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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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SIRE EVALUATION FROM FIVE-MONTH DAUGHTER RECORDS

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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 Mc-Gilliard (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				
Avrshire	9530	390	6808		275		
Guernsey	8334	400	6028		281		
Holstein	12776	470	8478		308		
Tersey	8015	421	5411		275		
Brown Swiss	10649	448	6784		277		
	5-year DHIA breed average						
Avrshire	9495	382	6333 a	(6779) b	255 a	(269) b	
Guernsey	8560	404	5710	(6189)	269	(284)	
Holstein	12359	445	8243	(8206)	297	(291)	
Tersey	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: AI₃₀₅=305 day AI breed average for AI daughters with records in the current report (September, 1961),

D₃₀₅=305-day daughter average, 0.9=regression coefficient for the regression of a daughter record on the adjusted stablemate average,

SM₃₀₅=305-day adjusted stablemate average (Henderson *et al.* 1954), and

DHIA₃₀₅=305-day 5-year DHIA breed average.

b. From 150-day records:

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

where: D_{150} =150 day daughter average, SM_{150} =150-day adjusted stablemate average,

DHIA₁₅₀=150-day 5-year DHIA breed average, and

AI₁₅₀=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 305day 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 40>N≥30 50>N≥40 N≥50	1 0 1 1	2 0 1 0	6 3 0 8	0 0 0	0 0 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 *

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

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.

No. Bulls Fat d Milk a Milk b Fat b Milk o Fat e Milk d Breed Fat a Number of both 150- and 305-day records per sire group≥20 Ayrshire 9 17 $0.63 \\ 0.19$ $0.67 \\ 0.28$ 0.40 $\begin{array}{c} 0.78 \\ 0.22 \\ 0.71 \end{array}$ 0.48 0.61 0.55 0.49 0.63 Guernsey 0.35 Holstein 0.67 0.59 0.63 0.63 0.69 0.87 0.83 0.70 0.85 Tersev 11 Brown Swiss 0.87 Number of both 150- and 305-day records per sire group≥10 19 30 143 0.56 0.34 0.70 0.37 Aryshire Guernsey 0.51 0.39 0.26 0.64 0.260.36 0.720.49 0.59 0.42 0.46 0.58 0.45 0.61 0.76 0.74 0.55 0.69 0.53 0.70 0.68 0.68 Holstein ersev Brown Swiss 0.61 0.62 0.69 0.34 0.28 Number of both 150- and 305-day records per sire group≥100 Holstein 0.86 0.80 28 0.84 0.76 0.86 0.80 0.940.94Number of both 150- and 305-day records per sire group≥200 Holstein 0.89 0.76 0.90 0.78 0.90 0.78 0.87

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

Same as B except that alternate 150-day 5-year DHIA breed averages were used.
 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, Vleck and Henderson Van (1961a).

Another factor to consider is the accuracy of the variance and covariance component es-

timates which determine the ratios, $\frac{n}{n+16.79}$

and $\frac{1.55n}{n+16.79}$. 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

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).

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-		A	Average difference from stablemates, l				
day stablemate difference=X		150	150-day		305-day		
Milk, lb.	No. bulls	Milk	Fat	Milk	Fat		
	Number of both 150- and	305-day records ii	n sire averages≥	20			
		Ayrshire					
X < -300	1	340	2.0	-624	-3.0		
-300≤X<-100	3	—1 29	-2.3	-413	-4.7		
$-100 \le X < 100$	1	_ 9	-5.0	— 86	—5.U		
$100 \le X < 300$	4	216	9.0	— 50	4.0		
		Guernsey					
X < -300	2	-520	—13.5	-42 1	-4.0		
$-300 \le X < -100$	4	-211	-11.8	-278	-13.5		
-100≤X<100	8	44	5.4	-371	-10.2		
$100 \le X < 300$	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		
$-100 \le X < 100$	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					
$-300 \le X < -100$	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		
	В	rown Swiss					
$-300 \le X < -100$. 3	202	-8.0	—165	-4.7		
$-100 \le X < 100$	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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