield and the other traits studied. These genetic correlations show that selection to increase milk yield in a tropical environment went with an indirect negative selection for physical characteristics of the coat, except for diameter. Of course, that selection to increased milk yield, aiming to a selection of Holstein cows with less dense coat and short, settled hairs is highly desirable in tropical environments, but it will contribute to decrease the percentage of black spots. This last effect would not be a problem for animals under permanent shade.

Conclusion

Predominantly white Holstein cows tended to present higher milk yield than the predominantly black ones, when managed in large stalls with fans and sprinklers ever in

Table 4 - Additive genetic (σ^2_a), environmental (σ^2_e) and phenotypic (σ^2_p) variances and heritabilities (h^2) for milk yield, proportion of black spots and physical characteristics of coat in 449 Holstein cows

Traits	σ^2_p	σ^2_e	σ^2_a	h^2
Milk yield	2252173.005	1490004.04	762168.95	0.34±0.000
Proportion of black spots*	-	-	-	0.75±0.076
Coat thickness	0.20987	0.17106	0.03881	0.18±0.120
Hair length	8.53569	5.26534	3.27036	0.38±0.143
Number of hairs	133231.4267	125665.776	7565.6502	0.06±0.056
Hair diameter	25.39840	15.56313	9.83527	0.39±0.144

*Source Maia et al., (2003)

Table 5 - Genetic (r_a), environmental (r_e) and phenotypic (r_p) correlation coefficients between milk yield and percentage of black spots and physical characteristics of coat in Holstein cows

Traits	Milk yield		
	r_g	r_e	r_p
Percentage of black spots	-0.18±0.000	-0.03±0.000	-0.09
Coat thickness	-0.99±0.365	0.03±0.115	-0.21
Hair length	-0.52±0.266	0.06±0.149	-0.15
Number of hairs	-0.82±0.258	0.02±0.000	-0.13
Hair diameter	0.07±0.293	0.01±0.150	0.03

tropical environments.

The proportion of black spots and the physical characteristics of the coat present negative associations with milk yield, except for hair diameter.

High heritability estimates together with the high genetic correlations between milk yield and hair properties show that it is possible to make a selection for increased milk yield and adaptation traits together, aiming to a less dense coat with thick, short, settled hairs which are the most desirable in

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Variação genética das características do pelame e da produção de leite em vacas Holandesas manejadas à sombra em ambiente tropical

Resumo

O presente estudo realizou uma avaliação genética e ambiental dos efeitos da cor e das características físicas do pelame sobre a produção de leite na primeira lactação de vacas Holandesas manejadas sobre sombra. Os dados são pertencentes a 449 vacas Holandesas e foram analisados pelo método de quadrados mínimos. O método da Máxima Verossimilhança Restrita (REML) foi utilizada para estimar os componentes de variância e covariância sob o modelo Animal. Os resultados mostraram que vacas Holandesas predominantemente brancas tendem a apresentar maior produção de leite do que aquelas predominantemente negras em um ambiente tropical, quando manejadas em free-stall providos de ventilação e aspersão. As características físicas do pelame apresentaram uma associação negativa com a produção de leite, exceto o diâmetro dos pêlos. Essa associação favorece a transferencia de calor através do pelame e, é amplamente favorável em ambientes quentes. As altas estimativas de herdabilidade

Palavras-chave:
Cor Pelame.
Parâmetros Genéticos.
Propriedades Pêlos.
Holandesas.
Produção de Leite.

juntamente com as altas correlações genéticas da produção de leite com aquelas propriedades físicas do pelame é uma evidencia da possibilidade de realizar uma seleção genética para aumento da produção de leite juntamente com uma seleção na direção de um pelame menos denso com pêlos grossos, curtos e assentados.

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