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SIRE EVALUATION FROM FIVE-MONTH DAUGHTER RECORDS

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Abstract: The chief advantages of sire evaluation based on five-month daughter records are: 1. Genetic progress is inversely proportional to the turnover rate in testing bulls so that if this interval is shortened by 10%, the rate of genetic progress will be increased by 11%. The turnover period can be shortened with the use of 5-month records from about 50 months to 45 months—a decrease of 10% in time. 2. Genetic progress is also related to how many top bulls are saved and how many poor ones are culled out of all those sampled. In other words, the more bulls tested with the same number saved for use, then the faster the progress which can be made. The shorter length of time which bulls have to be saved with five-month record evaluation can allow up to 10% more bulls to be tested with the same physical layout. 3. Returning a superior sire to service 5–6 months earlier will allow an increased service life for those sires. This could increase the service period by 15% and would also reduce the overhead costs to the stud as well as allow the dairyman the services of a superior bull for a few extra months. Some problems to be solved to enable bull studs to make practical use of five-month records are: 1. Suitable mature equivalent factors must be determined for all breeds for five-month records. 2. Breed averages for five-month records must be established. 3. The regression of daughter records on stablemate averages must be estimated. 4. Estimates of variance and covariance components used in the procedures must be confirmed from larger numbers of observations. 5. The importance of differential persistency between sire groups should be investigated.

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MANY current reports have indicated high genetic correlations between part lactation records and complete records. Recent research with part records has been accomplished in many countries, Hickman (1957, 1960) in Canada; Searle (1961a, b, c) in New Zealand; Mahadevan (1951), O'Conner and Stewart (1958), Rendel *et al.* (1959) in Great Britain; Dassart (1954) in Italy; Jöst (1959), Kliesch and Hoffer (1954) in Germany; and in the United States Madden, *et al.* (1956, 1959), Madden *et al.* (1955), Lamb and McGilliard (1959, 1960a, b), and Van Vleck and Henderson (1961b, c, d, g). The first widespread practical application of these results to evaluation of sires used in artificial insemination (AI) has been in New Zealand, Stitchberry (personal communication, 1961). There, due to seasonal freshening and the large number of young sires sampled per year, the New Zealand Dairy board plans to evaluate young sires used artificially in many herds on the basis of 1, 2, and 3 month milk and fat yield of their daughters. The New Zealand system of having all cows freshen in the spring will then allow the use of the selected young sires a full year earlier than if selection was based on complete lactation records.

This paper, however, presents the results of an evaluation of sires used artificially in New York on the basis of part records of their daughters.

Data

The 150-day records of all AI daughters which calved in New York between December, 1959 and August, 1960, inclusive, and which were available in the New York dairy records processing center were used. These records were corrected for age at freshening by factors taken from a study by Van Vleck and Henderson (1961a) based on Holstein records. As will be discussed later, such age factors may not be appropriate.

Comparisons were made between evaluations based on these records and evaluations based on 2x, M.E. complete records of other daughters of the same AI sires. The 305-day M.E. factors were those used in the New York dairy records processing center.

Methods of Evaluation

The future daughter performances of AI sires were estimated from the following equa-

TABLE 1. DHIA AND AI BREED AVERAGES FOR THE SEPTEMBER, 1961 305-DAY AND 150-DAY SIRE EVALUATION

Breed	305-day average, lb.		150-day average, lb.			
	Milk	Fat	Milk		Fat	
			AI breed average			
Ayrshire	9530	390	6808		275	
Guernsey	8334	400	6028		281	
Holstein	12776	470	8478		308	
Jersey	8015	421	5411		275	
Brown Swiss	10649	448	6784		277	
			5-year DHIA breed average			
Ayrshire	9495	382	6333 [a]	(6779) [b]	255 [a]	(269) [b]
Guernsey	8560	404	5710	(6189)	269	(284)
Holstein	12359	445	8243	(8206)	297	(291)
Jersey	7990	411	5329	(5393)	274	(268)
Brown Swiss	10609	434	7076	(6758)	289	(268)

[a] The 5-year 150-day DHIA breed average was estimated as 0.667 times the 5-year 305-day DHIA breed average.
[b] The 5-year 150-day average was estimated as the ratio of the 150-day to the 305-day AI breed average times the 5-year 305-day DHIA breed average (the alternate 5-year 150-day DHIA breed average).

tions where n is either the number of part or complete records:

1. Breeding value for 305-day yield
   a. From 305-day records:

$$EBV_{305}=AI_{305}+ \frac{n}{n+16.66} [D_{305}-0.9 (SM_{305}-DHIA_{305})-AI_{305}]$$

where: AI_{305}=305 day AI breed average for AI daughters with records in the current report (September, 1961),

D_{305}=305-day daughter average,

0.9=regression coefficient for the regression of a daughter record on the adjusted stablemate average,

SM_{305}=305-day adjusted stablemate average (Henderson et al. 1954), and

$DHIA_{305}$=305-day 5-year DHIA breed average.

   b. From 150-day records:

$$EBV_{305}=AI_{305}+ \frac{1.55n}{n+16.79} [D_{150}-0.9 (SM_{150}-DHIA_{150})-AI_{150}]$$

where: D_{150}=150 day daughter average,

SM_{150}=150-day adjusted stablemate average,

$DHIA_{150}$=150-day 5-year DHIA breed average, and

AI_{150}=150-day AI breed average for AI daughters with records in the current report.

2. Breeding value for 150 day yield—from 150-day records:

$$EBV_{150}=AI_{150}+ \frac{n}{n+16.79} [D_{150}-0.9 (SM_{150}-DHIA_{150})-AI_{150}].$$

The justification for these equations and the parameters used in them can be found in Henderson et al. (1954), Henderson (1956), Heidhues et al. (1961), and Van Vleck and Henderson (1961e, h).

Several points of possible inaccuracy have already become evident. The regression coefficient of 0.9 is appropriate for 305-day records but has not been estimated for part records in New York. Evidence from New Zealand (Searle, 1961c) indicates that it would be nearly the same for 150-day records as for 305-day records.

The other point which is much more likely to cause lack of accuracy is the estimate of the 150-day, 5-year DHIA breed average. This is unavailable since the 150-day records

have been collected for less than one year. It must be estimated from available data. The study of Van Vleck and Henderson (1961f) showed that the ratio of 150-day to 305-day milk yield for Holsteins was 0.667. Estimates of the 150-day DHIA breed average were made by multiplication of this factor by the 305-day DHIA 5-year breed average for all breeds. The ratio between the AI 150-day and 305-day averages, however, indicated that the former ratio is not appropriate for all breeds. Table 1 presents the AI and DHIA 305-day and 150-day breed averages for both milk and fat which were used in the preceding EBV equations. Alternate 150-day 5-year DHIA averages were estimated by multiplying the ratio of the 150-day AI average to the 305-day AI average by the 305-day DHIA 5-year breed averages. These values are given in brackets in the appropriate columns of table 1.

Results

One criterion which can be used to judge the effectiveness of 150-day records is how many sires have at least 20 150-day daughter records without having 20 with 305-day records. The number of such bulls is given in table 2 for various numbers of daughter records. Three sires appeared in the Ayrshire breed, 3 in the Guernsey, and 17 in the Hol-

stein. No other breeds contributed additional sires.

A second and more important criterion would be to determine whether any superior sires were discovered earlier or whether inferior sires could be sold earlier. The results of this classification appear in table 3. Two of the three Ayrshire bulls were in the top classification—their daughters averaging more than 300 lb. of milk above their stablemates. The average 305-day EBV for these two bulls was 10,219 lb. of milk and 412.1 lb. of fat or 724 lb. of milk and 30 lb. of fat above the DHIA breed average. These EBV's were computed using the alternate 150-day 5-year DHIA average. One of these bulls was already

TABLE 2. NUMBER OF BULLS IN VARIOUS CLASSES BASED ON NUMBER OF 150-DAY DAUGHTER RECORDS WHEN LESS THAN 20 305-DAY DAUGHTER RECORDS WERE AVAILABLE PER SIRE

Number of 150-day daughter records=N	Ayr-shire	Guern-sey	Hol-stein	Brown Swiss	Guern-sey
30>N≥20	1	2	6	0	0
40>N≥30	0	0	3	0	0
50>N≥40	1	1	0	0	0
N≥50	1	0	8	0	0

in service but ordinarily would not have been. The other bulls were gone.

One of the Guernsey bulls fell into the high level and one into the next lower level. The EBV of the high level bull was 200 lb. of milk and 5 lb. of fat above the breed average. The other bull showed an EBV of 100 lb. of milk and 16 lb. of fat above breed average but was not returned to service. It is of interest to note that a brother of this bull was returned to service based on 14 150-day daughter records which were 800 lb. of milk and 49 lb. of fat above their stablemates.

How do the 150-day evaluations compare with 305-day evaluations? This is a question which must be answered favorably before much reliance can be put on such evaluations. The genetic correlations of about 0.9 estimated by Van Vleck and Henderson (1961c, e) and Searle (1961c) indicate that the evaluations will be nearly the same. In actual practice, high correlations between 150-day and 305-

day daughter evaluations would be desirable to substantiate the other research.

The computed correlations between 305-day and 150-day evaluations are shown in table 4. The correlations were computed for sires having more than 10 daughters in each group, more than 20 in each, and for Holstein sires having more than 100 and more than 200 daughters in each group. It should be remembered that these sires are different from those discussed earlier which had 20 daughters with 150-day records and less than 20 305-day records with the exception of the correlations with 10 daughter records in each group. It would be expected that the correlations would increase as the number of daughter records in each group increases. This increase does occur and for the Holstein sires approaches the theoretical limit of about 0.9 when more than 200 daughters are represented in each length of record group.

It can be seen from the table that using the alternate 150-day DHIA breed average increases the correlation between EBV's based on 150-day and on 305-day records. This is generally true except for the Guernsey breed. The correlations for the Guernsey sire groups are very low which indicate some technical difficulty may be involved. Age factors may be at fault.

The otherwise high correlations indicate that selection on the basis of 150-day records does a satisfactory job of also selecting for 305-day yield. It must be emphasized that daughters having 150-day records did not also

TABLE 3. NUMBER OF BULLS IN VARIOUS CLASSES BASED ON DIFFERENCE OF 150-DAY DAUGHTER MILK AVERAGE FROM THEIR 150-DAY STABLEMATE MILK AVERAGES WHEN THE BULLS DO NOT HAVE 20 305-DAY DAUGHTER RECORDS AND DO HAVE AT LEAST 20 150-DAY DAUGHTER RECORDS [a]

Average 150-day stable-mate difference=X Milk (lb.)	No. bulls	Average 150-day stable-mate difference, lb.		Average 305-day EBV,[b] lb.		Average 150-day EBV, lb.		Average 150-day ME av., lb.	
		Milk	Fat	Milk	Fat	Milk	Fat	Milk	Fat
Ayrshire									
—300≤X<—100	1	—124	0.0	9349	383.6	6691	270.9	6634	274.0
300≤X	2	732	27.5	10219	412.1	7252	289.3	7554	305.5
Guernsey									
—100≤X<100	1	12	12.0	8445	410.5	6099	287.8	5786	271.0
100≤X<300	1	151	16.0	8655	419.8	6235	293.8	6117	289.0
300≤X	1	317	6.0	8761	408.8	6303	286.7	6583	300.0
Holstein									
X<—300	5	—637	—19.0	11901	436.2	7914	286.2	7903	289.8
—100≤X<100	3	—240	— 1.7	12102	445.9	8043	292.5	8280	306.0
—300≤X<—100	2	— 68	— 4.0	12413	446.2	8244	292.7	8540	305.5
100≤X<300	4	189	— 2.8	12728	453.1	8447	297.1	8796	308.5
300≤X	3	532	14.3	13127	469.3	8704	307.5	9029	321.7

[a] Values given are averages of the sire-group averages.
[b] EBV's were estimated using the alternate 150-day 5 year DHIA breed averages. The 305-day EBV's were estimated from the available 150-day daughter records.

TABLE 4. CORRELATIONS BETWEEN VARIOUS ESTIMATES OF BREEDING VALUE BASED ON 150-DAY AND 305-DAY DAUGHTER RECORDS

Breed	No. Bulls	Milk [a]	Fat [a]	Milk [b]	Fat [b]	Milk [c]	Fat [c]	Milk [d]	Fat [d]
			Number of both 150- and 305-day records per sire group≥20						
Ayrshire	9	0.63	0.30	0.67	0.40	0.78	0.48	0.61	0.55
Guernsey	17	0.19	0.35	0.28	0.39	0.22	0.37	0.49	0.63
Holstein	114	0.67	0.59	0.71	0.63	0.71	0.63	0.69	0.66
Jersey	11	0.87	0.70	0.83	0.72	0.84	0.70	0.94	0.85
Brown Swiss	7	0.83	0.84	0.85	0.85	0.87	0.88	0.90	0.84
			Number of both 150- and 305-day records per sire group≥10						
Aryshire	19	0.56	0.26	0.51	0.26	0.64	0.36	0.72	0.53
Guernsey	30	0.34	0.49	0.39	0.49	0.30	0.46	0.61	0.74
Holstein	143	0.70	0.55	0.69	0.59	0.68	0.58	0.76	0.68
Jersey	16	0.37	0.30	0.53	0.42	0.51	0.45	0.74	0.64
Brown Swiss	14	0.61	0.49	0.70	0.62	0.69	0.57	0.34	0.28
			Number of both 150- and 305-day records per sire group≥100						
Holstein	28	0.84	0.76	0.86	0.80	0.86	0.80	0.94	0.94
			Number of both 150- and 305-day records per sire group≥200						
Holstein	15	0.89	0.76	0.90	0.78	0.90	0.78	0.94	0.87

[a] Correlation between 150-day differences from stablemate averages and 305-day differences from stablemate average.
[b] Correlation between 305-day EBV's from 150-day and 305-day records (same estimates for correlation between 150-day EBV and 305-day EBV).
[c] Same as B except that alternate 150-day 5-year DHIA breed averages were used.
[d] Correlation between 150-day and 305-day mature equivalent averages.

have the same lactation record in the 305-day daughter average.

Table 5 compares the 150-day and 305-day stablemate differences by level of sire. These values show in another form what the correlations exhibit in more compact form. There is good agreement, as can be seen from table 5, between the average stablemate differences for 150-day and 305-day records.

The results shown in tables 2, 3, 4, and 5 illustrate the chief advantages of 150-day sire evaluations. The foremost is quicker evaluation which can result in longer service life for superior sires. The quicker turnover of sires can speed up genetic progress in two ways. The first way would be that a greater number of young sires could be tested with the same physical resources. The second is that the decreased generation interval also increases genetic progress since superior sires are replaced by even better sires at a more rapid rate.

The results also indicate several technical problems in sire evaluation based on 150-day daughter records. Two of the most important are probably: (1) the determination of appropriate long-term 150-day breed averages (this difficulty will, of course, disappear in time) and (2) the determination of suitable age factors for each breed. It is possible that effects of season, sire, and herd will be more important for 150-day records than for 305-day records in developing age factors. Some evidence suggests that different mature equivalent factors should be used for each season of freshening, Van Vleck and Henderson (1961a).

Another factor to consider is the accuracy of the variance and covariance component estimates which determine the ratios, $\dfrac{n}{n+16.79}$ and $\dfrac{1.55n}{n+16.79}$. At the present time these components have been estimated from a fairly limited amount of data. Experience with variance components for 305-day records suggests, however, that these ratios will not change significantly even when estimated from larger numbers of observations.

Persistency of production may vary from sire group to sire group. If high 305-day yield is the goal, then selection on 150-day yield may penalize sires having daughters with high persistency and provide unfair advantage to sires having daughters with low persistency. The high genetic correlation between 150-day and 305-day yield, however, indicates that this is an unlikely source of error, but still it should be considered as a possible source of inaccuracy.

Still another factor has been discussed previously. That is the regression of a daughter record on her stablemate average. For 305-day records it is 0.9 as estimated from adequate data. This factor may not be much different for 150-day records, Searle (1961c).

Summary

The chief advantages of sire evaluation based on five-month daughter records are:

1. Genetic progress is inversely proportional to the turnover rate in testing bulls so that if

TABLE 5. COMPARISON OF 150-DAY AND 305-DAY DAUGHTER DIFFERENCES FROM THEIR CORRESPONDING STABLEMATES CLASSIFIED BY AVERAGE 150-DAY DIFFERENCES FROM STABLEMATE AVERAGE WHEN EACH SIRE HAS AT LEAST 20 150-DAY AND 20 305-DAY DAUGHTER RECORDS

Average 150-day stablemate difference=X Milk, lb.	No. bulls	Average difference from stablemates, lb.			
		150-day		305-day	
		Milk	Fat	Milk	Fat
Number of both 150- and 305-day records in sire averages≧20					
Ayrshire					
X<−300	1	−340	2.0	−624	−3.0
−300≦X<−100	3	−129	−2.3	−413	−4.7
−100≦X<100	1	− 9	−5.0	− 86	−5.0
100≦X<300	4	216	9.0	− 50	4.0
Guernsey					
X<−300	2	−520	−13.5	−421	−4.0
−300≦X<−100	4	−211	−11.8	−278	−13.5
−100≦X<100	8	44	5.4	−371	−10.2
100≦X<300	3	192	18.0	267	25.3
Holstein					
X<−300	16	−464	−10.6	−494	−6.1
−300≦X<−100	24	−206	− 3.1	−248	0.8
−100≦X<100	30	− 2	3.0	−183	0.8
100≦X<300	26	185	6.8	50	4.0
300≦X	18	567	14.7	851	24.0
Jersey					
−300≦X<−100	1	−267	2.0	−583	−8.0
−100≦X<100	6	27	7.5	−113	4.7
100≦X<300	3	197	7.3	234	10.3
300≦X	1	479	5.0	571	11.0
Brown Swiss					
−300≦X<−100	3	−202	−8.0	−165	−4.7
−100≦X<100	2	− 22	7.5	−393	4.5
100≦X<300	1	242	19.0	105	18.0
300≦X	1	567	16.0	1135	38.0

this interval is shortened by 10%, the rate of genetic progress will be increased by 11%. The turnover period can be shortened with the use of 5-month records from about 50 months to 45 months—a decrease of 10% in time.

2. Genetic progress is also related to how many top bulls are saved and how many poor ones are culled out of all those sampled. In other words, the more bulls tested with the same number saved for use, then the faster the progress which can be made. The shorter length of time which bulls have to be saved with five-month record evaluation can allow up to 10% more bulls to be tested with the same physical layout.

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2. Breed averages for five-month records must be established.

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