GENETICS AND BREEDING

Effects of Percentage of White Coat Color on Holstein Production and Reproduction in a Subtropical Environment[1]

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ABSTRACT

Percentage of white coat color was measured visually on registry certificates of 4293 first lactation Holstein cows on eight Florida dairy farms; records of production and reproduction were obtained from DHI. Data were analyzed using derivative-free REML with an animal model to estimate heritability of nine performance measures and to establish their relationships with white percentage. Adjustment of other response variables for white percentage altered heritabilities very little. Regression of milk production on white percentage was 1.91 kg/1% white. Regression coefficients were negative for fat and protein percentages and positive for protein and fat production. Regression coefficients for reproductive traits on white percentage were negative (i.e., white was desirable) but were not statistically significant. Probability of survival to second parturition was higher but not significant for cows with higher white percentage. Interaction of white percentage and season for fat percentage and days open was significant. In a subtropical environment, white percentage appears to affect productive and perhaps reproductive performance. Economic aspects of selection for increased white percentage need to be investigated.

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(**Key words**: Holstein, coat color, production, reproduction)

Abbreviation key: **WP** = percentage of white coat color.

INTRODUCTION

Holstein cows producing under Florida conditions often are exposed to adverse subtropical weather. High temperature, solar radiation, and humidity are common, particularly in summer, and result in climatic stress to cattle. Effects of climatic stress include decreased milk production, changes in milk composition, and lowered reproductive performance (20). Among factors that have undesirable effects on cattle, incident solar radiation is important because it can directly increase body temperature. The heat load on cow bodies from solar radiation is produced by absorption of light and associated heat on the surface of animals exposed to sunlight. In combination with other climatic factors, solar radiation can result in heat stress and strain for cows unable to dissipate excessive heat by normal mechanisms.

Hair coat color of cattle is directly related to the amount of heat absorbed from solar radiation (6, 7). For many years, coat color was considered to have only aesthetic value, and most breeds of livestock were formed using color patterns as a trademark. Effects of color on production and reproduction were considered to be of little importance. However, a review by Buchanan-Smith and Robinson (3) showed interest by German researchers in studying relationships between coat color and performance. Earlier, Prawechenski (13) in Poland found no correlation between percentage of white coat color (**WP**) and milk production of Holstein cows.

A description of the physics of absorption and reflection of solar radiation by cattle hair was given by Stewart (18), who defined the absorption coefficient as the percentage of solar radiation that cattle absorb on exposure to direct sunlight and showed that great variability in absorption existed among and within cattle breeds; in particular, he (18) pointed out that a solid black Holstein cow absorbs 92% of the incident solar radiation through her coat, which is twice as much as a white cow.

Physiologists have for many years investigated effects of heat and solar radiation on productive, reproductive, and adaptive traits in relation to coat color. However, studies with large data files from field records are few. Schlegler (15) studied relationships of coat type and color with milk production for nine commercial Australian Illawarra Shorthorn herds; phenotypic correlations between intensity of color and milk and fat production were negative and highly significant ($r = -.287$ to $-.336$), as were the regressions. Coefficients tended to be lower for high producing herds (herd production by coat color interaction). More recently, King et al. (9), using data from a Holstein herd in Arizona for which sprinklers and shade areas were provided, found significant interactions between coat color and calving season for days open and services per conception. Neither color nor color by season interactions were detected for milk production traits. Low producing black cows often were culled more severely than white cows. For Holstein cows grouped by color and exposed to intense solar radiation, Hansen (8) found interactions between color and environment (shaded and unshaded areas) for four physiological variables for Holstein cows grouped by WP. White cows exposed to sun without shade showed smaller changes in the physiological variables and less depression in milk production. Becerril et al. (1) used records of first lactation Holsteins and found that WP had a positive linear association with milk production. These workers (1) reported a difference of 275 kg between solid white and solid black cows. Interactions between season and fat production and percentages also occurred for coat color (1).

The objectives of the present study were to determine whether WP for the coat of Holstein cows under adverse climatic conditions was related to productive and reproductive performance. Effects of WP on milk, fat, and protein production, fat and protein percentages, age at first parturition, days open, calving interval, and survival to second parturition were evaluated. Effects on heritability by adjustment of data for WP were determined. Estimates of sire breeding values were obtained only for those sires with ≥10 daughters.

MATERIALS AND METHODS

Data

Evaluations of 4293 registration certificates, obtained from Florida dairy farms and the Holstein Association of America, for heifers first freshening from November 1984 to April 1991 were used. Of 110 DHI herds in Florida, only 8 were reported to have >120 registered cows from which registration certificates could be obtained. No grade cows were used because of the sparsity of drawings for these cows. Herds were located in north and central Florida and varied in size and management. Data were not equally distributed among herds; 3 herds had 73% of the cows. Measurements of WP were by visual evaluation of registration certificates, as described by Becerril and Wilcox (2), on one side of the upper body only, including head, neck, and trunk, but not face, tail, legs, or belly. Correlations between estimates from the upper body and the total cow ranged from .95 to .99. Pedigree information from 1950 through 1989 also was obtained from the Holstein Association of America and the Animal Improvement Programs Laboratory, USDA to account for relationships among cows with WP measures. Only normal lactation records of >100 d, for cows between 540 and 1050 d of age, were used for production traits. For days open, only cows with >20 and ≤305 d were used, and calving interval was required to be from 295 to 610 d. A cow was deemed to have survived to second parturition if so recorded; subsequent postpartum performance was not considered. Days open were calculated for cows with a confirmed pregnancy or a second parturition.

Mathematical Model and Statistical Analyses

Univariate analyses were performed for each trait studied. The WP was included as a single, continuous linear effect (covariable) in the model; preliminary analyses (1) and analyses with these data failed to detect evidence of curvilinearity. Also included were first-order interactions between WP and calving season. A reduced model without WP was used to determine the possible effects of WP on heritability estimates. The complete model for cows with records was

$$\mathbf{y} = \mathbf{Xb} + \mathbf{Za} + \mathbf{e}$$

where

- $\mathbf{y}$ = N × 1 vector of observations for each trait, where N = the total number of cows with first lactation records, which can be <4293 because of missing data for some traits;
- $\mathbf{X}$ = N × p incidence matrix of fixed effects, including observations for covariates;
- $\mathbf{b}$ = p × 1 vector of fixed herd-year-season effects with cool (October to April) and warm (May to September) seasons, and covariables for age at parturition, DIM, times milked daily, WP, and WP by season interactions.

$$\mathbf{a} = g \times 1 \text{ vector,}$$

where

- g = N + number of sires + dams;
- $\mathbf{e}$ = N × 1 vector of errors;
- $\mathbf{Z}$ = N × g incidence matrix.

Relationships among cows were taken into account through $\mathbf{A}$, the g × g additive relationship matrix, having as a consequence $\mathbf{G} = \mathbf{A}\sigma_a^2$, the additive genetic matrix. Residuals were assumed to be uncorrelated with covariance matrix $\mathbf{I}\sigma_e^2$. All production traits were assumed to have normally distributed errors. For reproductive traits, no attempt at transformation was performed because no effect occurred on the estimate of genetic parameters for transformed variables by Raheja et al. (14). Solutions for fixed and animal effects and for additive genetic and error variances and heritability estimates were obtained by REML (10).

RESULTS AND DISCUSSION

Descriptive statistics for all traits are in Table 1. Mean milk production of 6943 kg was higher than the current Florida average for all cows of 6376 kg. Powell and Norman (12) found that first lactation registered cows produced more milk than grade cows within the same herd. This result could be because of genetic superiority from use of superior sires and possibly also because of preferential feeding and management. Overall, 48% of the cows were milked three times daily. Sprinklers and fans were provided to most cows. Observed mean production was lower than that in California, New York, and Wisconsin (4). Average age at first parturition was 799 d, lower than the 867 d reported by Silva et al. (16) for cows in Florida; this difference might be because of improvements in feeding and management of heifers during the last decade. Calving interval of 406 d agreed with the interval of 401 d of Silva et al. (17), who had more data covering a longer period; however, the average of 166 d open obtained herein was higher than that of 124 d of Silva et al. (17). Discrepancy in estimates of days open and

TABLE 1. Means and standard deviations for production and reproduction traits.

Trait	n	$\overline{X}$	SD
Milk production, kg	4239	6943	1646
Fat production, kg	4293	241	65
Protein production, kg	4143	217	50
Fat, %	4293	3.47	.49
Protein, %	4143	3.13	.20
Age at first parturition, d	4293	799	89
Days open, d	4041	166	109
Calving interval, d	3130	406	70
Survival to second parturition, %	3130	72.9	44

TABLE 2. Regression coefficients of productive and reproductive traits on white coat color percentage.

Trait	Regression coefficient[1]	SE
Milk production, kg	1.91**	.620
Fat production, kg	.015	.025
Protein production, kg	.067†	.041
Fat, %	–.00059*	.00025
Cool season	–.00078*	.00034
Warm season	–.00040	.00034
Protein, %	–.00046*	.00012
Age at first calving, d	–.014	.044
Days open	–.052	.065
Cool season	–.152†	.091
Warm season	.046	.090
Calving interval, d	–.021	.048
Survival to second parturition, %	.00013	.00024

[1]Change in traits associated with 1% difference in white coat color percentage.

†$P < .11$.

*$P < .05$.

**$P < .01$.

calving interval apparently arose from the deletion of 911 records (Table 1). Many cows were designated as pregnant but did not survive to second parturition and did not have a calving interval. The WP mean and standard deviation were 25.7 and 26.9%, similar to previous estimates (1, 2). Nearly 73% of the cows reached second parturition. Cows in Florida are culled mainly because of poor reproductive performance and low production (16).

Regression coefficients for the various traits on WP are in Table 2. The WP had a significant linear association with milk production; regression coefficient was 1.91 kg per WP ($P < .01$). This value was lower (but nonsignificantly) than the 2.75 kg found when a similar model, a smaller data file from a single herd, grade and registered cows, and method of ordinary least squares ANOVA were used (1). The possible range of 191 kg of milk for first lactation between solid black and solid white cows could be economically important. For fat and protein percentages, effects of WP were significant and negative; the former interacted with season. However, the regression coefficients were small and might not be of practical importance.

Becerril et al. (1) also found a significant interaction between WP and season for fat percentage, although the regression coefficient was higher and positive. According to results of the present study, white cows freshening in the cool season had reduced fat percentage, but no detectable difference occurred in the warm season. For protein production, the regression was .067 kg ($P < .11$), but no effect was detected for fat production.

For reproductive traits, days open decreased as WP increased, but only the regression for cool season was significant ($P < .10$). Cows were assigned to season according to their month of parturition. With a mean of 166 d from parturition to successful insemination, cows freshening during the cool season conceived during the warm season, on the average. King et al. (9) also found color by season interactions of days open for Arizona; in their study, white cows freshening during February and March had fewer days open and required fewer inseminations per conception. Effects of WP were not significant for survival of cows to second parturition. Other environmental factors not related to coat color could have played a more important role in reproductive performance under management conditions of our herds, in which cows were cooled by use of fans and sprinklers with shelter available.

Heritability estimates agreed with accepted values for dairy cows in temperate areas (Table

TABLE 3. Heritabilities of the various traits for the full model (with white percentage) and reduced model (without white percentage).

Trait	Full model		Reduced model		Change[1]
	h^2	SE	h^2	SE	
					(%)
Milk production	.328	.043	.324	.043	1.2
Fat production	.278	.043	.277	.042	.4
Protein production	.370	.046	.368	.045	.5
Fat, %	.385	.048	.392	.048	−1.7
Protein, %	.503	.042	.502	.042	.2
Age at first calving	.131	.040	.130	.039	.8
Days open	.047	.021	.047	.014	0
Calving interval	.087	.043	.086	.046	1.2
Survival to second parturition	.026	.021	.026	.021	0

[1](h^2 from full model − h^2 from reduced model) × 100.

3). Deletion of WP from the model did not affect heritability estimates appreciably, even when WP effects were significant. For all production traits except fat percentage, for which heritability was smaller than other estimates obtained with similar methodology, our estimates of heritability agreed with those in the literature (5, 19). For these traits, inclusion of WP in the model slightly increased heritability for all traits except fat percentage.

For production traits, correlations were calculated among estimated breeding values of the 90 sires with >10 daughters and for cows with records, from both reduced and complete models. The correlations of breeding values from both models were very high (r = .99, $P <$ .01) for sires and cows. Because changes in the rankings were minor, they may not greatly affect sire selection schemes.

Heritability estimates for reproduction traits were generally low (<.15) and smaller than previous estimates obtained with the same methodology (5) but close to previous Florida estimates (17). Heritability of survival to second parturition was not different from zero and was smaller than the .11 reported by Dong and Van Vleck (5). For beef cattle, Meyer et al. (11) found heritabilities of .01 to .08 for this trait. No transformation was attempted for this trait despite its categorical nature. Changes in heritabilities from full and reduced models were small and positive for all traits except fat percentage. The possibility of obtaining improved heritability estimates for milk production and economically important reproductive traits suggests that multivariate analysis be considered in the future.

CONCLUSIONS

Effects of WP were significant for milk production ($P < .01$), fat and protein percentages ($P < .05$), and the interaction of calving season and fat percentage ($P < .05$). Apparently, white cows produce more milk than black cows in first lactation; when other factors are equal, percentages of fat and protein are reduced. Fat production from cows with more WP tended to be higher, but this effect was not significant. For protein production, WP effects approached significance ($P < .11$). Small differences in protein production would be of little present importance for the fluid milk market of Florida but could be of greater importance in different economic situations. Age at first parturition, days open, and calving interval were not affected significantly by WP, but the three corresponding regression coefficients indicated that reproductive performance was lower for black cows. The interaction WP by calving season was significant ($P = .10$) for days open. Most cows in this study were producing under management conditions designed to avoid heat and climatic stress; shade, fans, and sprinklers were provided.

In general, small positive increases in heritability estimates occurred for production and reproduction traits when WP was included in the model, but differences probably were not important. Also, for milk production, rankings of cows according to estimated breeding values were not greatly affected by inclusion of WP in the model. Regression of WP on milk production did not differ from our earlier single herd estimate (2); that herd was part of the present study, but, because only 1984 to 1991 were included herein, it was one of the smaller herds.

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