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Abstract

New York Holstein herds (1,152) including 75,875 cows were classified by housing system (stanchions, free stalls, and other combinations). Records initiated in these herds from 1964 to 1968 were used to determine the degree to which housing type might affect variance of milk production records in herds with 45 or more cows.

The within-herd variances by lactation for each housing system in each year-season were examined by Bartlett's test for nonhomogeneity among housing systems. Records in the stanchion systems were less variable than those in free-stall systems. This difference was not large enough to require adjustment for type of housing in the present production analysis procedures.

Introduction

The growing number of free-stall housing units in New York State has focused attention upon the possible effects of this changed environment on milk production records. There has been a steady increase in the proportion of cows kept in free-stall systems where cows are not individually confined. At present, dairy farms with these facilities manage about one-fourth of the cows in New York's herds of over 45 cows.

As cows are handled more as a group, less variability among cows' records and perhaps a lower over-all mean have been postulated, since the cows would be less likely to receive the individual attention asumed required to permit those of highest potential to express their maximum.

The question, Will cows of equal genetic potential achieve equal phenotypic expression in different housing systems? is of considerable concern. A recent study by Albrectsen (1) indicated that average production for herds that switch to free stalls from stanchions does not decline and that roughly equal numbers of the herds had a higher average as had a lower average in comparison with the years before change, even with increasing numbers of cows per herd. His study thus discounts the probability of a significant difference in means between housing systems.

The question still remains concerning the relative variability of records produced in the two housing systems. If a distinct difference exists in variability, this would mean that use of deviations from herdmates as a measure of genetic merit would bias estimation in favor of cows in the more variable housing system when selection is in the upper half of the distribution.

Variance of milk production is directly related to production level (7), but whether environmental factors can divide the population into groups with different variances yet with similar means is not known.

A practical situation illustrating the results when variance is not homogeneous is the selection of dams for planned matings to produce future sires for artificial insemination (AI). Typically, these dams are selected from the top 3 to 5% of all cows on their deviations from herdmate average and with consideration of their sire's proof. This system is successful in selecting the cows with the highest true genetic value as long as variances in herds are equal.

For illustration, a satisfactory ranking of true genetic value for cows each with one record deviated from the mean is assumed. For a standard deviation (SD) of milk records of 1,000 kg and the desired superiority of records of dams selected for planned matings of +2,000 kg, Table 1 shows the effect on the per cent selected from each housing system (HS) if the system divides the population into groups of nearly equal numbers but with different SD. The effect of increasingly different SD on the per cent selected is illustrated.

If the standard deviations of the housing systems were 400 kg different, essentially all of the selection would be from the more variable system, thus rejecting some cows of equal genetic merit from the less variable housing system and selecting some cows of lesser merit from the more variable housing system (Table 1).

The motivation for this study is, although a minority now, a larger and larger pro-

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TABLE 1. Percentage of cows selected from different housing systems when standard deviations vary but phenotypic superiority of selected group is constant.

Housing[a] system	Standard deviation of records (kg)	2,000 kg In standard deviation units	Fraction of records[b] above 2,000 kg
1	800	2.50	.0062
2	1,200	1.67	.0475
1	850	2.35	.0094
2	1,150	1.74	.0409
1	900	2.22	.0132
2	1,100	1.84	.0329
1	950	2.11	.0174
2	1,050	1.90	.0287
1	1,000	2.00	.0228
2	1,000	2.00	.0228

[a] Housing System 1, records produced in less variable housing system.
Housing System 2, records produced in more variable housing system.
[b] From Steel and Torrie (4). Normal population table.

portion of cows will be housed in free stalls. If free stalls provide an environment which tends to reduce the within-herd variance, this may soon be of practical importance. Therefore, knowledge of within-herd variances for these housing types seems warranted.

Data

The information on housing system was gathered by questionnaire to 188 Dairy Herd Improvement Association (DHIA) supervisors in New York. The questionnaire was prepared from information in the December, 1968, monthly test reports.

Only large herds were included in the study, to ensure that comparisons between housing systems would not be affected by size of herd. The amount of information requested from the supervisors was reduced by using only herds with 45 or more cows; yet nearly all free-stall systems would be included.

Seventy per cent of the questionnaires were returned on about 1,200 herds. These herds were classified into seven housing systems. The milk (2×, 305-day, mature equivalent) production records for the cows with one or more records initiated since January 1, 1964, were selected from the DHIA herd file for this analysis.

Methods

The statistical model to describe a record of the j^{th} cow in the i^{th} herd within a housing system, year-season, age, and sire-type grouping was:

$$y_{ij} = \mu + b_i + w_{ij} \quad \text{where}$$

μ is a population constant,

b_i is the effect common to records in the i^{th} herd, and

w_{ij} is the random effect of the j^{th} cow in the i^{th} herd where b_i and w_{ij} are independent and have zero means and variances σ_b^2 and σ_w^2, respectively.

This simple, one-way classification model with random effects was applicable because the statistic of interest is the within-herd variance, σ_w^2. This variance was computed to determine the effects of:

A. Housing systems
   1. Stanchions
   2. Parlor with free stalls
   3. Pipeline with stanchions
   4. Parlor with loose housing (not free stall)
   5. Parlor with stanchions
   6. Stanchions with some free stalls
   7. Parlor with stanchions and free stalls

B. Year-Season
   1. January to April
   2. May to August
   3. September to December

C. Lactations defined as first calving in each age period as follows:

1. Age 20 to 36 months.
2. 36 to 48 months.
3. 48 to 60 months.

D. Sire type

1. Artificial insemination sire
2. Natural service sire

This method blocked possible sources of variability and allowed the estimates, $\hat{\sigma}_w^2$, to be tested for heterogeneity by Bartlett's test (2), because of its flexibility for comparing variances in more than two housing systems. The test statistic was

$$M = \sum_{i=1}^{a} D_i \ln \overline{\sigma_w}^2 - \sum_{i=1}^{a} D_i \ln \hat{\sigma}_{w_i}^2 \text{ where } \overline{\sigma_w}^2 = \sum D_i \hat{\sigma}_{w_i}^2 / \sum D_i$$

a = number of estimates

D_i = degrees of freedom in the i^{th} estimate, and M is distributed as χ^2 with a-1 degrees of freedom.

TABLE 2. Comparison of within-herd variances of different housing systems pooled over year-seasons from 1964 through 1967 for groups of records defined by sire type and lactation number.

Lactation number	Housing[a] system	Degrees of freedom	Weighted mean (kg)	Weighted[b] within herd variance kg^2	Within herd standard deviation (kg)	Bartlett's[c] test
		All sires, mature-equivalent records				
1	1	25,884	6,848	1,093,070	1,046	
	2	7,724	6,782	1,187,916	1,090	
	3	5,368	6,882	1,197,054	1,094	32.81
		AI-sired, mature-equivalent records				
1	1	12,786	7,019	1,078,398	1,038	
	2	2,970	7,092	1,111,243	1,054	
	3	2,394	7,074	1,211,875	1,101	14.24
		Naturally sired, mature-equivalent records				
1	1	10,442	6,644	1,062,765	1,031	
	2	4,268	6,633	1,234,272	1,111	
	3	2,481	6,692	1,159,566	1,077	36.44
		All sires, deviations from herdmates				
1	1	25,884	155	1,184,338	1,088	
	2	7,724	356	1,251,589	1,119	
	3	5,368	212	1,277,440	1,130	18.40
		All sires, incomplete records only				
1	1	2,501	5,701	1,182,414	1,087	
	2	850	5,380	1,527,143	1,236	
	3	461	5,598	1,095,102	1,046	25.89
		All sires, mature-equivalent records				
2	1	20,348	6,940	1,240,526	1,114	
	2	5,734	6,746	1,321,800	1,150	
	3	4,402	6,944	1,339,972	1,158	16.65
		All sires, mature-equivalent records				
3	1	13,489	6,828	1,133,600	1,065	
	2	3,456	6,614	1,198,716	1,095	
	3	3,029	6,883	1,219,343	1,104	9.23

[a] 1. Stanchions. 2. Parlor with free stalls. 3. Pipeline with stanchions.
[b] Weighted by degrees of freedom.
[c] All significant at .01 level.

Results and Discussion

Effect of housing system. Housing system accounted for significant differences in within-herd variance in about one-third of the year-seasons. Results when the variance estimates were weighted by degrees of freedom and pooled over the period 1964 through 1967 also indicated that housing system does affect the within-herd variance to a statistically significant degree. These pooled results are recorded in Table 2, which includes the information for Housing Systems 1, 2, and 3. The other systems studied were not included in the final analysis, because too few records were involved to allow for meaningful comparisons. Also, estimates for those systems were sufficiently different to make any combinations arbitrary. System 3, stanchions with pipeline milking, was included because it had nearly as many cows as System 2, free stalls, and because of its physical similarity to System 1. The survey indicated that 91% of the stanchion cows, 58% of the free-stall cows, and 81% of the cows in stanchions with pipelines were individually fed. There was no response on individual feeding for 6% of the cows in stanchions with pipelines, but no response for only 2% of the cows in the two other systems. The within-herd variances were more alike in Systems 2 and 3 than in 1 and 3. The mean production levels are almost the same for each housing system, much as expected.

The slightly greater within-herd variance for free-stall systems may result in part from the greater importance of cows' aggressiveness in a group-handling situation. This factor is probably much more important where cows are in direct competition with one another than when individually confined.

Year-season. The within-herd variances were primarily in the range of 1 to 1.5 million kg^2 over the year-seasons studied. Season 3 (September–December) had the least difference among housing types and also the largest number of cows.

Sire types. Type of sire had little effect on the relative within-herd variances, System 1 being least variable in each case. The records by artificially sired cows were about 455 kg superior to those by naturally sired cows, which confirms other studies (6) reporting the superiority of artificially inseminated cows in New York.

Incomplete records. The proportion of incomplete records (2×, 305-day, mature equivalent) was the same for each housing system, increased with lactation number, and was higher for naturally sired animals. The per cent of incomplete records was 13, 17, 18, and 20% for Lactations 1 to 4, respectively. These incomplete records were more variable and had a lower mean than normal records.

Deviations from herdmate production. Variances of deviation records within herds were consistently larger than variances of nondeviated records, yet rankings remained the same. This finding suggests that the variance of deviation records included some variance due to herd effects when compared to variances calculated from mature-equivalent records (3, 5).

Conclusions

Housing system accounted for statistically significant differences in within-herd variances. Records produced in herds with stanchions were less variable than those in free-stall operations. This evidence rejects the theory that group handling in a free-stall operation leads to more similarity among records, a smaller within-herd variance, than in stanchion herds where cows might be handled more individually. However, these results may not be applicable to herds with less than 45 cows, where stanchioned cows may receive more individual attention than cows in a free-stall situation.

The higher within-herd variance for free-stall systems was not sufficiently greater to be of practical importance. Thus, no adjustments for housing system in present production-reporting procedures are indicated, at least for herds of 45 or more cows.

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