Rev. Brasil. Genet. 17, 1, 65-68 (1994)
(Brazil. J. Genetics)

GENETIC EFFECTS AND RELATIONSHIP OF MILK PRODUCTION AND PERCENTAGE OF WHITE COAT IN A SUBTROPICAL HOLSTEIN HERD*

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ABSTRACT

First lactations of 795 cows in the Florida Agricultural Experiment Station dairy herd from 1960 through 1989 were analyzed. Percentage of white coat was obtained by visual evaluation of drawings on registry certificates. Phenotypic correlation between percentage of white (WP) on the two sides of the body was .97 ($P < .01$). The distribution of individual percentages was not normal ($P < .01$) (skewed to the right), with mean, standard deviation, median and mode of 23.9, 25.6, 15 and 0, describing a mostly black cow sample. Least squares means for milk and fat yields, fat percent and percent white were 4556 kg, 166 kg, 3.46%, and 23.5%. Percentage white was related linearly (positively) with milk yield, with $\beta = 2.75$ kg (per 1% white). Interactions of percentage white and calving season were detected for fat yields; regressions were $\beta = .21$ kg and $\beta = .002$ kg for cool (Oct - Mar) and warm (Apr - Sept) seasons. Interaction also was important for fat percentage. Heritability of percentage white from intraclass (paternal half-sib) correlation was .77; genetic correlations of white color with milk yield, fat yield and fat percent were -.12, -.39, and -.38. Additional research seems warranted to establish the relationships of percentage white color and economically important traits of dairy cattle.

INTRODUCTION

Hair coat color of cattle is important to many cattlemen because it is a characteristic that allows easy differentiation of cattle and breeds. Coat color allows one to differentiate among individuals within the same breed in terms of intensity, patterns and amounts of each color. There exists considerable variety in coat colors among cattle breeds, ranging from solid black (Angus) through pure white (Charolais). There also are cattle breeds with more than one color, such as Hereford, Indubrasil and Simmental in beef, and Holstein and Guernsey in dairy. Many breed associations have tried to characterize their breeds with a specific color pattern, and use it as a trademark, especially at early stages of breed formation. Coat color also may be related to productivity, because color of hair coat is directly related to absorption of solar radiation (Stewart, 1953), and thereby affects heat flux on the surface of the cow (Finch, 1986; Hansen, 1990).

Stewart (1953) described the physics of absorption and reflection of solar radiation by cattle hair. The absorption coefficient was defined as the percentage of solar radiation an animal absorbs on exposure to direct sunlight. Solid black cows absorb 92% of the incident solar radiation through their coats, twice as much as solid white cows.

In subtropical climates, the degree of solar radiation is negatively associated with milk yield (Sharma *et al.*, 1983) and reproduction (Badinga *et al.*, 1985; Gwazdauskas *et al.*, 1975), among other things. Coat color (relative amounts of black or white) could affect the ability of Holsteins to resist effects of heat stress associated with a high incidence of solar radiation. White coat color was found to interact with season in the effect on reproductive traits of first lactation Holsteins (King *et al.*, 1988). Also, whiter cows showed fewer detrimental effects when exposed to high incident solar radiation (Hansen, 1990).

In Holsteins, coat color can be characterized by the proportion of different amounts of black and white, ranging from mostly black animals to individuals with almost no black. The amount of spotting on the coat of Holsteins can

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* Florida Agricultural Experiment Station Journal Series No. R02919.

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be measured easily by visual evaluation of drawings of the animal (Becerril and Wilcox, 1992). This method is an important tool for obtaining data from animals which are no longer available for inspection.

Neither the relationship between Holstein coat color and performance nor its genetic and environmental interrelationships with productivity have been studied extensively. Heritability of Holstein coat color has been estimated and considered to be over .90 (Briquet and Lush, 1947), but no genetic correlations with productivity have been reported. The objectives of this research were to study relationships of degree of white coat color with productive traits such as milk and fat yields, and fat percentage, and to estimate heritability and genetic correlations between such traits.

Table I - Least squares means and standard deviations (SD) of traits under study.

Trait	Mean	SD
Milk yield (kg)	4556	1720
Fat yield (kg)	166	73.3
Fat percentage	3.46	1.24
WPL	23.3	25.1
WPR	23.7	25.8
WPA	23.5	25.2

WPL, white percentage left, right (WPR), and average of left and right (WPA). Mathematical model included year, days in milk, and sire for milk and fat yields and fat percentage.

MATERIAL AND METHODS

First lactation production records and registry certificates of 795 Holstein cows, producing from 1960 through 1989 at the Dairy Research Unit of the University of Florida, were used in this study. The initial data set consisted of approximately 1000 first lactation records; abnormal records and those with incomplete information were deleted. Both registered and grade cows were included. During the last decade, most cows had access to shade and were provided with fans and sprinklers to reduce adverse environmental effects. White coat color percentage (WP) measurements were obtained by visual evaluations of the upper body (head, neck, and trunk) as described by Becerril and Wilcox (1992).

For this data set both sides of each cow were evaluated. Statistical analysis was done by the method of ordinary least squares analysis of variance and restricted maximum likelihood (Harvey, 1990). Mathematical models for effects of WP on production traits included year, calving season (cool, October to March, and warm, April to September), year by calving season interactions, age and days in milk, WP and the interaction WP by calving season, as fixed effects; sire was the only random effect besides the error term. For genetic correlations, WP was considered to be a dependent variable with the other remaining factors in the model. For estimation of heritability of WP, no fixed effects were included in the model, since none were expected and none were found in preliminary analyses.

RESULTS AND DISCUSSION

Least squares means and standard deviations are presented in Table I. Milk and fat yields can be considered low for current Florida conditions, but the present results come from 30 years of data. As expected, means for white coat color were almost the same for left and right sides of the same cow. The estimate of 23% WP was higher than the 13% WP obtained from a small sample of 32 observations (Becerril and Wilcox, 1992) from the same herd, although the latter sample was taken from the foundation cows which happened to be mostly black. The standard deviations of 25 also were higher than the value of 13 obtained before, although the coefficient of variation also was over 100%. Mode and median were 0 and 15, agreeing with previous results. All of these results indicate that the Holsteins in this herd were mostly black on their upper body. With 50% of the cows less than 15% white, and lower frequencies for higher WP values, the distribution of values was skewed to the right, also agreeing with previous results (Becerril and Wilcox, 1992).

Linear effects of WP on milk yield were found to be significant ($P < .02$) with $\beta = 2.75 \pm 1.13$ kg per 1% white. There was no evidence of a curvilinear relationship. Thus, a solid white cow would be expected to produce 275 kg more milk than a solid black cow in her first lactation, if other factors were constant. This value might be even higher in commercial dairies with no facilities to protect cows against adverse climatic effects, such as solar radiation, or for production systems based on grazing. This result disagreed with that of King *et al.* (1988), who did not find that coat color affected milk yield under commercial conditions in Arizona, that include environmental modification during summer.

For fat yield and percentage, interactions between coat color and season were significant. WP showed a significant linear effect on fat yield and percentage for cows freshening during the cool season, $\beta = .207 \pm .063$ kg ($P < .04$) and $\beta = .0018 \pm .0010\%$ ($P < .09$). For the warm season, linear regressions for these traits on WP were not statistically different from zero.

Least squares estimates of heritability, and genetic and phenotypic correlations for three different measures of

Table II - Heritability[1], genetic and phenotypic correlations between white percentage left (WPL), right (WPE) and average (WPA).

Trait	WPL	WPR	WPA
WPL	.770	.816	.949
	(.145)		
WPR	1.006	.741	.957
	(.004)	(.143)	
WPA	1.002	1.002	.773
	(.001)	(.001)	(.145)

[1] Heritabilities on diagonal, phenotypic correlations above, and genetic correlations below diagonal. Mathematical model included only sire effects. Estimates were by ordinary least squares analysis of variance using computer program by Harvey (1990) Model 2.

Standard errors of estimates are in parentheses.

WP, are presented in Table II. As shown, heritability of WP was high, > .77 and close to the estimates between .9 and 1.0 of Briquet and Lush (1947). This high heritability allows for a rapid change of coat color in Holsteins and suggests only a small influence of the environment and non-additive genetic effects in the determination of the proportion of white spotting.

Genetic and phenotypic correlations among different WP measurements also were very high. Any of these measurements can be considered as being almost the same for estimating genetic and phenotypic parameters. Maximum likelihood estimates of heritability also were obtained; they were slightly lower than their least squares counterparts.

Genetic, environmental and phenotypic correlations between WP (left and average) and productive traits are shown in Table III. Phenotypic correlations were very small, although positive. Genetic correlations were negative, though low for milk yield and moderate for fat traits. However, these estimates were obtained from a small data set. Environmental correlations were positive; their interpretation is not clear at this point, since WP was not shown to have an important environmental component.

Table III - Genetic, environmental and phenotypic correlations between white percentage and production traits[1].

Trait	Genetic		Environmental		Phenotypic	
	WPL[2]	SPA	WPL	WPA	WPL	WPA
Milk yield (kg)	-.14	-.12	.30	.27	.02	.02
Fat yield (kg)	-.41	-.39	.55	.54	.05	.02
Fat percentage	-.39	-.38	.48	.50	-.02	-.02

[1] From ordinary least squares analysis of variance. See Table I for mathematical model.

[2] White percentage left (WPL) and average of left and right (WPA).

Phenotypic and genetic change in WP during 1960 through 1989 were evident, though no conscious selection was performed on WP. Phenotypic change was curvilinear (fifth order regression of WP on year, $P < .03$); WP increased but in an irregular fashion. Linear regression was .84% WP per year. This change was essentially totally genetic since no year effects or trends could be detected within sires.

Percentage WP did not affect age at first parturition or length of lactation record. Production data were adjusted for these variables. Records were terminated at 305 days. Partial correlations of WP and age and length of record were -.033 and .058 (not significant). This suggests that whiter heifer freshened younger and milked longer. Additional research to clarify this relationship seems warranted.

CONCLUSIONS

In this research herd, WP was found to be a non-normal variable skewed to the right. The mean, mode and median of 23, 0, and 15 describe a mostly black cow sample. WP had a measurable effect on milk yield ($P < .01$), interacting with calving season for fat yield ($P < .04$) and percentage ($P < .09$). The increase in milk yield favored more white over black, regardless of calving season, and could represent an important source of income for the dairy herds found in subtropical areas of the world with environments similar to Florida. The positive effect found on fat-related traits suggests the possibility of the same kind of effect for protein yields and composition. Given the importance of heat stress for reproductive functions, these results suggest that reproductive traits also should be studied. Heritability of WP appears to be very high (.77). With such an estimate, there is little room for sources other than additive genetic variance explaining most of WP total variability. Genetic correlations with productive traits were found to be negative with medium to low values; analyses of larger data sets and a multitrait analysis should be valuable.

ACKNOWLEDGMENTS

Financial support for the senior author was provided by the Consejo Nacional de Ciencia y Tecnologia, Mexico, and Colegio de Postgraduados, Chapingo, Mexico. Partial support was provided by the Florida Dairy Check-off Program.

RESUMO

Foram analisadas as primeiras lactações de 795 vacas do rebanho leiteiro da "Florida Agricultural Experiment Station", de 1960 até 1989. A porcentagem de pelagem branca foi obtida pela avaliação visual de desenhos nos certificados de registro. A correlação fenotípica entre porcentagem de branco nos dois lados do corpo foi 0,97 ($P < 0,01$). A distribuição das porcentagens individuais não foi normal ($P < 0,01$) com média, desvio padrão e mediana de 23,9, 25,6 e 15. A média dos quadrados mínimos para leite e produção de gordura, porcentagem de gordura e percentual de pelagem branca foram, 4556 kg, 166 kg, 3,46% e 23,5%. A porcentagem de pelagem branca foi relacionada linearmente com a produção de leite com $\beta = 2,75$ kg (para 1% de branco). Interações entre a porcentagem de pelagem branca e estação de parição foram detectados para produção de gordura; a regressão para cada estação foi $\beta = 0,21$ kg e $\beta = 0,002$ kg nas estações frias (Outubro - Março) e quente (Abril - Setembro). A interação também foi importante para porcentagem de gordura. A herdabilidade da porcentagem de pelagem branca pela correlação intra-classe (meio-irmãos) foi 0,77; a correlação genética entre a cor branca com a produção de leite, gordura e porcentagem de gordura foi -0,12, -0,39 e -0,38. Pesquisas adicionais parecem garantir o estabelecimento de relação entre a porcentagem da cor branca e as peculiaridades da importância econômica em gado leiteiro.

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(Received January 25, 1993)