DIFFERENTIAL REMOVAL OF DAUGHTERS AMONG AI SIRES

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ABSTRACT

DIFFERENTIAL REMOVAL OF DAUGHTERS AMONG AI SIRES

by Arthur D. Dayton

Accurately comparing sires in AI may be difficult if the number of daughters eliminated from test is disproportionate among bulls and related to performance.

The purposes of this study were to determine if rates of removal at young ages among the daughters of AI sires are equal or if some sires have a larger per cent of their daughters leaving the herd than others, to determine the distribution of removals among various voluntary and involuntary reasons, and to measure the extent individual differences in reasons for disposal are heritable.

The data were taken from Michigan DHIA records from 1957 through 1962. Only daughters resulting from artificial insemination by sires in the Michigan Animal Breeders Co-op., American Breeders Service, and Curtiss Breeding Service were included. Over 1,300 Guernsey cows out of 42 sires and 7,800 Holstein cows out of 266 sires were used. To compare fairly bulls which were not contemporary, the analysis was within lactations and by numbers of tested daughters per sire.

Clearly, cows in first lactation were removed at a disproportionate rate among sires regardless of the number of tested daughters per sire.

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Heritability of reasons for disposal during the first lactation only ranged from 0 to .18 for specific reasons and was .24 for total removals in the Holsteins. When the heritabilities were adjusted for average incidences by transformation to the probit scale, heritability ranged from 0 to .67 for specific reasons and was .62 for total removals. The Guernsey data were similar; however, heritability for total removals was unreasonably large, perhaps due to the small number available.

DIFFERENTIAL REMOVAL OF DAUGHTERS AMONG AI SIRES

By

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INTRODUCTION

Many dairymen today depend for their breeding programs either wholly or in part on sires from the different Artificial Insemination (AI) units to sire the next generation of milking cows. Fifty-five per cent of the milk cows in Michigan, for example, were bred to AI dairy bulls in 1964 (Dairy Herd Improvement Letter 1965a). The dairymen select the bulls to be used in their herds by such criteria as the sire's daughters' production and type or his rate of conception.

The initial summary of a sire used in AI service is usually made from the first records of 305-day lactations of his daughters. Biased evaluations can result when sires have disproportionate numbers of daughters removed from lactation prior to completing a record and when these incomplete terminal records are not included in their summaries or are included in the summary but are extended to 305 days with ratios or regression coefficients for normal records in progress rather than with values developed for incomplete terminal records, Aulerich (1965). The rank of a bull having a large proportion of his daughters removed as compared with a bull with few daughters discarded might not then be accurate if any difference in production is associated with the difference in removals.

The current policy of the United States Department of Agriculture (USDA) for sire evaluation is to project or extend incomplete records to a 305-day basis by ratios appropriate for normal records in progress. Incomplete records are those reported to the USDA with conditions affecting records (CAR) codes 2, 3, and 8 with days in milk less than 305 and more than 14. Records reported with CAR codes of 0, 4, 5, 6, and 7 are complete, are not projected, and are used in sire evaluations if the days in milk range from 180 to 305 days. They are not used if days in milk are less than 180 days. Records reported with CAR codes of 1 and 9 are not used for sire evaluations (Dairy Herd Improvement Letter 1965b).

CAR codes used by USDA.

Code	Interpretation
0	Dry or 305-day record with no other conditions affecting it.
1	Estimated (Incomplete or missing first part of lactation).
2	Sold presumably for dairy purposes.
3	Died or sold for beef.
4	Injury
5	Mastitis.
6	Ketosis.
7	Other sickness.
8	Record terminated by abortion.
9	Nurse cow.

From every dairy herd a number of milking cows are removed each year for various reasons. Little information is available in the literature to indicate whether these causes are genetically influenced or are caused mainly by environmental and managerial factors.

The purposes of this study were to determine if rates of removal of daughters at young ages among AI sires are equal -- do some sires have a larger per cent of their daughters leaving the herd than others, to determine the distribution of removals among various reasons, and to measure the extent individual differences in reasons for disposal are heritable.

REVIEW OF LITERATURE

Literature concerning removals of cows contains a considerable amount of information on age, production, per cent removals, and causes for disposal. This information has been collected in large part by survey.

Average age of cows

The average age of cows and the average length of time cows stay in the herd indicate what proportion of the cows leave the herd each year. Becker and Arnold (1954) found cows raised at home remained in 14 Florida herds 4.7 years after attaining producing age; whereas, in 101 herds that purchased their replacements, the average was 3.9 years. In a similar study of 138 Jersey and 174 Holstein cows, Seath *et al*. (1943) observed 3 years 8.3 months and 3 years 9.3 months, respectively for Jersey and Holstein cows, as the actual time spent in the Louisiana milking herd. O'Connor and Hodges (1963) estimated the average herd life in Private Milk Record herds from first calving to disposal was between 3.5 and 4.5 years, and the average life span from first calving to death was between 5 and 6 years. The average milk producing life of Michigan DHIA cattle from 1931-39 was 3.7 to 4.0 years (Baltzer, 1940).

Rendel and Robertson (1950) put four lactations as the average productive life and stated further that an increase in productive life by one lactation would raise the mean production of the herd by less than one per cent. Horton et al. (1960), reporting on 894 animals of four dairy breeds from the Arkansas Agricultural Experiment Station herd, found an average number of lactations per cow of 3.4 for Holsteins, 3.3 for Jerseys, 3.0 for Guernseys, and 2.2 for Brown Swiss. Seath et al. (1943) found the average number of freshenings for Jersey and Holstein cows was 3.78.

One concept of average age, as pointed out by Slobodkin (1962), is that of the age attained by a median individual. He explains the median age by imagining a group of 100 animals of a particular species born at the time instant t_o. There will be a time when the 50th individual has just died. If this time is referred to as t_{o+md}, the median age of the animals or the median life expectancy at birth is equal to the interval $(t_{o+md}-t_o)$. This method has a tendency to make the median life expectancy short in species with high mortality rates in the young.

Slobodkin explains another concept of average life called the mean life expectancy. This is the number of years of life that will be lived by an average animal in a group. Defining the number of individuals born alive at the time instant t_o as l_o and defining the number of these individuals alive at a subsequent instant t_x as l_x, the graph of l_x against time can be constructed, Figure 1. The graph shows four basic types of survivorships. Mean life expectancy is calculated for any given age by computing the area under the survivorship curve for all subsequent ages and dividing by l_x.

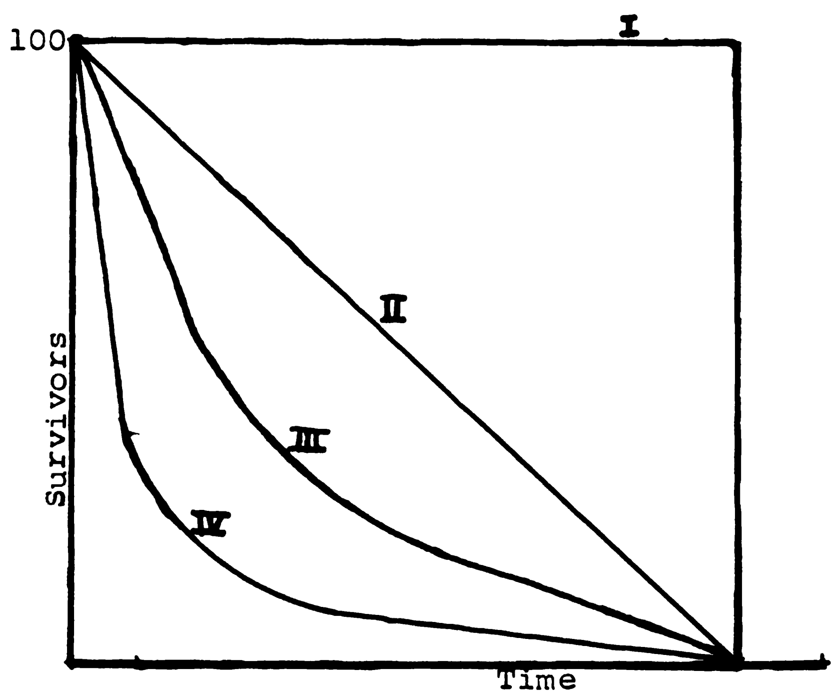

Figure 1. The four simple types of survivorship curves. In type I, mortality is concentrated in the old animals. Type II is characterized by a constant number of deaths per unit of time. Type III is found when the risk of death is constant with age. Type IV has mortality concentrated at the young stages.

Cannon and Hansen (1939) using information from the Iowa Cow Testing Association during 1927-28 and 1930-36 calculated the life expectancies for 147,596 dairy cows. These life expectancies were compared with the life histories of cows that had passed through the Iowa State College herd. In most cases the life expectancies for the two groups were similar. In the association herds a cow freshening at an age less than 2 years was considered 2-3 years old; whereas, in the college herd uncalved two-year-olds were included, but yearlings that had freshened were not used in the calculations. For every 100 cows in the 2-3 year-old group, 72.3 reached the 3-4 year-old group in the cow testing association herds, but in the college herd 77.1 of the 2-3 year-olds reached the 3-4 year-old group. Cannon and Hansen attributed this difference to more removals for low production in the association herds than in the college herd. The average ages of the cows in the association and college herds were about 4.7 and 4.2 years, respectively. Even though drought conditions and the business depression were confounded with years, the yearly differences for rate and age of removals were small with the exception for 1927-28.

Using herd book records of four dairy breeds in Great Britain (Shorthorn, Ayrshire, Jersey, and British Friesian), Smith and Robison (1950) gave the average age of cows at calving of 5.5 years. Specht and McGilliard (1960) found an average age at calving of 4.4 years for Michigan DHIA tested cows. At the Illinois Agricultural Experiment Station the average age at disposal was 5.9 years for 877 cows of five dairy breeds during a 20 year period, (Johannson, 1961). The average age of 6,976 cows that died or had to be slaughtered as removals from Dutch farms was 6 years 10 months, (Hoekstra, 1960).

Removal rates

Tables 1 and 2 illustrate the wide range of percentages removed annually and of causes of cow removals given in various studies.

A variety of influences possibly have biased the results in these reports. Factors that can influence the percentages for removals are:

(1) More than one reason for disposal may apply to a removal. For example, a percentage removal given for low production might include cows with declining production in late lactation which are non-breeders. These cows should be included in percentages recorded for cows removed because of infertility rather than low production. In the Beltsville herd, Parker et al. (1960) found 41.3% of the Holsteins and 21.3% of the Jerseys were removed as non-breeders. They considered these figures -- higher than usually reported in this country -- to be more accurate than DHIA reports because many DHIA cows removed for low production become low producers when there is no prospect of calving because they are non-breeders.

(2) Managerial procedures affect the information in the studies. In herds where selection intensity is greater, the per cent of annual removals may be higher. That a wide range in selection intensity does exist was indicated by Seath (1940). In an extensive study to find how much selection occurs in dairy herds; records from 147 Iowa herds and 37 Kansas herds were used. All herds studied were continuously on test 3 to 6 years. Cows which had completed a year in a cow testing association but had left the herd for any reason before completing the next testing year were defined as culls. Culls were 28.6% and 32.9%, respectively, of 8,010 Iowa cows

Table 1

Annual Rates of Removal Reported in the Literature

Report	Country	Annual removal rate
Baltzer (1940)	United States (Michigan)	24.1%
Seath (1940)	United States (Kansas)	30.9%
Asdell (1951)	United States	16.8%
Johnson (1958, 1959, 1960, 1961, 1962, 1963)	United States (Michigan)	25.4% 1958 29.0% 1959 27.6% 1960 26.6% 1961 27.9% 1962 29.9% 1963
Specht and McGilliard (1960)	United States (Michigan)	26.3%
Rabold (1958)	Germany	15.0%
Leali (1956)	Italy	8.8%
Clark (1958)	Australia	16.8%
Withers (1955, 1957, 1959)	Great Britain	22-24%
O'Connor and Hodges (1963)	Great Britain	29.3% 1957-58 23.4% 1959-60

Table 2

Causes and Frequencies of Removals
(Per cent of Total Removals)
Reported in the Literature

Report	Country	Causes and Frequencies
Seath (1949)	United States (Kansas)	Disease (39.1%), low production (30.5%), dairy purposes (19.0%), deaths (6.6%)
Arnold *et al.* (1949)	United States (Florida)	Udder trouble (21.0%), low production (14.7%), deaths (12.4%), reproductive trouble (9.3%)
Asdell (1951)	United States	Low production (33.3%), dairy purposes (23.3%), udder trouble (11.4%), sterility (8.2%), abortion (6.8%)
Horton *et al.*	United States (Arkansas)	Physiological or anatomical (27.5%), low production (21.6%), disease (21.6%)
Snick and Kinit (1964)	Belgium	Low production (30.8%), infertility (22.9%)
Guba and Illes (1959)	Hungary	Sterility (29.8%), low production (13.2%)
Ziegenhagen (1952)	Germany	Infertility (39.7%), udder trouble (16.8%)
Jeske (1958)	Germany	Sterility (41.6%), low production (11.9%) T.B. (9.9%), udder trouble (2.4%)
Rabold (1958)	Germany	T.B. (28.7%), sterility (24.7%), sold for slaughter (16.6%), dairy purposes (7.9%), disease (5.7%)
Leali (1956)	Italy	Infertility (29%) in herds with average milk production of 2000-3000 liters, (59-63%) in higher yielding herds.

Table 2 Continued . . . .

Report	Country	Causes and Frequencies
Nai (1958)	Italy	Sterility (48.3%), low production (15.4%), bangs and T.B. (11.2%), mastitis (9.6%).
Mutovin (1961)	Russia	Udder trouble (31.8%)
Hoekstra (1960)	Netherlands	Reproductive disorders (32%) udder trouble (15%), low production (11%)
New Zealand Dairy Board (1958)	New Zealand	Low production (37.0%), disease (38.0%), old age (11.1%), dairy purposes (10.6%)
New Zealand Dairy Board (1963)	New Zealand	Low production (32.1%), sterility (20.5%), T.B. (11.7%), old age and other (10.7%), dairy purposes (6.9%)
Withers (1955)	Great Britain	Disease and accident (26.6%), low production (19.7%), infertility (17.6%), old age (8.6%), death (4.2%)
Stewart and O'Connor (1958)	Great Britain	Low production (23.5%), disease and accident (18.9%), infertility (13.4%), old age (7.6%), death (4.2%)
Clark (1952)	Australia	[1]Dairy purposes, low production, old age, udder trouble, sterility
Clark and Paul (1954)	Australia	[1]Low production, old age, dairy purposes, sterility, udder trouble
Clark (1958)	Australia	Low production (44.4%), old age (16.5%), udder trouble (6.1%), sterility (6.1%), injury (4.9%), calving trouble (2.8%)

[1]Main reasons for disposal, no percentages given.

and 4,087 Kansas cows. This indicated a productive life of 3.5 years for Iowa and 3.2 years for the Kansas cows. The range in annual removal rates was from 25.6% in 1932 for Iowa to 36.9% in 1934 for Kansas. In the Iowa herds no significant difference was found between per cent of purebreds and of grades removed; whereas, in Kansas almost one third more culling was practiced in grade than in purebred herds. Part of this difference was attributed to the desire of Kansas herd owners to increase the number of purebred animals in the herds.

(3) For information gathered by survey, the form of the questionnaire, the order of questions used, or the approach of the questioner may influence the results and the interpretations. Data gathered by O'Bleness and Van Vleck (1962) illustrate the influence survey forms can have on the answers obtained. They used two survey forms in New York DHIA tested herds to determine the causes of removals from October, 1960, to March, 1961. The only difference between the two forms used was the order in which the reasons were listed. A sample Chi Square indicated a difference in responses was not due to chance. Responses to questions on 7,362 cows gave the following ranges in percentages regarding reasons for removal: 27-32% for low production, 16-19% for sterility, 14-20% for udder trouble and mastitis, and 14-15% as being sold for dairy purposes. Two to four per cent were removed for undesirable dairy type and less than one per cent for bangs and T.B.

(4) Economic conditions influence rates of removal and reasons for disposal. Asdell (1951) found this to be the biggest factor affecting the year to year variation in rates of removal in his study from 17 states. He found a reduction in abortions and a steady increase in sterility as reasons for removals from 1932 to 1949. In the latter years sterility became second after low production among the major reasons for removal.

Heritabilities

Few attempts have been made to relate the information regarding the causes of removal to inheritance. Meek (1962) in a study covering 21 years in 11 Iowa Holstein herds estimated heritability by regression of daughter on dam and also by four types of half-sib analysis of seven causes of disposals. Mastitis showed a value of .10 for heritability, calving trouble .05, reduced fertility .05-.10, and low production .08-.35. Heritabilities of other reasons were essentially zero. Meek concluded some attention to mastitis and reduced fertility in young heifers seems worth while in any large scale breeding plan which involves the possibility of a bull being followed by his sons in an AI stud. Meek's findings support additional study to determine the degree to which the causes of removal are genetically influenced.

Some of the variation in rates of annual removals and in percentage removals given for specific reasons can be attributed to environmental factors such as management, economic conditions, etc. Unanswered is the question of how much of the variation is genetically caused. Clear definitions of terms such as culling, wastage, voluntary and involuntary removals, and a standardized procedure for classifying the reasons for removals of cows would facilitate study and comparisons between studies of removals.

SOURCE OF DATA

The data were taken from Michigan Dairy Herd Improvement (DHIA) records from 1957 through 1962. Since 1957 was the first year all DHIA records in Michigan were processed by machine, most of the records in this study were from the latter years. Only daughters resulting from Artificial Insemination (AI) by sires in the Michigan Animal Breeders Co-op., American Breeders Service, and Curtiss Breeding Service were used; no natural daughters of these sires were included.

Disposals

Whenever a cow is removed from a tested herd, the reason-only one reason--for her disposal is given. The reasons for disposal are classified into nine categories of "sold" and seven of "died".

Terminated records of milk and fat production of cows sold or dying between 0 and 305 days in milk were extended to 305-days with ratio factors developed by Lamb and McGilliard (1960), were adjusted to twice-a-day milking and corrected for age by DHIA factors. Cows sold or dying after 305 days in milk or cows removed while dry were excluded. Removals of 1,322 Guernsey cows out of 42 sires and of 7,839 Holstein cows out of 266 sires were used. Table 3 shows the reasons for removal and the frequencies of each for two breeds. Table 4

Table 3

Distribution of Holstein and Guernsey AI Daughters by Reason for Removal

Reason	Code	Holstein		Guernsey	
Sold		No.	%	No.	%
Dairy Purposes	30	879	11.2	126	9.5
Low Production	31	3309	42.2	758	57.3
Physical Injury	32	957	12.2	115	8.7
Mastitis	33	775	9.9	66	5.0
Bangs	34	115	1.5	21	1.6
T.B.	35	187	2.4	6	.5
Hard Milker	36	229	2.9	26	2.0
Sterility	37	882	11.3	135	10.2
Old Age	38	143	1.8	12	.9
Died					
Milk Fever	40	18	.2	2	.2
Acetonemia	41	8	.1	2	.2
Hardware	42	94	1.2	11	.8
Bloat	43	75	1.0	6	.5
Accident	44	143	1.8	18	1.4
Old Age	45	13	.2	3	.2
Poisoning	46	30	.4	9	.7
Unknown		42	.5	6	.5
Total		7839		1322	

% Per cent of total removals

Table 4

Distribution of Michigan DHIA Cows by Reason for Removal

Reason	Code	1957 No.	1957 %	1958 No.	1958 %	1959 No.	1959 %	1960 No.	1960 %	1961 No.	1961 %	1962 No.	1962 %	1963 No.	1963 %
Sold															
Dairy Purposes	30	887	11.8	1145	11.5	1856	11.7	1757	10.6	1929	10.9	1841	9.0	1990	8.4
Low Production	31	3483	46.4	4338	43.7	6478	40.7	6619	40.1	7311	41.4	9066	44.4	10875	46.1
Physical															
Injury	32	709	9.4	992	10.0	1557	9.8	1551	9.4	1557	8.8	1949	9.5	2168	9.2
Mastitis	33	467	6.2	607	6.1	1145	7.2	1303	7.9	1297	7.4	1507	7.4	1638	6.9
Bangs	34	245	3.2	413	4.2	219	1.4	221	1.3	189	1.1	192	.9	106	.5
T.B.	35	102	1.4	233	2.3	589	3.7	534	3.2	319	1.8	109	.5	56	.2
Hard Milker	36	126	1.7	197	2.0	290	1.8	322	2.0	313	1.8	404	2.0	475	2.0
Sterility	37	1085	14.5	1482	14.9	2326	14.6	2737	16.6	3215	18.2	3627	17.8	4296	18.2
Old Age	38					458	2.9	453	2.7	515	2.9	549	2.7	655	2.8
Died															
Milk Fever	40	44	.6	40	.4	136	.9	132	.8	124	.7	185	.9	231	1.1
Acetonemia	41	10	.1	17	.1	42	.3	42	.3	54	.3	66	.3	91	.4
Hardware	42	61	.8	75	.8	170	1.1	168	1.0	199	1.1	182	.9	186	.8
Bloat	43	57	.8	46	.5	145	.9	162	1.0	100	.6	101	.5	109	.5
Accident	44	58	.8	89	.9	365	2.3	388	2.4	405	2.3	457	2.2	507	2.1
Old Age	45	20	.3	42	.4	60	.4	55	.3	44	.2	49	.2	57	.2
Poisoning	46							39	.2	38	.2	35	.2	44	.2
Unknown		148	2.0	234	2.4	88	.6	24	.1	36	.2	104	.5	101	.4
Total		7503		9917		15924		16507		17645		20423		23584	

% Per cent of total removals.

gives the number and per cent removals for each reason for all Michigan DHIA cows, all breeds, for 1957 through 1963.

Non-disposals

Records for non-disposals were by all daughters of the AI sires of disposals that completed one or more lactations through 1962 and included any complete records for cows subsequently removed. Complete records of milk and fat were corrected for age and adjusted to twice-a-day milking, but complete records less than 305 days were not adjusted for length regardless of their duration. The Holstein sires had 30,308 complete records and the Guernsey sires had 2,763 completed records through 1962.

METHODS AND RESULTS

The first problem in analyzing removal rates of daughters of AI sires was to find some method of comparing non-contemporary bulls since daughters of varying ages during the 5 years represented bulls from a much larger span of time. Since the literature indicates a larger rate of removal during the first lactation than during later lactations, the data were grouped by parity into three categories. Group I was first lactation; group II, second and third lactation; and group III was fourth or later lactation. Sires were compared on the proportion of their daughters that left the tested herds during certain lactations of their daughters regardless of when the bulls were in service.

The cows were classified according to their lactation number when it was available or by age if no number of lactation was indicated. Fritz (1960) found less than five per cent of the first lactations of Michigan DHIA cows started after 36 months of age at calving and less than three per cent of the third lactations began after 62 months of age at calving. Therefore, all records without lactation number were designated first lactations if the cow was less than 36 months of age at calving, second or third lactations if the cow was 36-62 months of age at calving, and all older

cows were considered to have four or more lactations.

Tables 5 and 6 give the number and per cent of total removals by reason within age-lactation for Holsteins and Guernseys.

A cow with a terminated record in age-lactation II (second and third lactation) could have a completed record in age-lactation I. She was a non-disposal in the age-lactation I but a disposal in age-lactation II.

The analysis of disproportionate removal rates of daughters of sires was done by Chi Square goodness of fit. The question was whether the distribution of terminated and complete records was the same for all sires or whether selection was much stronger and removals more frequent for specific reasons among daughters of some sires.

Since the test is of independence or agreement between expected and observed frequencies and not total numbers in each cell, the hypothetical frequency or the expected value for each cell was computed from the marginal totals in the corresponding rows and columns:

$$\text{Expected cell value} = \frac{(\text{-row total})\quad(\text{column total})}{N}$$

N = total number of observations.

In Chi Square goodness of fit the number expected in any cell should be not less than five for the probability distribution to be reasonably accurate. In cases where sires had only a few tested daughters, the frequencies expected in many of the removal classes were quite likely to be very low

Table 5

Number of Holstein Disposals and Non-Disposals by Reasons Within Age-Lactation

Age-Lactation	Sold									Died	Non-Disposals
	30	31	32	33	34	35	36	37	38		
I	388	987	218	91	34	48	84	170	4	123	10003
%	18.1	46.0	10.2	4.2	1.6	2.2	3.9	7.9	.2	5.7	
II	340	1550	361	283	49	100	85	353	3	164	12865
%	10.3	47.1	11.0	8.6	1.5	3.0	2.6	10.7	.1	5.0	
III	151	772	378	401	32	39	60	299	136	136	7440
%	6.3	32.1	15.7	16.7	1.3	1.6	2.5	12.4	5.7	5.7	

% Per cent of total removals.

Table 6

Number of Guernsey Disposals and Non-disposals by Reason Within Age-Lactation

Age-Lactation	Sold									Died	Non-Disposals
	30	31	32	33	34	35	36	37	38		
I	56	230	34	10	7	4	9	23	0	24	781
%	14.1	57.9	8.6	2.5	1.8	1.0	2.3	5.8	0	6.2	
II	43	318	44	24	5	2	9	58	1	23	1263
%	8.2	60.3	8.4	4.6	1.0	.4	1.7	11.0	.2	4.5	
III	27	210	37	32	9	0	8	54	11	10	719
%	6.8	52.8	9.3	8.0	2.3	0	2.0	13.6	2.8	2.7	

% Per cent of total removals.

if all sires were analyzed in one group without regarding the number of daughters per sire. In order to prevent expected values of less than five in many of the removal classes, sires were classified within age-lactation group according to the number of tested daughters. The first group was sires with 11-20 tested daughters, group two was 21-49 tested daughters per sire, and the last group was sires with 50 or more tested daughters.

In each group there were as many different classes of removal as possible with at least five expected in each cell. In cases where expected values were less than five, observations in two or more classes of removal were pooled into one class. If, for example, the expected frequencies of removal for physical injury and mastitis each were less than five, the observations were pooled into one class.

Tables 7 and 8 give the number of tested daughters per sire within age-lactation and the Chi Square values for disproportionate removals between the sires. Table 7 indicates clearly in every case for Holsteins except for sires with 11-20 tested daughters in age-lactation II and sires with 11-20 tested daughters in age-lactation III, a disproportionate rate of removal between sires. The probability was less than .05 for the former group; the latter group showed no statistical difference in removal rates among the 37 sires represented.

Table 8 reveals similar results for Guernseys with significant Chi Square values at the probability of .01 with the exception of three groups where no statistical differences in removal rate were observed. The three groups were sires with 11-20 tested daughters in age-lactation I and III and sires with 50 or more tested daughters in age-lactation III.

The trend in AI, especially in young sire programs, is to put a great deal of emphasis in selection on the sire summary based on first lactations of the sire's daughters. An inaccurate evaluation can result when sires have disproportionate numbers of daughters removed from lactation prior to completing a record, the incomplete records are not included in their summaries, and the difference in removals is associated with any difference in production. The disproportionate removals among sires is shown clearly for Holsteins by the highly significant Chi Square values for every group within age-lactation I regardless of how many tested daughters a sire had. The Guernsey sires with 21-49 tested daughters and more than 49 tested daughters differed in removal rates during the first lactation.

In spite of the different rates of removal for various sires, bulls could be compared fairly if the removals were not related to production or if all incomplete records were extended to a 305-day basis with the proper extension factors and were included in the sire summaries.

The average milk and fat production, age in months at calving, and days in milk during terminal records are shown for the two breeds in Tables 9 and 10. The difference

Table 7

Holstein Disposals and Non-disposals for Number of Tested Daughters per Sire Within Age-Lactation

Age-Lactation	Number of tested dau. per sire	No. of sires	Number of disposals	No. of non-disposals	Total	Range[1]	X^2	d.f.
I	11-20	41	143	473	616	.05-.69	153**	80
I	21-49	41	179	1153	1332	.12-.64	188**	80
I	> 49	44	1584	8086	9670	.11-.42	694**	172
II	11-20	40	134	463	597	.22-.64	103*	78
II	21-49	46	394	1135	1529	.13-.89	367**	135
II	> 49	70	2596	11134	13730	.04-.65	1191**	345
III	11-20	37	144	412	556	.10-.52	885	72
III	21-49	48	352	1123	1475	.08-.59	250**	141
III	> 49	51	1735	5598	7333	.03-.48	538**	250

** P .01
* P .05
[1] Range in proportion removed for individual bulls.

Table 8

Guernsey Disposals and Non-disposals for Number of Tested Daughters per Sire Within Age-Lactation

Age-Lactation	Number tested daug. per sire	No. of sires	Number of disposals	No. of non-disposals	Total	Range[1]	X^2	d.f.
I	11-20	10	34	114	148	.07-.41	15.8	18
I	21-49	14	127	229	426	.09-.71	102.9**	39
I	> 49	4	94	247	341	.10-.65	82.2**	15
II	11-20	18	68	197	265	.05-.68	74.7**	34
II	21-49	17	128	382	510	.07-.78	79.7**	32
II	> 49	7	144	544	688	.12-.34	43.1**	18
III	11-20	15	71	148	219	.09-.59	29.8	28
III	21-49	14	143	257	400	.17-.81	78.4**	52
III	> 49	2	63	141	204	.28-.32	3.5	4

** P .01

1 Range in proportion removed for individual bulls.

between production of the non-disposals and disposals is shown for each reason for disposal. The differences in production support the accuracy of the reason given for disposal in cases of low production. Some of the other reasons may indicate cows are removed because of mastitis, sterility, or physical injury only when production has been affected. For example, if a cow had severe mastitis and was a good producer, the dairyman could justify drying up one quarter and keeping the cow in the herd; whereas, an average or below average producer would be removed.

The terminal records in the table were extended to 305 days with factors developed by Lamb and McGilliard (1960). The differences in production between non-disposals and disposals would be larger had the factors developed by Aulerich (1965) been used to extend the terminal records to 305 days. Aulerich found the lactation curves of cows removed involuntarily from the herd--cows which could not have been retained even if the owner wanted--were similar to those of cows completing their records. However, cows removed involuntarily from the herd generally initiated their lactations with a slightly lower yield than the cows completing their records. The projection factors used for extending an incomplete non-terminal lactation can be employed to estimate 305-day milk yields of cows involuntarily removed from the herd during lactation; however, they may underestimate the 305-day yield due to the slightly faster

Table 9

Average Production, Age of Calving in Months, and Days in Milk During Terminal Records of Holstein

Reason for disposal	Number of disposals	Age	Days in milk	Milk	Fat	(Non-disposals-disposals) Milk	Fat
Dairy purposes	879	42±.7	142±2.9	12927±94	474±4	-146	-4
Low production	3309	47±.4	181±1.2	10229±42	370±2	2552	100
Physical injury	957	57±.9	157±2.6	12072±97	443±4	709	27
Mastitis	775	63±.9	153±2.7	11867±125	425±4	914	45
Bangs	115	49±2.1	148±8.2	12742±274	466±11	39	4
T.B.	187	47±1.4	169±5.7	12971±195	476±7	-190	-6
Hard milker	229	49±1.6	147±5.5	11804±183	426±7	967	44
Sterility	822	56±.9	232±1.9	12029±91	441±4	752	29
Old age	143	108±2.5	197±6.1	12090±476	419±9	691	51
Death	423	53±1.3	138±4.3	12360±163	458±6	421	12

Table 10

Average Production, Age at Calving in Months, and Days in Milk During Terminal Record of Guernseys

Reason for disposal	Number of disposals	Age Mean	Days in Milk Mean	Milk Mean	Fat Mean	(Non-disposals-disposals) Milk	Fat
Dairy purposes	126	43 ± 2.2	142 ± 8.2	9040 ± 201	441 ± 10	-22	-2
Low production	758	$49\pm.8$	179 ± 2.7	7065 ± 65	338 ± 3	1953	101
Physical injury	115	50 ± 2.3	146 ± 7.9	8171 ± 201	404 ± 11	847	35
Mastitis	66	59 ± 3.1	162 ± 9.9	8315 ± 256	393 ± 11	703	46
Bangs	21	56 ± 5.5	160 ± 22.1	8774 ± 326	413 ± 15	244	26
T.B.	6	29 ± 3.7	218 ± 36.3	9059 ± 633	434 ± 44	-41	5
Hard milker	26	50 ± 5.0	127 ± 16.1	8078 ± 345	398 ± 17	940	41
Sterility	135	60 ± 2.6	224 ± 50.4	8179 ± 164	404 ± 82	839	35
Old age	12	101 ± 8.1	202 ± 21.3	8657 ± 622	401 ± 33	361	38
Death	57	47 ± 3.9	117 ± 10.4	8620 ± 327	416 ± 16	398	23

decline of the lactations terminated involuntarily. The shapes of the curves of voluntarily incomplete terminal lactations--lactations terminated by the owner willfully removing the cow--were unlike those of the cows completing records. The cows voluntarily removed from the herd initiated their lactations at a lower milk yield and declined at a faster rate during lactation than cows completing 305 days. Aulerich developed separate factors for extending voluntarily terminal records to 305 days.

The two breeds differed little in average days in milk during terminal records or in mean age at calving for the various reasons for removal.

The same information for milk and fat production in the two breeds but within age-lactation is given in Tables 11 and 12. The differences in production between the non-disposals and disposals as well as the differences in production between non-disposals and all cows are indicated. The difference in production between the selected cows (non-disposals) and all cows was nearly twice as large for Guernseys as for Holsteins.

Heritabilities of reasons for disposal

Heritabilities of reasons for disposal during the first lactation only were calculated by analysis of variance within and between sires. Estimates of heritability from cows in first lactation should be more meaningful than from any other age-lactation group or combination of all the data because of the lack of previous selection for production.

Only sires with eleven or more tested daughters were used. The data are an all-or-none kind in that each animal was either removed or kept in the herd during the 305 day lactation period.

The results for total disposals for Holsteins and Guernseys are presented in Table 13. The components of variation expected in the mean squares are designated as E and S. E is the variance between paternal half sisters and S is the extra variance between means of groups of paternal sisters. The heritabilities of differences in fates of individuals in Table 14 were calculated by 4S/(S+E). For example, the heritability of total removals in Holsteins was .276 where S = .0085 and E = .1289.

Most of the applications of heritability have been to characters continuously distributed on the phenotypic scale. However, the concept of heritability extends equally to traits which may be expressed phenotypically on an all-or-none or discontinuous basis.

To treat a character with an all-or-none phenotypic expression as dependent on an underlying continuous variable seems reasonable, Lush (1948). The value of each underlying variate in a particular individual would depend on both genetic and non-genetic factors, and the phenotypic expression of the character would require that some threshold be exceeded. Heritabilities measured from the all-or-none data could provide a basis for computation of genetic gains

Table 11

Average Production of Holstein Disposals and Non-disposals Within Age-Lactation

Age-Lactation		Number	Milk	Fat	(Non-disposals-disposals)		(Non-disposals-all cows)	
					Milk	Fat	Milk	Fat
I	Disposals	2147	11563	422	1251	50	221	9
	Non-disposals	10003	12814	472				
	All cows	12150	12593	463				
II	Disposals	3288	11312	413	1690	63	344	13
	Non-disposals	12865	13002	476				
	All cows	16153	12658	463				
III	Disposals	2404	11386	410	967	48	249	12
	Non-disposals	7440	12353	458				
	All cows	9844	12117	446				
Total	Disposals	7839	11405	415	1376	55	283	11
	Non-disposals	30308	12781	470				
	All cows	38147	12498	459				

Table 12

Average Production of Guernsey Disposals and Non-disposals Within Age-Lactation

Age-lactation		Number	Milk	Fat	(Non-disposals-disposals)		(Non-disposals-all cows)	
					Milk	Fat	Milk	Fat
I	Disposals	397	7863	384	1305	65	440	22
	Non-disposals	781	9168	449				
	All cows	1178	8728	427				
II	Disposals	527	7462	364	1436	72	423	21
	Non-disposals	1263	8898	436				
	All cows	1790	8475	415				
III	Disposals	398	7731	363	1335	69	476	25
	Non-disposals	719	9066	432				
	All cows	1117	8590	407				
Total	Disposals	1322	7664	370	1354	69	438	23
	Non-disposals	2763	9018	439				
	All cows	4085	8580	416				

Table 13

Analysis of Variance of Disposals in First Lactation (Disposals for all Reasons) Among AI Daughters

Holsteins

Source of Variation	d.f.	Sum of Squares	Mean Squares	Components of Mean Squares
Total	11617	1593.31		
Between Sires	125	111.68	.8934	E+90.04S
Within Sires	11492	1481.63	.1289	E

Components: E = .1289 S = .0085

Guernseys

Source of Variation	d.f.	Sum of Squares	Mean Squares	Components of Mean Squares
Total	914	183.93		
Between Sires	27	82.61	3.0597	E+32.03S
Within Sires	887	101.32	.1142	E

Components: E = .1142 S = .0920

expected from selection. However, in some instances inaccuracies could result in the estimates since the genetic variance which may be additive for the underlying variate could lose this property on the phenotypic scale. Since the limiting genotypic values for the all-or-none trait are 0 and 1, a given gene substitution is unlikely to have the same effect near these limits as in the middle of the range.

Lush *et al.* (1948) held that probit transformation avoids some of the objections of the coarse phenotypic scale. The transformation is based on the concept of an underlying variate with a normal environmental distribution whose variance is independent of the genotypic level. The heritability on the probit scale is independent of the threshold value; whereas, on the phenotypic scale, heritability varies approximately in proportion to z^2/pq where z is the ordinate of a unit standard normal curve cutting off an area equal to p. p equals the fraction of the population removed from the herd and q equals (1-p). Heritability on the phenotypic scale would be low for values of p near zero or unity and relatively high for intermediate values.

The heritabilities estimated from the data were transformed to correct for average incidences of the removals. The transformations were done by multiplying the heritabilities actually observed by pq/z^2.

Table 14 gives the heritabilities of reasons for disposal for each breed in original units of removal and retained and in the transformed units of the probit scale.

Table 14

Heritability Estimates of Reasons for Disposal Before and After Transportation to the Probit Scale

Reason for	$\underline{p}$[1]	Holstein		$\underline{p}$[1]	Guernsey	
		Estimate	Transformed		Estimate	Transformed
Dairy purposes	.029	.051	.326	.046	.245	1.171
Low production	.077	.148	.499	.151	.173	.402
Physical injury	.015	.070	.699	.027	.082	.545
Mastitis	.006	.018	.368	.008	.020	.337
Bangs	.003	.011	.465	.005	.002	.043
T.B.	.004	.002	.065	.003	.082	2.718
Hard milker	.007	.020	.364	.004	.019	.501
Sterility	.013	0	0	.019	0	0
Deaths	.009	.012	.184	.013	0	0
Total disposals	.164	.276	.623	.246	1.784	3.347

[1] $\underline{p}$ fraction removed from total cows included in heritability estimates.

CONCLUSIONS

Reasons for disposal

The literature for the most part indicates that dairy cows are removed from herds primarily for low production and reproductive difficulties. This study supports low production and other voluntary disposals as the predominant reason cows sired by AI bulls leave herds and indicates involuntary disposals are considerably less frequent. However, Meek (1962) found in the Iowa institution herds involuntary reasons were a larger percentage of total removals when calves and heifers were included because calf and heifer losses are usually forced disposals. Death of animals from first calving onward was 8% of the total but death as a reason for disposal when calves and heifers were included was 13.5% in the Iowa data (Meek, 1962). This study indicates about 5% of the total disposals are caused by death.

The other reasons for involuntary losses in this study were sterility, bangs, and tuberculosis. These three reasons accounted for 14-17% of all disposals, with sterility accounting for 11%. Sterility or reduced fertility is effectively natural selection. Therefore, little progress could be made to reduce involuntary losses by non-managerial practices.

Physical injuries, mastitis, and hard milker are involuntary reasons for disposal. Severe injuries, acute mastitis or a chronic hard milker may force the dairyman to remove the cow in order to conserve labor even though the cow's production would warrant her remaining in the herd. This study shows 8.7% of the Guernseys and 12.2% of the Holsteins leaving the herds were removed for physical injuries--more than reported in the literature. However, this category could include animals that are sold because of bad feet and legs or undesirable conformation since no other category is available for such cows.

Removal for mastitis was the fourth most frequent involuntary reason for disposal accounting for nearly 10% of the Holsteins and 5% of the Guernseys. This category has much economic importance to the dairyman because mastitis causes a loss of milk production for part of the lactation period and possibly permanent damage to udder tissue. Since only cows with severe cases of mastitis would be removed from the herd and recorded as removed for this reason, that some cows have mastitis and are not removed and others are removed for low production--the direct result of mastitis--suggest mastitis probably occurs more frequently in the herd than the data on disposal indicate.

"Sold for dairy purposes" includes cows that leave one herd but join another herd; that is, they still remain in the dairy population. Animals sold in consignment sales or breed promotion sales would be included in this group. This study shows 9-11% of the disposals were sold for dairy purposes.

"Sold for low production" is by far the largest single classification given to cow removals in this study and also the most frequent reason reported in the literature. However, this category may be used as a catch-all for animals whose production has been reduced by some other condition such as mastitis, milk fever, or hard milking.

Removal rates between sires

The initial proof of an AI sire is based primarily on the production of his daughters' first 305-day records and can be biased if a large proportion of his daughters--those producing less milk--are removed prior to completing a record. If AI sire summaries are determined from completed records only or if incomplete records are extended with normal factors and included, the ranking of bulls could be inaccurate when disproportionate numbers of daughters are removed. Aulerich (1965) found involuntarily terminated records are probably slightly but not seriously underestimated when extended to 305 days with normal factors. However, cows voluntarily removed should have their 305-day estimate determined with special factors.

Van Vleck (1962) concluded from a study of New York DHIA first lactation records of AI Holstein cows that no bias in sire evaluation results when incomplete records are excluded from sire proofs. The New York data included:

(1) A relatively small fraction (5-7%) of first lactation records were incomplete and (2) the magnitude of the sire summary and the fraction of incomplete records were independent. In a later study, Van Vleck and Henderson (1963) used records of New York AI Holstein daughters to measure the effect of removal after the first lactation on sire evaluation based on both first and second lactation records. Van Vleck and Henderson concluded that a differential removal rate after the first lactation did not bias the sire evaluation based on first and second lactation records only.

On the other hand this study indicated 18% of the AI Holstein cows and 34% of the AI Guernsey cows were removed during the first lactation and Aulerich (1965) estimated that 16% of the Holstein cows in first lactation in Michigan were removed before completing a lactation. These larger rates of removal would increase the opportunity for disproportionate removals among sires to affect their test.

This study indicated, especially clearly in first lactation cows, a disproportionate rate of removal between sires for Holsteins and Guernseys Tables 7 and 8. Also unequal rates of disposal were between sires with daughters in their second and third lactations and in their fourth and later lactations.

<u>Heritabilities of reasons for disposal</u>

Estimates of heritability indicate the extent to which individual differences in causes for disposal are transmitted. Heritabilities provide a basis for computation of genetic gains expected from selection. Meek (1962), using Iowa data, measured heritabilities by four different paternal sister analyses. In each of the models slightly different assumptions were made. In the first case all the disposal records were treated as a single large population and the analysis was within and between sires. In the second analysis the population was first divided into herds and then into groups of paternal sisters within herds. The third analysis was also hierarchical but the intraherd differences between years of disposal of the cows were removed before computing the intrayear differences between groups of paternal sibs. This would be importantly different from the preceding if some factors, other than sires, which varied from year to year had a marked effect on the reasons for disposal. Another analysis was run using the same model but classifying the cows on year of birth rather than by year of disposal. In the last analysis the subclass numbers in the sire component were almost three times as large as in the previous one because the daughters of a sire were usually born within one or two years but their disposal usually extended over many years. Meek reported a range in heritability from .03 for death to .35 for low production and concluded that analysis should be within herds but not within year of disposal because the sire component is automatically inflated whenever the probability of disposal varies according to age.

The heritabilities in Michigan ranged from 0 to .18 for specific reasons for disposal and the estimate for total removals was .24 in Holsteins, Table 14. When the heritabilities were adjusted for average incidences by transformation to the probit scale, the range was 0 to .67. Adjustment to probit scale was necessary to allow comparison between the different reasons for disposal since the per cent removals for each reason varied considerably. The Guernsey data were similar; however, the heritability estimate for total removals was 1.86 indicating a large sampling error in estimation, perhaps due to the small number available.

Using the first lactation rather than all lactation records should have eliminated the effects of factors such as previous selection for production and different probabilities of disposal for different ages, which could bias the estimates of heritability.

SUMMARY

The most frequent reasons given for disposals of 7,839 Holstein cows out of 266 AI sires and 1,322 Guernsey cows out of 42 AI sires were low production, dairy purposes, physical injury, and sterility. Removals for low production and dairy purposes decreased with parity while losses from injury, sterility, and mastitis were more frequent in later lactations.

Disproportionate removals among sires were shown clearly for first lactation daughters and suggest a possible source of bias in sire evaluation if incomplete records are not included in the data used for the evaluation. Aulerich's (1965) results indicate bias caused by differences in production being associated with differences in removal can be eliminated if incomplete records are extended to 305 days with ratio factors developed for incomplete terminal records and are included in the evaluation.

Heritability estimates ranged from 0 to .18 for specific reasons for disposal and indicate that some of the variation in rates of total removals and in rates of removals given for specific reasons is genetically caused.

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