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I am submitting herewith a thesis written by David Eugene Harmon entitled "Predicting Longevity in Dairy Cattle from the Paternal Half Sib's Production and Conformation Ratings." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

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Thesis

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Cap. 2

PREDICTING LONGEVITY IN DAIRY CATTLE FROM THE PATERNAL
HALF SIB'S PRODUCTION AND CONFORMATION RATINGS

A Thesis
Presented for the
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Degree
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ABSTRACT

The purposes of this study were to use type and progeny summaries of dairy sires born prior to 1960 to determine their usefulness toward increasing longevity and production in the Guernsey, Holstein, and Jersey breeds.

Data for this study were obtained from USDA-DHIA Sire Summaries for production, and from official type summaries for classification data over a six year period (1967 to 1973).

The analysis of the three breeds indicates negative correlations of -0.37, -0.25, and -0.40 between the number of records and percent of incomplete records for Guernsey, Holstein, and Jersey breeds, respectively. Records per daughter had 0.12, 0.24, and -0.01 correlations with average score in the Guernsey, Holstein and Jersey breeds, respectively. Milk and fat were negatively correlated with type in the Holsteins and Jerseys.

The Guernsey, Holstein, and Jersey breeds should be primarily concerned with their selection programs to increase longevity. Since an increase in longevity would require fewer heifer replacements, it would be very economical for dairymen to consider those sires with more records per daughter, along with high predicted differences for milk and fat.

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CHAPTER I

INTRODUCTION

In the last ten to fifteen years tremendous progress has been made in developing technology for the evaluation of breeding merit of individual sires for lactation production.

This technology has been accepted readily by the dairy industry. The results have increased demand for semen from sires with outstanding progeny test records. Variable semen pricing was instituted as a logical way of equating semen supply and demand.

The consumer demand for a semen of a given sire is probably a function of numerous factors but chief among these factors are his ability to sire high production in his daughters, the conformation of his daughters and the bull's fertility level.

With semen prices per ampule varying widely, it is imperative that dairymen be able to project the returns from money invested in semen of various sires. Currently such an evaluation must be based on assumptions as to the number of ampules of semen required per pregnancy, the survival rate of heifers, and expected duration of productive life of the daughters. Reasonable assumptions can be made on the first two factors but little information is available on the average expected life and how it might vary with other traits.

Therefore, this study was undertaken to relate the longevity of a sire's daughters to their predicted difference for milk, percent of incomplete records, and their average classification score and to determine the correlation between type traits and milk production in sire summaries.

CHAPTER II

REVIEW OF LITERATURE

Phenotypic and genetic correlation between type ratings, milk, and butterfat production. Several investigations have been conducted to determine the correlation between type ratings and production. Harvey and Lush (16) found that although selection on the basis of type would bring about genetic improvement in production, it would require six to ten generations to obtain results that would take one generation if selection were on the basis of production. Genetic variation constituted about 18 percent of the intra-herd and intra-year variance in single records of fat production and 14 percent of intra-herd difference in official type ratings.

Touchberry (29) found phenotypic correlations of 0.18 and 0.25 for milk and butterfat production with type ratings. The genetic correlation between milk production and fat production was 0.71. Touchberry's research suggests that selection for milk production automatically produces a correlated response in butterfat production. Rennie (26) predicted that production increases an average of 11.6 pounds of butterfat for each increase of one classification rating of Jersey cows.

In a study of genetic relationships between type and production, Grantham et al. (14) found a correlation between predicted difference for milk and final score to be -0.14 for the 1,095 sires with 20 classified daughters in 10 herds and -0.23 for a subset of 455 sires with a minimum of 100 classified daughters in 10 herds. The general relationship between type and production was consistently negative except for dairy character.

Freeman and Dunbar (12) estimated the phenotypic and genetic correlations between various traits of 1,180 Ayrshire daughter-dam pairs. Phenotypic correlations between type components and butterfat production ranged from 0 for rump to 0.14 for general quality or dairy character. Genetic correlation between type components and butterfat production ranged from -0.86 for general quality to 0.22 for middle and loin. Phenotypic and genetic correlations for final type and butterfat production were 0.08 and -.52, respectively. Phenotypic correlations between final rating and all components of type were in excess of 0.50. The great variability in genetic correlations was due to sampling errors in the data. In a similar study by Johnson and Fourt (17), the phenotypic correlations between butterfat production and final type and all components of type, except rump, were significant at the 0.01 level of probability. All phenotypic correlations were relatively low with the highest being 0.319 between dairy character and butterfat

production followed by 0.276 between mammary system and butterfat production. General appearance and mammary system had the highest relationship to final type of any of the components, 0.794 and 0.759, respectively. Genetic correlations between the components of type and butterfat production ranged from 0.21 for rump to 0.48 for rear udder. The estimate of the genetic correlations between final type and butterfat production was 0.24.

An early study in Ayrshires was conducted by Tyler and Hyatt (30) to determine the correlation between classification rating and butterfat production. The intra-sire regression of daughter on dam was 0.28. Butcher et al. (7) analyzed the intra-sire-herd variances and covariance of 8,165 Ayrshire daughters. The average of all available type and production records were used. Phenotypic correlations between the components of type and milk fat production and final type rating with milk fat production were low, ranging from 0.03 to 0.13. The phenotypic correlations between the various type ratings ranged from 0.14 to 0.62 with a standard error less than 0.01. The genetic correlations between the components of type and milk fat production were also low, ranging from -0.15 to 0.16, whereas the genetic correlation between final type rating and milk fat production was 0.02. The genetic correlations between the various type ratings ranged from 0.17 to 1.00, with a standard error less than 0.10.

O'Bleness et al. (24) estimated the heritability for 27 type traits and milk and fat production and the genetic correlation of type traits with production. Phenotypic correlations of type traits with production which were greater than 0.15 but less than 0.21 were dairy character, depth of barrel, udder shape, depth of udder, and feeding habits. Estimates of genetic correlations of type traits with production were inconclusive due to lack of confidence in the components of the correlations for production.

Liang and Fosgate (18) analyzed 13 official type classification ratings and milk and milk fat production for 382 Jersey cows in one herd. Significant simple correlations were found between milk and fat yield and final classification rating, mammary system, dairy character, fore udder, rear udder, teats, general appearance, and breed character. Significant partial correlations were found between yield and final classification rating, dairy character, general appearance, breed character, teats, rump, and tail setting. Classification rating and dairy character were of the most value and about equal in predicting results. Wilcox et al. (38) used records of 233 Holstein cows to determine phenotypic and genetic correlations between type traits and production. Phenotypic correlations between overall rating and measure of yield ranged from 0.13 to 0.15. Genetic correlations were low but positive.

Mitchell et al. (20), using high, medium, and low production herds, found that the higher positive genetic correlations were found in the medium group. The genetic correlations in the medium group ranged from -0.07 for butterfat and feet and legs to +0.84 for butterfat and dairy character. In a later study by Mitchell et al. (21), 59,511 Holstein cows were divided into the following stratified groups: low or below 11,960 pounds of milk; medium from 11,960 to 13,260 pounds of milk; and high or above 13,260 pounds of milk. Phenotypic correlations between type ratings and milk and fat production ranged from 0.02 to 0.25, with a standard error of 0.01 to 0.02. In all groups, final type ratings showed uniformly high phenotypic and genetic correlations with the subratings, general appearance, and mammary system. The corresponding correlations between final rating and the other four subratings ranged from 0.39 to 0.53 for phenotypic and from 0.31 to 0.96 for genetic.

Vinson and White (36) stated that there is a danger in selecting for too many traits when evaluating strengths and weaknesses of daughters sired by AI bulls. Also, there is difficulty in combining performance evaluations for type and production to determine overall merit. Several indices involving milk and fat yield, fat percent, and type were constructed by Tabler and Touchberry (28) to determine how effectively these indices would indicate the relative breeding worth of individual cows. The genetic value for

milk yield can be estimated 10 percent more accurately by taking into consideration the cow's fat yield. The expected genetic improvement of milk and fat yield was greatest when milk yield alone was the basis for selection. Selection for type as well as milk and fat yield resulted in a 15 percent decrease in the expected genetic gain of milk and fat yield. Cassell et al. (9) used 30,715 Holstein daughter-dam pairs and found that the genetic correlations among score card traits were sizeable and positive with final score being correlated with general appearance at level of 0.93. This study indicated that hind feet and legs should possibly be removed from the score card since little productive value can be associated with them.

Heritability of milk and butterfat production and type ratings. Mitchell et al. (20) found that the heritability of milk yield in high, medium, and low production herds was 0.19, 0.24, and 0.20, respectively. Similar values were obtained for butterfat. The heritabilities for type ranged from 0.06 for dairy character to 0.31 for rump. Johnson and Fourt (17) determined the heritability estimates and found them to range from 0.19 for feet and legs to 0.36 for rump.

Berousek et al. (5) found that heritability and repeatability of milk, butterfat and type are important in evaluating the effectiveness of a selection program. The heritability of milk and fat yield was 0.18 and 0.19,

respectively, while the repeatability estimates for milk and fat were 0.47 and 0.41. Standard deviations for official classification and characteristics presented by Rakes (25) showed that there was enough variation in milk production to warrant selection for this characteristic with present heritability estimates. Dual selection for type classification may hinder progress in production characteristics.

The heritability estimates found by O'Bleness et al. (24) were: temperament, 0.36; depth of udder, 0.21; pin-bone width, udder shape, and hind legs, 0.04; udder texture and strength of rear udder attachment, 0.23. Estimated genetic correlations of type traits with milk production were: feeding habits, 1.04; dairy character, 0.95; temperament, 0.05; and rear leg movement, -0.10.

Rennie (26) indicated in his study of Jerseys that the heritability of type rating was 0.16. Evans et al. (11) found intra-sire regression estimates for the heritabilities of milk production per day of productive life, length of productive life, breeding efficiency, and type to be 0.24 ± 0.12 , 0.00 ± 0.09 , 0.07 ± 0.13 , and 0.34 ± 0.16 , respectively. The heritability of final type score was 0.18 and milk fat production was 0.15, according to Butcher et al. (7).

Causes of variation of type ratings. Basinger's study (3) indicated that classification ratings are affected by years, age, stage of lactation, and body weight. His

findings also showed that classifiers are influenced more by the appearance of mammary system at classification than any other type component. Norman and Van Vleck (22) used 49 body, udder, and management traits to determine the importance of year, herd, sire, and herd x sire effects. Most appraisal traits had low heritabilities. Year effects were almost nonexistent. Herd effects for udder traits accounted for almost 10 percent of the variation. For body weight, intensity of edema, persistency of edema and ketosis, herd components were 19 to 25 percent. Heritabilities and repeatabilities for most of the type appraisal traits were low. Estimates of only six of twenty-one traits exceeded 0.11. These were strength of rear attachment, rear teat spacing, depth of udder, height of rear udder, udder quartering, and udder slope.

Van Vleck (33) analyzed type appraisal scores to determine the influence of sire and herd effects. Within-herd heritability was less than 10 percent for most traits. Herd effects had a much smaller influence on most type traits than on milk or milk fat production. Major exceptions were feeding habits, udder edema, and persistence of edema. Rennie et al. (27) also analyzed type appraisal traits. Although effects of age, stage, and season of classification were in most cases significant statistically, they were small. Genetic correlations among type traits were positive and ranged from 0.06 between dairy character

and legs and feet to 1.18 between final score and final classification. The phenotypic correlations were smaller than the genetic correlations.

Carter et al. (8) used data from 29,000 Holstein cows from Ontario. Variance components showed less than 8 percent of the variance due to between-herd differences, 7 percent due to sire-within-herd differences, and 83 percent due to other within-herd (error) variance. Heritabilities of type characteristics on a within-herd basis were as follows: type score, 0.32; general appearance, 0.11; mammary system, 0.28; feet and legs, 0.19; percent Breed Canadian Average milk, 0.36; percent Breed Canadian Average fat, 0.39.

Barr et al. (2) categorized Jersey herds as official registered research and grade research. Differences for herd status were significant ($P < .05$) for general appearance, mammary, teats, suspensory ligament, dairy character, chest-barrel, quality, and back, rump and tail. Differences for age were significant for general appearance, stature, breed character, dairy character, chest-barrel, fore udder, teats, suspensory ligament, quality, and back, rump and tail setting. Heritabilities ranged from 0.19 for feet and legs to 0.68 for stature. Herds accounted for 9.6 percent of the variation in total score and sires accounted for 10.1 percent of the variance.

Relationship of longevity, type, and production.

Gaalaas and Plowman (13) studied the relationship between

first-lactation milk and milk fat production, and longevity of 3,879 daughters of 123 Holstein sires. Regression coefficients were small but highly significant. The higher producing first-lactation cows had a longer productive life. Basinger (3) found that the effects of years were highly significant ($P < .01$) on classification and production. The effects of age on feet and legs, dairy character, breed character, mammary system, and predicted difference for milk and fat were highly significant ($P < .01$). There was a negative regression coefficient for feet and legs and mammary system.

Van Vleck (32) used records from five breeds, Ayrshire, Guernsey, Holstein, Jersey, and Brown Swiss, to show that high producers in the first lactation complete more subsequent lactations and continue at a higher level of production than the lower producers in the first lactation. White and Nichols (37) used records from 4,819 Holstein cows to obtain the correlation of first-lactation production with subsequent performance and length of herd life. They found that the higher producing first-lactation cows produced significantly ($P < .01$) more milk and fat in later life than the lower producing first-lactation cows. Those cows in the higher first-lactation groups remained in the herd longer than the lower producers.

The relationship of first score and length of life in the herd of females which were two and three years of age

at the first classification was measured by Specht et al. (31). Less than 5 percent of the variation in herd life could be attributed to the relationship between first score and herd life. Differences among herds accounted for about 10 percent of the total variance in over-all type score and in the individual type traits. Differences among sires accounted for 5 to 8 percent of the variation in over-all score and in each of the categories. An analysis of variance components on 7,927 artificially inseminated sired animals gave a heritability of 0.16 for over-all type score.

Norman and Van Vleck (23) used phenotypic and genetic correlations to determine the importance of appraisal traits in a breeding program. This study suggested that bulls that sire daughters with high production tend to sire daughters with weaker udder attachments. High genetic correlations of first-lactation milk and fat with lifetime milk were estimated as 1.14 and 0.90. This research supported the utility of selection on first-lactation production and type rating. Allaire and Henderson (1) investigated phenotypic selection among Holstein cows on the deviation of milk yield from the herd-mate average and type appraisal traits. The largest selection differentials in standard deviation units for the second, third, fourth, fifth, or later lactations were breeding trouble, incidence of mastitis, depth of body, and udder attachment, respectively. The intra-lactation index

indicated that milk yield had a weighting coefficient about twice as large as depth of body and dairy character.

Miller et al. (19) studied progeny group means of predicted difference for milk yield, predicted difference for fat yield, percent of daughters with incomplete first lactations and descriptive type for 417 active Holstein artificial insemination sires. Progeny average type was nearly independent of progeny average milk yield. Udder traits were most related to utility of a sire's daughters, as measured by yield and staying-ability in first lactation. The most consistently useful type trait for predictive purposes was the rear udder. Fore udder, udder support and floor, and udder quality may also have some utility though in some cases more desirable type was associated with decreased progeny performance.

In a study by Van Vleck and Norman (35), reasons for disposal were compared with type appraisal and milk yield in first lactation. Reasons for disposal were production, udder, reproduction, inabilities or disease, workability, type and other. Few traits which were measured before the cow was 49 months of age had any significant value in predicting a cow's disposal. Type traits measured in the first lactation have only a limited value in selection for longevity. Burnside et al. (6) found that milk production and age were phenotypically associated with variation in udder height and udder height minus back height. Higher production was

associated with lower udders. A significant correlation (-0.14) between udder height and clinical mastitis was found. Berger et al. (4) used two measures of herd life in six different herds. The results obtained in this study indicated that type score was .81, 1.86, .38, .47, .85, and 1.65 as important as milk yield in determining the months of productive life in the six herds.

A recent study by Griffin (15) indicated that dairymen should not select dairy animals on any trait other than milk production. The results obtained in this study may have been different if AI organizations were following single trait selection. Dickinson (10) suggested several ways to have a profitable breeding program. Since computers have made available more complete and accurate information at a smaller cost than ever before, dairymen should take advantage of all available information in order to supplement their own knowledge.

Summary. Studies show that higher producing first-lactation cows had a longer productive life; however, Van Vleck and Norman (35) showed that few traits which were measured before the cow was 49 months old had any significance in predicting reasons for a cow's disposal.

Classifiers are influenced more by the appearance of mammary system than any other component. Most appraisal traits have low heritabilities.

The expected genetic improvement of milk and fat yields was greatest when milk yield alone was the basis for selection. Heritability and repeatability of milk, butterfat, and type are important in evaluating the effectiveness of a selection program. Although selection for type will produce genetic improvement, selection for production will produce the same results in a shorter time.

The phenotypic correlations between butterfat production and final type were low and ranged from 0.03 to 0.25. The genetic correlation between final type rating and milk fat production ranged from -0.52 to 0.24.

CHAPTER III

EXPERIMENTAL PROCEDURE

The data used in this analysis was collected from the USDA-DHIA Sire Summaries for production and from official type summaries for classification data over a six year period (1967 to 1973). Three breeds, Guernsey, Holstein and Jersey, were considered in this study. The most recent summaries were used on each sire.

Data Collection

Sires that had been out of service long enough for the majority of their daughters to have completed their lifetime and, therefore, to have produced as many records as possible were used. Bulls born in (BYR) 1959 or prior to this time were selected for this research as arbitrarily meeting the above criteria. The Guernsey sires that had a registration number of less than 54000, the Holstein sires that had a registration number of less than 135000, and the Jersey sires that had a registration number smaller than 58000 were assumed to have been born prior to 1960. In Guernsey and Jersey breeds only sires with at least 100 daughters were used, while in the Holstein breed sires with 500 daughters or more were used.

Statistical Analysis

The data are presented by using terms and abbreviations which are used by all breeds and some which are used only in certain breeds. Each breed uses the same measures for production which are: predicted difference for milk (Milk) and fat (Fat); percent incomplete (INC); and number of records per daughter (RECS). Predicted difference for milk and fat is the expected average deviation of a bull's progeny from their herdmates in breed average herds. Percent incomplete first lactation records include first lactation records which were terminated because the daughter aborted, died, was culled for low production, or was sold to a non-testing herd for either dairy or non-dairy purposes. Records is a term used for the average number of lactations produced per daughter of each sire. Variables and their abbreviations for the three breeds appear in Table I.

Predicted difference for type (PDT), age adjusted score (AASC), percent above breed average (BAA) are used only by the Holstein breed. Predicted difference for type estimates the genetic abilities of sires to transmit overall type to their daughters. They are expressed in terms of type points above or below (plus or minus) breed average. A sire with a PDT of +1.40 would be expected to sire daughters whose average scores exceed breed average dams by 1.40. Age adjusted score indicates that all the daughters of a particular sire have been adjusted to what they would be expected to

TABLE I

CLASSIFICATION COMPONENTS AND PRODUCTION VARIABLES USED
IN THE STATISTICAL ANALYSIS AND THEIR ABBREVIATIONS

Variable	Abbreviation		
	Guernsey	Jersey	Holstein
Birth Year	BYR	BYR	BYR
Percent Incomplete Records	INC	INC	INC
Records Per Daughter	RECS	RECS	RECS
Predicted Difference for Milk	Milk	Milk	Milk
Predicted Difference for Fat	Fat	Fat	Fat
Average Score	AVESC	AVESC	
Age Adjusted Score			AASC
Percent of Daughter Deviating from Breed Age Average			BAA
Predicted Difference for Type			PDT
General Appearance	GA	GA	
Front Feet and Legs	FFL		
Hind Feet and Legs	HFL		
Feet and Legs		FL	
Mammary System	MS	MS	
Fore Udder	FU	FU	
Rear Udder	RU	RU	
Teats	Teats	Teats	

classify as a mature cow. Percent above breed average is the percentage of a sire's daughters which excels the average of the Holstein breed.

Both Jerseys and Guernseys use average score (AVESC). Average score is the average classification score of all the daughters of a given sire. General appearance (GA) and mammary system (MS) are two of the major components in the classification score card for the Guernsey and Jersey breed. Feet and legs (FL) is one of the breakdowns of general appearance for the Jerseys, while the Guernseys use front feet and legs (FFL) and hind feet and legs (HFL). The mammary system consists of fore udder (FU), rear udder (RU), and teats (Teats) for both breeds. Each of these major components and sub-components in Guernseys and Jerseys, as well as the age adjusted score for Holsteins, ranged from 70 to 90.

The stepwise regression procedure was used to analyze each production and type variable of the sire summaries. This technique first finds the single-variable model which produces the largest R^2 statistic reflecting that variable's contribution to the model were it to be included. Any variable not producing a partial F-statistic significant at the 0.1 level, except for the sire's birth year which was forced into the model, is then deleted. The process stops when no variable meets the conditions for inclusion in the model or when the variable to be added to

the model is one just deleted from it. Each model consisted of one dependent variable and other variables which were eligible to be independent variables by being significant ($P < .1$).

All means, regressions and correlations were calculated using SAS programs. Each calculation and statistical analysis was done with the aid of the IBM 360/65 data processing system of the University of Tennessee Computing Center.

CHAPTER IV

RESULTS AND DISCUSSION

The classification ratings and production data of 176 Guernsey sires, 667 Holstein sires and 100 Jersey sires were used to compute the correlation and regressions between type and production. The summaries of all the Guernsey sires represented a total of 60,340 cows, Holstein sires represented a total of 1,221,596 cows, and all Jersey sires represented a total of 28,585 cows.

The means, standard deviations, and coefficient of variations of the type and production variables for all three breeds are presented in Tables II, III, and IV. The average percent of incomplete records ranged from 9.82 for Holsteins to 13.58 for Guernseys. The average number of records per daughter ranged from 2.43 for Holsteins to 2.70 for Jerseys. The lowest average predicted difference for milk breed was Holstein with -66 and the highest was Jersey with +15. The average classification score was 83.9 for the Jersey breed, 82.6 for Guernseys, and 80.0 for Holsteins.

The gross correlation coefficients for all variables are in Tables V, VI, and VII. The correlations coefficients within the year of the sire's birth are in Tables VIII, IX, and X. The correlations within birth year were used for the analysis since the author felt that it was necessary to

TABLE II
MEANS AND STANDARD DEVIATIONS FOR THE VARIOUS VARIABLES
FOR THE GUERNSEY BREED

Variable	Number of Sires	Mean	Standard Deviation	Coefficient of Variation (percent)
INC (percent)	176	13.6	5.49	40.4
RECS	176	2.58	0.44	17.1
Milk (pounds)	176	-65	331.10	511.7
Fat (pounds)	176	-4	15.38	433.7
AVESC	176	82.6	1.16	1.4
GA	176	82.4	1.22	1.5
FFL	176	82.7	0.86	1.0
HFL	176	80.8	0.86	1.1
MS	176	82.3	1.22	1.5
FU	176	82.6	1.16	1.4
RU	176	83.3	1.16	1.4
Teats	176	81.9	1.40	1.7

TABLE III
MEANS AND STANDARD DEVIATIONS FOR THE VARIOUS VARIABLES
FOR THE HOLSTEIN BREED

Variable	Number of Sires	Mean	Standard Deviation	Coefficient of Variation (percent)
INC (percent)	667	9.8	4.09	41.6
RECS	667	2.43	0.44	18.1
Milk (pounds)	667	-66	486.36	741.0
Fat (pounds)	667	-2	16.74	1012.1
AASC	667	80.0	1.32	1.7
BAA	667	8	0.13	3.5
PDT	667	-0.82	0.97	118.3

TABLE IV
MEANS AND STANDARD DEVIATIONS FOR THE VARIOUS VARIABLES
FOR THE JERSEY BREED

Variable	Number of Sires	Mean	Standard Deviation	Coefficient of Variation (percent)
INC (percent)	100	12.8	5.81	45.5
RECS	100	2.70	0.50	18.5
Milk (pounds)	100	15	383.10	2606.1
Fat (pounds)	100	0	16.93	4031.6
AVESC	100	83.9	1.43	1.7
GA	100	84.7	1.19	1.4
FL	100	84.2	1.10	1.3
MS	100	84.0	1.31	1.6
FU	100	84.2	1.38	1.6
RU	100	84.4	1.29	1.5
Teats	100	83.9	3.21	3.8

TABLE V

GROSS CORRELATION COEFFICIENTS AMONG THE VARIOUS VARIABLES
FOR THE GUERNSEY BREED

	BYR	INC	RECS	Milk	Fat	AVESC	GA	FFL	HFL	MS	FU	RU	Teats
BYR	1.00	0.31	-0.39	0.00	0.03	0.08	0.10	-0.16	0.09	0.15	0.14	0.08	0.07
INC		1.00	-0.46	-0.39	-0.29	-0.00	0.05	0.05	0.09	0.07	0.07	0.04	0.04
RECS			1.00	0.11	0.06	0.09	0.06	0.16	0.03	0.03	0.06	0.05	0.02
Milk				1.00	0.69	0.17	0.13	0.03	0.08	0.05	0.04	0.06	0.05
Fat					1.00	0.15	0.12	0.08	0.10	0.06	0.08	0.03	0.06
AVESC						1.00	0.97	0.65	0.67	0.83	0.82	0.81	0.67
GA							1.00	0.65	0.65	0.78	0.78	0.77	0.64
FFL								1.00	0.65	0.45	0.48	0.50	0.34
HFL									1.00	0.50	0.52	0.48	0.39
MS										1.00	0.95	0.90	0.80
FU											1.00	0.82	0.74
RU												1.00	0.70
Teats													1.00

$P < .05$ when $r > |.15|$.

$P < .01$ when $r > |.20|$.

TABLE VI
GROSS CORRELATION COEFFICIENTS AMONG THE VARIOUS VARIABLES
FOR THE HOLSTEIN BREED

	BYR	INC	RECS	Milk	Fat	AASC	BAA	PDT
BYR	1.00	0.66	-0.55	0.09	0.01	-0.15	0.10	0.03
INC		1.00	-0.53	-0.23	-0.27	-0.06	0.11	0.08
RECS			1.00	-0.06	0.03	0.08	-0.06	-0.02
Milk				1.00	0.70	-0.23	-0.16	-0.21
Fat					1.00	-0.27	-0.21	-0.27
AASC						1.00	0.80	0.84
BAA							1.00	0.94
PDT								1.00

$P < .05$ when $r > |.08|$.

$P < .01$ when $r > |.11|$.

TABLE VII

GROSS CORRELATION COEFFICIENTS AMONG THE VARIOUS VARIABLES
FOR THE JERSEY BREED

	BYR	INC	RECS	Milk	Fat	AVESC	GA	FL	MS	FU	RU	Teats
BYR	1.00	0.31	-0.22	-0.01	-0.04	-0.37	-0.33	-0.35	-0.32	-0.28	-0.28	0.04
INC		1.00	-0.43	-0.48	-0.46	-0.22	-0.16	-0.22	-0.17	-0.07	-0.21	0.17
RECS			1.00	0.15	0.20	0.26	0.10	0.09	0.27	0.23	0.31	0.01
Milk				1.00	0.82	-0.19	-0.25	-0.05	-0.25	-0.32	-0.12	-0.05
Fat					1.00	-0.15	-0.23	-0.06	-0.24	-0.33	-0.16	-0.02
AVESC						1.00	0.84	0.67	0.86	0.81	0.74	0.18
GA							1.00	0.69	0.75	0.71	0.62	0.13
FL								1.00	0.66	0.64	0.60	0.07
MS									1.00	0.94	0.91	0.19
FU										1.00	0.85	0.16
RU											1.00	0.18
Teats												1.00

$P < .05$ when $r > |.20|$.

$P < .01$ when $r > |.25|$.

TABLE VIII
CORRELATION COEFFICIENTS AMONG THE VARIOUS VARIABLES FOR THE GUERNSEY BREED
ON A WITHIN-YEAR OF SIRE'S BIRTH BASIS

	INC	RECS	Milk	Fat	AVESC	GA	FFL	HFL	MS	FU	RU	Teats
INC	1.00	-0.37	-0.45	-0.37	-0.03	0.02	0.15	0.11	0.01	0.02	0.01	-0.03
RECS		1.00	0.11	0.08	0.12	0.10	0.07	0.03	0.09	0.11	0.09	0.03
Milk			1.00	0.70	0.17	0.12	0.01	0.07	0.04	0.02	0.06	0.04
Fat				1.00	0.14	0.12	0.06	0.10	0.05	0.06	0.03	0.05
AVESC					1.00	0.97	0.66	0.65	0.83	0.82	0.81	0.67
GA						1.00	0.67	0.63	0.78	0.77	0.77	0.64
FFL							1.00	0.64	0.50	0.51	0.53	0.36
HFL								1.00	0.50	0.51	0.48	0.39
MS									1.00	0.95	0.91	0.79
FU										1.00	0.82	0.73
RU											1.00	0.70
Teats												1.00

$P < .05$ when $r > |.15|$.

$P < .01$ when $r > |.20|$.

TABLE IX
CORRELATION COEFFICIENTS AMONG THE VARIOUS VARIABLES
FOR THE HOLSTEIN BREED ON A WITHIN-YEAR
OF SIRE'S BIRTH BASIS

	INC	RECS	Milk	Fat	AASC	BAA	PDT
INC	1.00	-0.25	-0.39	-0.37	0.05	0.08	0.09
RECS		1.00	-0.02	0.03	-0.01	-0.01	0.00
Milk			1.00	0.70	-0.22	-0.17	-0.22
Fat				1.00	-0.28	-0.21	-0.27
AASC					1.00	0.84	0.85
BAA						1.00	0.94
PDT							1.00

$P < .05$ when $r > |.08|$.

$P < .01$ when $r > |.11|$.

TABLE X

CORRELATION COEFFICIENTS AMONG THE VARIOUS VARIABLES FOR THE JERSEY BREED
ON A WITHIN-YEAR OF SIRE'S BIRTH BASIS

	INC	RECS	Milk	Fat	AVESC	GA	FL	MS	FU	RU	Teats
INC	1.00	-0.40	-0.50	-0.46	-0.21	-0.15	-0.17	-0.15	-0.05	-0.17	0.14
RECS		1.00	0.11	0.15	0.24	0.07	0.02	0.29	0.25	0.33	-0.02
Milk			1.00	0.80	-0.11	-0.17	0.02	-0.13	-0.20	-0.01	-0.04
Fat				1.00	-0.10	-0.19	-0.01	-0.15	-0.24	-0.07	-0.03
AVESC					1.00	0.79	0.60	0.85	0.78	0.70	0.17
GA						1.00	0.64	0.70	0.63	0.54	0.11
FL							1.00	0.58	0.56	0.53	0.06
MS								1.00	0.92	0.90	0.22
FU									1.00	0.83	0.18
RU										1.00	0.21
Teats											1.00

$P < .05$ when $r > |.20|$.

$P < .01$ when $r > |.25|$.

remove any effects caused by birth year or changes in culling patterns over time.

Each of the breeds have a reasonably large negative correlation of the percent incomplete records with the number of records per daughter as well as with milk and fat. The average number of records per daughter was positively correlated to milk, fat, and most of the measures of type in each breed. However, the magnitude of these correlations was generally quite low and nonsignificant.

Small positive correlations were found in the Guernsey and Holstein breeds when percent of incomplete records was correlated with type components. The largest correlations were 0.15 and 0.11 when percent of incomplete records was correlated with front feet and legs and hind feet and legs in Guernseys. Results of the Jersey data, on the other hand, indicated rather consistently negative values when percent of incomplete records and predicted differences for milk and fat were correlated with the type components. This is similar to results of other studies (7, 12, 14, 17, 21, 30, 34).

When the number of records is correlated with the type variables, Guernseys and Holsteins have correlations of very low magnitude with most being positive. The Jersey breed exhibits somewhat larger positive correlations ranging from 0.33 for rear udder to -0.02 for teats when the number

of records per daughter were correlated to the type components. This was also shown in the data analyzed by others (16, 19).

As expected, the type variables were highly related to each other. In the Holstein data the variables were all expressions of the level of conformation of the bull's daughters. In Guernseys and Jerseys overall score is based on four major breakdowns and each of these on sub-categories. The conformation ratings were all rather highly related to each other and this agrees very well with previous reports in the literature (3, 17, 18, 20, 21, 27, 38).

The results of the stepwise regression procedures with the four production measures, percent of incomplete records, number of records per daughter, and predicted differences for milk and fat, as dependent variables for each of the breeds are shown in Tables XI through XXII. Birth years of sires was a dependent variable and was forced into each model. The analysis of all three breeds shows that percent incomplete was affected by milk, records per daughter and by at least one measure of classification. In the Holstein data, the measure of conformation included in the stepwise method was age adjusted score. In the Jersey breed it was the sub-rating for teats and in Guernseys it was the front feet and legs score. The relative importance of these two sub-ratings was surprising. Sub-ratings were

TABLE XI
STEPWISE REGRESSION OF DEPENDENT VARIABLE PERCENT OF
INCOMPLETE RECORDS FOR GUERNSEY SIREs

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.37
Error				171	0.19	
Intercept			-0.72			
BYR	1.62	0.01	0.00			
Milk	6.38	0.01	-0.00			
RECS	5.98	0.01	-0.00			
FFL	10.96	0.02	0.01			

TABLE XII
STEPWISE REGRESSION OF DEPENDENT VARIABLE PERCENT OF
INCOMPLETE RECORDS FOR HOLSTEIN SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.57
Error				661	0.07	
Intercept			-0.04			
BYR	22.45	0.01	0.01			
Milk	2.58	0.01	-0.00			
RECS	4.07	0.01	-0.00			
Fat	0.94	0.01	-0.00			
AASC	2.19	0.08	-0.00			

TABLE XIII
STEPWISE REGRESSION OF DEPENDENT VARIABLE PERCENT OF
INCOMPLETE RECORDS FOR JERSEY SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.48
Error				94	0.19	
Intercept			0.73			
BYR	0.70	0.05	0.00			
Milk	6.99	0.01	-0.00			
RECS	2.90	0.01	-0.00			
GA	13.51	0.01	-0.00			
Teats	9.48	0.02	0.00			

TABLE XIV
STEPWISE REGRESSION OF DEPENDENT VARIABLE RECORDS
PER DAUGHTER FOR GUERNSEY SIREs

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.30
Error				172	13.77	
Intercept			-0.90			
BYR	171.44	0.01	-0.04			
INC	461.58	0.01	-0.03			
FFL	628.87	0.03	0.07			

TABLE XV
STEPWISE REGRESSION OF DEPENDENT VARIABLE RECORDS
PER DAUGHTER FOR HOLSTEIN SIREs

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.36
Error				663	12.20	
Intercept			4.68			
BYR	64.98	0.01	-0.04			
INC	714.60	0.01	-0.04			
Milk	131.70	0.01	-0.00			

TABLE XVI
STEPWISE REGRESSION OF DEPENDENT VARIABLE RECORDS
PER DAUGHTER FOR JERSEY SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.27
Error				95	19.28	
Intercept			1.56			
BYR	13.38	0.59	-0.01			
INC	340.36	0.01	-0.03			
RU	191.20	0.01	0.14			
FL	81.51	0.04	-0.11			

TABLE XVII
STEPWISE REGRESSION OF DEPENDENT VARIABLE PREDICTED DIFFERENCE
OF MILK FOR GUERNSEY SIREs

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.52
Error				172	533.60	
Intercept			-1.44			
BYR	430.56	0.63	0.06			
Fat	68039.14	0.01	0.14			
INC	7493.27	0.01	-0.13			

TABLE XVIII

STEPWISE REGRESSION OF DEPENDENT VARIABLE PREDICTED DIFFERENCE
OF MILK FOR HOLSTEIN SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.52
Error				662	1145.07	
Intercept			-7.26			
BYR	26153.78	0.01	0.23			
Fat	547374.47	0.01	0.18			
INC	39690.92	0.01	-0.28			
RECS	9755.06	0.01	-0.01			

TABLE XIX

STEPWISE REGRESSION OF DEPENDENT VARIABLE PREDICTED DIFFERENCE
OF MILK FOR JERSEY SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.69
Error				96	472.18	
Intercept			-3.65			
BYR	749.37	0.21	0.09			
Fat	63260.02	0.01	0.17			
INC	2606.81	0.02	-0.11			

TABLE XX

STEPWISE REGRESSION OF DEPENDENT VARIABLE PREDICTED DIFFERENCE
OF FAT FOR GUERNSEY SIREs

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.48
Error				173	1.24	
Intercept			-0.10			
BYR	0.34	0.60	0.00			
Milk	199.54	0.01	0.00			

TABLE XXI

STEPWISE REGRESSION OF DEPENDENT VARIABLE PREDICTED DIFFERENCE
OF FAT FOR HOLSTEIN SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.52
Error				662	1.37	
Intercept			1.34			
BYR	1.00	0.60	0.00			
Milk	590.62	0.01	0.00			
AASC	312.39	0.01	-0.02			
INC	21.04	0.01	-0.01			

TABLE XXII

STEPWISE REGRESSION OF DEPENDENT VARIABLE PREDICTED DIFFERENCE
OF FAT FOR JERSEY SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.67
Error				97	0.96	
Intercept			0.12			
BYR	0.44	0.51	-0.00			
Milk	189.82	0.01	0.00			

not available for the Holstein breed. The R^2 values ranged from 0.57 in the Holsteins to 0.37 in the Guernseys.

Guernsey data indicated that the number of records per daughter was affected ($P < .01$) by the percent of incomplete records. Front feet and legs also had an effect ($P < .05$) on the number of records per daughter.

The number of records per daughter was affected ($P < .01$) by the percent of incomplete records and rear udder in the Jersey breed. The feet and legs had a less significant effect on the number of records.

Holsteins also had two factors affecting ($P < .01$) the number of records per daughter. These were the percent of incomplete records and the predicted difference for milk.

It should be expected that the number of records per daughter would be affected by the percent of incomplete records. Sires with higher percent of daughters failing to complete their first lactation records would be expected to sire daughters which had fewer total records. This explains the negative relationship between the number of records per daughter and the percent of incomplete records. Certainly dairymen would desire those sires whose daughters produce more records and, consequently, the price of the semen of those superior sires should tend to be above those sires with daughters producing fewer records.

The front feet and legs in Guernseys is a rather surprising factor to influence the number of records per

daughter. Jerseys, as well, indicate that the number of records per daughter is affected by the score of feet and legs. The hind feet and legs is an indirect reason given by many dairymen for culling cows; the primary reason being low production. Dairymen often believe that low production is a result of the inability of cows to move readily on their hind legs and feet. Seldom, if ever, is the inability to move on the front legs and feet given as a reason for culling cows. However, the Guernsey data indicates that the classification score of front feet and legs does have a significant effect on the number of records per daughter.

To demonstrate the ability of these models to differentiate among sires, hypothetical sires were compared. The individual models for the records per daughter in the stepwise regression procedure were used to determine superior sires. The regression coefficients for the independent variables, percent of incomplete records and front feet and legs, and one standard deviation from their mean was used to determine the expected increase in longevity of Guernsey cows. Those sires with daughters having one standard deviation below the mean for the percent of incomplete records and front feet and legs score should have daughters that will produce 0.22 more records than the daughters of sires of one standard deviation above the mean for the two variables. The regression model for the longevity of daughters of Holstein sires suggests that the sire with daughters of one standard

deviation above the mean for percent of incomplete records and predicted difference for milk will produce 0.33 more records than those other daughters. The Jerseys, with percent of incomplete records, rear udder, and feet and legs in their model, suggest that those sires with values of one standard deviation below the mean for those independent variables should produce daughters with 0.35 more records. This strongly suggests that increased longevity is found in the cows of Jersey and Guernsey breeds whose sires have a low percent of incomplete daughters; however, in Holsteins, with the large standard deviation for milk, those daughters of sires with large predicted differences for milk will have greater longevity than the small predicted differences.

As is expected, milk is affected by fat in all breeds. The percent of incomplete records also affects milk with regression coefficients ranging from $-.28$ in Holsteins to $-.11$ in Jerseys. Holsteins show that the number of records had a highly significant effect ($P < .01$) on the predicted difference for milk with a slightly negative regression coefficient. Holsteins were also the only breed in which age adjusted score had an effect on fat.

The stepwise regression procedure with the measures of average score as the dependent variables are in Table XXIII through XXV. The R^2 values were very large, ranging from 0.96 in Guernseys to 0.74 in the Holsteins. The average score for Guernseys and Jerseys and age adjusted

TABLE XXIII
STEPWISE REGRESSION OF DEPENDENT VARIABLE
AVERAGE SCORE FOR GUERNSEY SIREs

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.96
Error				169	0.05	
Intercept			-0.07			
BYR	0.17	0.08	-0.00			
GA	400.83	0.01	0.07			
MS	37.01	0.01	0.02			
Milk	0.44	0.01	0.00			
HFL	8.95	0.01	0.01			
INC	0.19	0.06	-0.00			

TABLE XXIV
STEPWISE REGRESSION OF DEPENDENT VARIABLE
AGE ADJUSTED SCORE FOR HOLSTEIN SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.74
Error				661	298.38	
Intercept			8.24			
BYR	14.67	0.01	-0.01			
PDT	39.86	0.01	0.00			
BAA	12.47	0.01	0.00			
Fat	5.27	0.01	-0.00			
INC	1.81	0.04	-0.00			

TABLE XXV
STEPWISE REGRESSION OF DEPENDENT VARIABLE
AVERAGE SCORE FOR JERSEY SIRES

Source	Partial SS	PROB F	B-Values	D.F.	Mean Square	R ²
Regression						0.84
Error				95	0.35	
Intercept			-0.61			
BYR	0.32	0.66	-0.00			
MS	188.46	0.01	0.05			
GA	164.85	0.01	0.05			
RECS	1.13	0.07	0.00			

score for Holsteins are all affected by most of the other type components, as well as a few production traits. The percent of incomplete records affected the average score for both Guernseys and Holsteins with negative regression coefficients. This indicates that the lower scored daughters will have more incomplete records.

Records per daughter had a slight positive effect, which approached significance on average score, in Jerseys. Therefore, it would be expected that the Jersey cows with greater longevity would have a higher classification rating than those lower classified Jersey cows.

The results of this study on the longevity of dairy cows should be used cautiously. This data consisted of sires born several years ago and some trends which were observed may have changed. Classification programs have changed and presumably nonfunctional aspects are of less importance in more recent years. The results do strongly indicate that it would not be economical for dairymen to select dairy sires on classification data alone.

If type is to receive the special attention that it has been given in the past, it seems proper that breeders and stud organizations should develop a classification system whereby more functional aspects of conformation receive greater emphasis. It is suggested that breeders consider the percent of incomplete records along with predicted differences for milk and fat before selecting sires

to be used in their herd. The stud organizations also should consider the longevity, or number of records per daughter, in pricing the semen of their bulls. Today's practices tend to base the price of semen entirely on predicted differences for milk and fat and little attention is given to the longevity of a sire's daughters.

CHAPTER V

SUMMARY

The primary objectives of this study were to use type and production progeny summaries of dairy sires to determine their usefulness toward increasing longevity and production in the Guernsey, Holstein, and Jersey breeds.

Data for this study were obtained from USDA-DHIA Sire Summaries for production, and from official type summaries for classification data over a six year period (1967 to 1973). The data included 176 Guernsey, 667 Holstein, and 100 Jersey sires. These were selected on the basis of having at least 100 daughters for the Guernsey and Jersey sires and 500 or more daughters for the Holstein sires. Only sires born prior to 1960 and those with complete type data were analyzed.

The longevity was measured by the number of records per daughter and percent of incomplete records. The analysis of the three breeds indicates negative correlations of -0.37, -0.25, and -0.40 between the number of records and percent of incomplete records for Guernsey, Holstein, and Jersey breeds, respectively. Percent of incomplete records was negatively correlated with most measures of type in the Jersey breed. The Guernseys and Holsteins indicate small positive correlations when percent of incomplete records was

correlated with type data. Records per daughter had 0.12, 0.24, and -0.01 correlations with average score in the Guernsey, Holstein, and Jersey breeds, respectively. Milk and fat were negatively correlated with type in the Holsteins and Jerseys. The teat classification score in Jerseys and front feet and legs in Guernseys had a significant ($P < .05$) effect on the percent of incomplete records, according to the stepwise regression procedure. Guernseys also showed that front feet and legs had a significant effect and the feet and legs in Jerseys had a slight effect on the number of records per daughter.

The results of this study of the longevity of dairy cows should be used cautiously. This data consisted of sires born several years ago and many of those trends that are suggested to be changed are now in the process of changing in many breeding programs today. The results do strongly indicate that it would neither be economical nor practical for dairymen to select dairy sires on classification data alone. The conclusions were not the same for each of the breeds since their classification systems have caused their breeding programs to vary.

If type is to receive the special attention that it has been given in the past, it seems proper that breeders and stud organizations should develop a classification system whereby more functional aspects of conformation receive greater emphasis. Improved standards or different

measures of scoring the legs and feet of dairy cows should be developed. The Guernsey, Holstein, and Jersey breeds should be primarily concerned with their selection programs to increase longevity. This could be accomplished by decreasing the percent of incomplete records and increasing the number of records per daughter. Since an increase in longevity would require fewer heifer replacements, it would be very economical for dairymen to consider those sires with more records per daughter, along with high predicted differences for milk and fat.

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VITA

David Eugene Harmon was born in Greene County, Tennessee, on July 27, 1951. Before enrolling in the University of Tennessee, Knoxville, he was the chosen speaker at his graduation from Greeneville High School in 1969.

His first years at the University were also the concluding years of his 4-H Club work. Two trips to National 4-H Congress in Chicago and being named the National Public Speaking winner were the last events in his 4-H career.

Midway in his college career, he was presented the Ambrosia Chocolate Award for being superior in the judging of dairy products.

While a member of the University's Dairy Cattle Judging team, he was high individual for judging Jersey cows in the National and Mid-South Inter-collegiate Dairy Judging Contests.

Just prior to receiving his Bachelor of Science degree in December of 1973, one of his Guernsey heifers, D Harmons Am V Valentine, was selected as National Junior Champion at the World Dairy Exposition in Madison, Wisconsin. He received the 1973 Special Breeders Award from The American Guernsey Cattle Club. "Valentine" later was chosen as All-American for the second time.

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