Selection on Test-Day Fat Percentage and Milk Production

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Abstract

Selection procedures which weight equally each test day sample may not be optimum for selection on test days.

Monthly test day data from 63,300 records of artificially sired Holsteins with 305-day lactations were from the New York Dairy Records Processing Laboratory. Heritabilities (h^2) were estimated intraherd-year-season from sire components of variance for monthly test day production within lactations 1, 2, 3, 4, and 5 or greater. Heritability of lactation fat percentage decreased from .60 to .40 from first to fifth lactations whereas heritability for 305-day milk yield increased slightly from .25 to .37 with succeeding lactations. Heritabilities for both fat percentage and milk production of monthly test days were lower for early and later tests than for middle monthly tests. Genetic and phenotypic correlations for early and late months with total lactation were less than for middle months.

Estimates of genetic gain by selecting on bimonthly or trimonthly test days were almost as great as by selecting on the completed 305-day lactation record. Quadramonthly records showed only a slight decrease in relative response as compared to bi- or trimonthly testing. Selecting on part records would not result in any measurable loss of genetic gain in total milk yield or lactation fat test as compared to monthly testing.

Introduction

The purpose was to test the feasibility of changing from a monthly testing scheme for fat percentage to a less time-consuming and less costly program perhaps involving only bi- or trimonthly testings or even one test per lactation. Relationships of lactation milk yield to monthly milk weights were also studied.

Data

Test-day data from the Dairy Records Processing Laboratory were from 2,022 herds in New York State, 1959 to 1967. The data consisted of up to 10 monthly test day milk weights along with their corresponding fat percentages for each lactation. These records by artificially sired Holstein cows were assigned by age at freshening to parities 1, 2, 3, 4, and ≥ 5. Each record was in a herd-year-season of freshening. Seasons were: December to March, April to July, and August to November. Records with less than six monthly test days were omitted. Numbers of sires, lactation records, and herd-year-seasons for each lactation are in Table 1.

Analysis

The model describing the individual observations was:

$$y_{ijk} = \mu + s_i + h_j + (s \times h)_{ij} + e_{ijk}$$

where y_{ijk} is the amount of milk or the fat percentage for an individual test day sample from a daughter of the i^{th} sire in the j^{th} herd-year-season.

μ is a constant,

s_i is the effect due to the i^{th} sire,

h_j is the effect due to the j^{th} herd-year-season,

$(s \times h)_{ij}$ is the associated interaction effect between the j^{th} herd-year-season and the i^{th} sire, and

e_{ijk} is the random error associated with the record of the k^{th} cow by the i^{th} sire in the j^{th} herd-year-season.

The s_i, h_j, $(s \times h)_{ij}$ and e_{ijk} are independently distributed with zero means and variances σ^2_s, σ^2_h, $\sigma^2_{s \times h}$ and σ^2_e.

Variance components were estimated by equating the usual quadratics to their expected values with no correlations among the sire and herd-year-season effects [Method 1 of Henderson (4)]. Intraherd heritability was estimated by four times the intrasire correlation for each of the ten monthly milk weights and fat percentages for each lactation.

Results and Discussion

Table 2 lists heritabilities of fat percentage for the ten monthly test days and for the complete lactation. Heritabilities for fat percentage decreased from .60 for first lactation to .40 for fifth and greater lactations. Within lactation, estimates of heritability peaked during the sixth

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TABLE 1. Number of records, sires, and herd-year-seasons in heritabilities for each lactation.

	Lactation				
	1	2	3	4	⩾5
Records	23,006	13,667	9,589	6,755	10,283
Sires	480	420	386	343	374
Herd-year-seasons	9,112	7,255	5,905	4,648	6,152

or seventh monthly test day period and decreased gradually thereafter, however, never going as low as the first few monthly tests (agrees with Van Vleck and Henderson, 11). Individual monthly values were not as large as heritabilities overall for a given lactation. Estimates for the first two months in every lactation were consistently lower than any other months within the same lactation.

Heritability estimates for fat percentage were affected by stage of lactation; lower heritabilities were associated with early months when milk production is highest (13) and were larger during the middle and later months when production decreases which agrees with trends reported by Van Vleck and Henderson (11) and Spike and Freeman (9).

Table 2 shows heritabilities for milk production. Some trends readily apparent include a slight increase in heritability of milk overall as lactation number increases. Overall and test-day heritabilities for milk were also considerably less than corresponding values for fat percentage. Heritabilities for early months were low (within lactations) and increased as lactation progressed. But there was not a noticeable peak as for fat percentage. The consistency of the overall heritability estimates across lactations suggests that heritability for milk remains nearly unchanged as cows increase in age and that stage of lactation seems not to affect the estimates.

Estimates of heritability from sire components of variance are lower than estimates other workers have found from regression of daughter on dam due in part, perhaps, to the differing populations. The population in this study consisted only of daughters of AI sires which may not be as variable as all possible sires or all possible cows. These heritability values, however, are appropriate for estimating genetic progress possible by selection among this population of AI sires.

Covariance components were estimated by the same model as for test day heritabilities. Table 3 shows genetic correlations for first lactation. Genetic correlations between monthly test days and total yield of milk or average fat percentage were high—ranging in the first lactation from .76 to .99. Production of early and late months was less highly correlated than the middle months with total production or average

TABLE 2. Intra-herd-year-season heritabilities for fat percentage and milk production for monthly test day samples for each lactation.

	Test day	Heritabilities for fat percentage										Lactation
		1	2	3	4	5	6	7	8	9	10	
Lactation	1	.17	.24	.32	.34	.36	.41	.39	.39	.39	.29	.60
	2	.14	.16	.24	.29	.32	.34	.34	.35	.29	.27	.46
	3	.15	.19	.22	.24	.27	.30	.34	.31	.31	.26	.45
	4	.11	.10	.17	.26	.28	.28	.31	.30	.30	.28	.39
	⩾5	.17	.16	.17	.23	.28	.28	.33	.33	.33	.26	.40

	Test day	Heritabilities for milk production										Lactation
		1	2	3	4	5	6	7	8	9	10	
Lactation	1	.14	.19	.20	.20	.22	.24	.23	.23	.22	.20	.25
	2	.14	.20	.26	.23	.25	.25	.25	.25	.25	.20	.28
	3	.19	.20	.22	.23	.23	.23	.24	.27	.24	.22	.30
	4	.19	.25	.23	.24	.20	.21	.21	.21	.19	.20	.29
	⩾5	.21	.25	.26	.27	.29	.28	.28	.27	.24	.19	.37

TABLE 3. Phenotypic and genotypic correlations between individual test days for first lactation.

	Test day										Lactation	Total variance	b
	1	2	3	4	5	6	7	8	9	10			
						Milk (kg)							
1	.52[a]	.96	.90	.82	.78	.73	.65	.54	.45	.36	.78	17.6	.22
2	.76	.71	.98	.94	.91	.84	.79	.68	.58	.47	.88	17.8	.31
3	.69	.84	.77	.98	.96	.93	.88	.79	.70	.56	.94	17.2	.35
4	.64	.79	.86	.77	1.00	.97	.94	.86	.77	.62	.97	16.0	.37
5	.59	.73	.80	.86	.84	.99	.97	.91	.84	.69	.99	15.3	.39
6	.55	.68	.75	.81	.86	.88	.99	.95	.88	.74	.98	14.5	.36
7	.50	.63	.70	.76	.81	.86	.85	.98	.93	.79	.97	14.3	.35
8	.44	.55	.62	.68	.73	.79	.85	.82	.98	.84	.97	14.5	.35
9	.36	.46	.51	.57	.63	.69	.74	.82	.74	.95	.89	14.8	.28
10	.25	.34	.37	.42	.47	.53	.58	.66	.79	.58	.77	17.2	.26
Lactation	.70	.82	.86	.89	.90	.90	.89	.85	.79	.65	1.00	10^6	.38
						Fat percentage							
1	.27[a]	.86	.76	.70	.66	.63	.64	.60	.62	.58	.76	.33	.13
2	.44	.43	.97	.95	.92	.88	.88	.83	.83	.79	.95	.19	.14
3	.31	.53	.54	.98	.97	.94	.94	.89	.86	.83	.97	.17	.12
4	.24	.46	.59	.57	1.00	.98	.97	.93	.92	.88	.98	.17	.10
5	.21	.41	.54	.63	.59	.99	.98	.96	.94	.89	.98	.17	.11
6	.19	.38	.50	.58	.66	.63	.98	.97	.95	.92	.97	.18	.12
7	.19	.37	.48	.55	.61	.67	.62	.99	.99	.96	.98	.18	.10
8	.17	.35	.45	.50	.55	.60	.67	.59	.99	.97	.96	.20	.13
9	.17	.32	.41	.45	.49	.53	.59	.64	.56	.97	.95	.23	.13
10	.15	.28	.35	.37	.41	.45	.49	.53	.62	.42	.92	.32	.13
Lactation	.50	.67	.73	.75	.76	.76	.76	.73	.69	.60	1.00	.10	.14

[a] Above diagonal: genetic correlation; below: phenotypic.
Diagonals: genetic progress in complete lactation yield by selection on individual test days relative to selection on complete lactation yield.

[b] Fraction of total phenotypic variance due to herd-year-season effects.

fat percentage. The middle monthly test days were the most highly correlated with the total lactation parameters ranging for the first lactation from .94 to .99, agreeing with Fritz, McGilliard, and Madden (3) and Johnson (5) and Madden, McGilliard, and Ralston (8). The pattern of correlations was the same for succeeding lactations.

One measure of the possible increase in total yield from part records can be expressed quantitatively by the correlated response in total production by selection on an individual monthly test day. The usual formula for relative correlated response in Trait 2 from selection for Trait 1 is the genetic correlation between traits one and two times the square root of the ratio of the heritabilities of traits one and two with equal selection intensity and selection on only one record per cow. The diagonals in Table 3 represent the relative progress in total production possible by selection on single test day records which are lower than those reported by Lamb and McGilliard (6).

Selection procedures on 305-day milk yields assign equal weights to the individual test days sampled, regardless of the correlations of individual test day yields with total yield. This form of selection with equal weights may not be the optimum procedure for selection on test days. An alternative procedure would be to maximize genetic gain by selecting on certain test day milk weights. One way to evaluate such a procedure in relation to present methods of evaluation would be by means of the ratio of the response in 305-day yield when selection is on an index of individual

test days and the response when selection is on 305-day milk weights with equal selection intensities.

The formula for relative selection response is:

$$R\,R = b_{G_1 \cdot I_2} \Delta I_2 / \Delta I_1$$
$$= \frac{\sigma_{G_1 I_2}}{\sigma^2_{I_2}} D\, \sigma_{I_2} / D\, \sigma_{I_1}$$
$$= \frac{\sigma_{G_1 I_2}}{\sigma_{I_2}\, \sigma_{I_1}}.$$

$\sigma_{G_1 I_2}$ is the covariance between the 305-day trait and the index value for selecting for 305-day traits by indexing individual test days.

σ_{I_2} is the standard deviation of the index values for indexing 305-day traits by indexing individual test days.

σ_{I_1} is the standard deviation of the index values for selecting directly on 305-day traits.

D is the selection intensity.

Table 4 shows the relative response for selecting on individual cumulative test day data for milk and fat percentage. After six monthly records additional monthly tests do not seem to warrant the effort and money for collecting milk samples [Van Vleck and Henderson (12) and Madden, Lush, and McGilliard (7)]. Appropriate weighting of the first six monthly test days gives .97 relative response for milk whereas ten monthly tests only give an increase of .04 above the six test days. This trend is the same for second and third lactations. The relative response for fat percentage for six monthly test days is .96 whereas for ten monthly tests it is only 1.02, an increase of .06 (6).

Everett, McDaniel, and Carter (2) discussed the accuracy, advantages, and disadvantages of bimonthly, trimonthly, and quadramonthly testing. Some advantages of these methods over the present monthly testing schemes are a decrease in the amount of work of a tester and a possible increase in the number of herds on test as well as a substantial decrease in the cost of testing to the farmer.

Table 4 also shows relative responses from

TABLE 4. Relative response in complete lactation yield by selection on functions of part lactation records relative to selection on complete lactation yield.

		Cumulative months									
		1	2	3	4	5	6	7	8	9	10
		Milk									
Lactation	1	.60	.75	.85	.89	.93	.97	.99	1.00	1.01	1.01
	2	.58	.67	.77	.85	.91	1.00	1.01	1.03	1.04	1.04
	3	.64	.70	.78	.86	.91	.94	.98	1.01	1.02	1.03
		Fat percentage									
Lactation	1	.40	.63	.78	.87	.92	.96	.98	1.00	1.01	1.02
	2	.36	.59	.76	.87	.93	.98	1.00	1.02	1.03	1.04
	3	.33	.64	.78	.87	.93	.96	1.01	1.02	1.03	1.04

		Bimonthly[a]		Trimonthly[b]			Quadramonthly[c]			
		I	II	I	II	III	I	II	III	IV
		Milk								
Lactation	1	.99	.98	.95	.94	.96	.93	.93	.90	.90
	2	1.00	1.01	.98	.98	.97	.94	.94	.92	.95
	3	1.00	1.00	.98	.96	.95	.93	.95	.93	.90
		Fat percentage								
Lactation	1	1.00	1.00	.99	.98	1.00	.98	.99	.97	.97
	2	1.01	1.04	1.00	1.00	1.03	.99	1.02	.97	.99
	3	1.00	1.01	1.01	.99	.97	.99	.97	.95	.99

[a] Test days
I; 1,3,5,7,9
II; 2,4,6,8,10

[b] I; 1,4,7,10
II; 2,5,8
III; 3,6,9

[c] I; 1,5,9
II; 2,6,10
III; 3,7
IV; 4,8

selecting cows on these bases. The average estimated relative response of the bimonthly testing scheme for the first lactation is 1.00 for lactation milk production and .99 for fat test. This means that from selecting on bimonthly records essentially the same genetic progress in 305-day yield can be made as when selection is on the complete 305-day milk yields which agrees with Castle and Searle (1) and Van Vleck and Henderson (10).

Trimonthly testing is also nearly as efficient as selecting on the total lactation, the average estimated relative response for selecting on trimonthly tests for the first lactation is .99 for milk and .95 for fat percentage—again there seems to be little if any difference between trimonthly and monthly testing.

Quadramonthly testing is also nearly as efficient as selecting on trimonthly or bimonthly records—the average relative responses for quadramonthly testing are .98 for milk and .92 for fat percentage for the first lactation.

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