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ESTIMATION OF HERITABILITY AND BREEDING VALUES USING SINGLE TEST DAY RECORDS OF FIRST LACTATION MILK YIELD OF HOLSTEIN COWS

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SUMMARY

Data used in this study comprised 10945 test day (TD) milk records of 1163 first lactation Holstein cows belonging to a commercial farm. The objective was to estimate heritability and breeding values for cows and sires using both single test day and 305-day milk records. Additive genetic variance, heritability and breeding values were estimated using DF-REML (Meyer,1998).

Heritability estimates of single TD records, except the first, sixth and ninth, were higher than those estimated for 305-days. The highest estimates of heritability were observed for the second and third TD milk records.

The product-moment and rank correlations between breeding values, of both sires and cows, estimated from 305-day and single TD milk records were positive and significant. Shifts in rank for various top cows and sires, ranked by their breeding values for 305-day and single TD milk yields, showed that extreme changes in ranks occurred in cows than in sires.

Keywords: *Holstein, first lactation, heritability, breeding value, rank correlation, single test day records.*

INTRODUCTION

The test day model has recently been used more for genetic evaluations of milk production traits than standardized 305 day records. It better accounts for non-genetic factors that affect each test day yield and consequently increases accuracy of predicting genetic merit of cows and bulls (Jamrozik *et al*, 1997 and Murray and Brand, 2003). Also, with better accuracy and more confidence in genetic evaluation and breeding decisions can be made earlier, therefore speeding up genetic progress.

The most common techniques of using TD in genetic evaluation are : the first four TD records, the entire ten TD records of the lactation and the single TD records. The latter seems to be the most appropriate for developing countries to minimize cost and effort.

The objective of this study was to compare estimates of heritability and breeding values derived from single test day records as compared with those estimated from the traditional 305 day milk yield.

MATERAL AND METHODS

Data :

The data used in this study comprised 10945 first lactation test day records of 1163 Holstein cows belonging to El-Tobgy dairy farm about 100 km south of Cairo. The data covered the period from 1992 to 2002. The average age at first calving was 25 months. Data editing was done according to Swalve (1995) on length of interval from calving to the first test day (4 to 45 days) and the length of interval between calving and second test day (14 to 70 days). Details of data structure are presented in Table 1.

Table 1. Data structure

Data type	Number
No. of cows	1163
Test day records	10945
Average test day records per cow	9.4
No. of sires	59
Average number of daughters per sire	9.6

Traits:

305-day milk yield:

Once-a- month test day milk records were used to calculate total milk yield (TMY). The TMY and lactation period (LP) were used for calculating 305 day milk yield according to the following ICAR formula (ICAR, 2000):

305-day milk yield = TMY* 405/(LP+100)

Single test day records (TD):

In the case of single test day records, the first ten test day yields were used. Test day yield (TDY) records were calculated by the test interval method (Mao, 1995) as follows:

TDY1, (TDY1+ TDY2)/2,(TDY2+TDY3)/2, .. , (TDYn-1+TDYn)/2, and TDYn

Variance components (additive genetic and residual), heritabilities and breeding values for 305 day and individual TD milk yield records were estimated by the Derivative-Free Restricted Maximum Likelihood (DF-REML) procedure (Meyer, 1998). The models used were as follows:

Model (1): For 305-day milk yield

$Y_{ijk} = \mu + S_i + a_j + bx_{ijk} + e_{ijk}$

where:

Y_{ijk} = 305-day milk yield record,

μ = the overall mean,

S_i = the fixed effect of year-season of calving classes; i=22 levels: 11 years (1992 to 2002) and two seasons (cool season = September to February and hot season = March to August),

a_j = animal's random additive genetic effect,

b = the regression coefficient of 305-day milk record on age at first calving,

x_{ijk} = age at first calving, as a co-variable, and

e_{ijk} = random residual effect.

Model (2): For single test day records

$Y_{ijk} = \mu + TD_i + a_j + b1x1_{ijk} + b2x2_{ijk} + e_{ijk}$

where:

Y_{ijk} = milk yield record for a single test day,

TD_i = the fixed effect of test date classes,

b1 = the regression coefficient of single test day milk record on age at first calving,

$x1_{ijk}$ = age at first calving, as a co-variable,

b2 = the regression coefficient of single test day milk record on days in milk at first test date,

$x2_{ijk}$ = days in milk at first test date, as a co-variable, and

e_{ijk} = random residual effect.

Product-moment and rank correlation coefficients (SAS,1996) were used for estimating the strength of the relationship between the breeding values estimated by 305-day milk records and those calculated from single test day records.

RESULTS AND DISCUSSION

Means and standard deviations for 305-day and single test day (TD) milk yield and days in milk (DIM) for the first 10 TDs are given in Table 2. Milk yield peak (26 Kg) was attained at 81 days and then daily yield declined as lactation progressed. Stanton *et al.* (1992), Swalve (1995) and Kaya *et al.* (2003) observed that the highest milk yield was obtained at 45 DIM then declined as lactation progressed.

Table 2. Means (X) and standard deviations (SD) for 305- day and single test day milk yield records

Traits	No.	DIM (day)		Milk yield (Kg)	
		X	SD	X	SD
305-day	1163	-	-	7185	1580
TD1	1117	20	9.2	23	6.5
TD2	1139	50	9.5	25	6.7
TD3	1163	81	11.3	26	6.9
TD4	1163	112	12.8	26	6.0
TD5	1163	143	13.0	25	6.1
TD6	1157	173	13.3	25	6.1
TD7	1150	204	13.8	24	6.0
TD8	1133	235	14.3	23	5.9
TD9	1053	264	13.8	21	5.8
TD10	706	290	13.3	20	5.8

Estimates of variance components (additive and residual variance), heritabilities, phenotypic and residual coefficient of variability (PCV% and RCV%, respectively) and phenotypic standard deviation (PSD) are presented in Table 3. The heritability (h^2) estimate was 0.08 for 305-day milk yield. However, the values of h^2 calculated from single TD milk records ranged from 0.03 for TD1 to 0.33 for TD3. Heritability estimate for 305-day milk yield in this study was lower than the estimates found in

the literature (Swalve (1995,0.39); Schaeffer (1996,0.33); Jamrozik and Schaeffer (1997, 0.32) and Kaya *et al.* (2003,0.25)).

The h^2, estimates of 305-day milk yield (0.08) was less than corresponding estimates for TD's, except for that of TD1 (0.03), TD6 (0.07) and TD9 (0.06). This result is in agreement with that reported by Meyer *et al.*, (1989) and Strabel and Szwaczkowski (1997), but disagrees with the estimates of Swalve (1995). These results may indicate that use of some single TD milk records may be more adequate than 305-day record for selection schemes.

In agreement with the results shown in Table 3, the general pattern of the estimates as reported by several researchers (Searle, 1961; Van Vleck and Henderson, 1961; Kumar *et al.*, 1979; Wilmink, 1987; Meinert *et al.*, 1989; Meyer *et al.*, 1989; Danell, 1990 and Swalve, 1995) was an increase of h^2 estimates toward mid lactation and a decrease of estimates toward the start and the end of lactation. Most of the previous authors stated that the increase in h^2 of TD milk records for mid lactation was more a function of increasing additive genetic variance and permanent environmental differences between cows and decreasing residual variance. This explanation can be seen clearly in estimates presented in Table 3.

The estimate of heritability for the first test day (TD1) was the lowest. This finding was not only attributable to high residual variance, but also to a rather small estimate of the additive genetic variance. This result is in agreement with Swalve, 1995. Also, the decreased heritabilities for the later TD milk records indicate that production during the later months of the lactation is determined more by temporary environmental influences and less by permanent differences between cows than production during the early TD records.

Table 3. Variance components and heritability ($h^2 \pm$ SE) for 305-day and single test day (TD) milk yield records of first lactation of Holstein cattle

Trait	a	e	PCV%	PSD	RCV%	h^2	SE
305-day	145632	1759579	19.2	1380.3	18.5	0.08	0.08
TD1	0.870	31.5	24.7	5.7	24.4	0.03	0.08
TD2	8.619	30.4	25.3	6.2	22.1	0.22	0.18
TD3	12.866	25.9	23.7	6.2	19.6	0.33	0.15
TD4	2.083	22.3	18.9	4.9	18.2	0.09	0.08
TD5	3.308	21.3	19.5	5.0	18.5	0.13	0.07
TD6	1.723	22.8	20.2	5.0	19.1	0.07	0.07
TD7	2.606	22.3	21.2	5.0	19.7	0.11	0.08
TD8	2.271	22.1	21.9	4.9	20.4	0.09	0.08
TD9	1.376	22.6	22.9	4.9	22.6	0.06	0.07
TD10	2.077	22.4	24.3	4.9	23.7	0.09	0.15

a= Additive genetic variance; e= error variance; PCV%= Phenotypic coefficient of variability %; PSD = Phenotypic standard deviation and RCV%= residual coefficient of variability %.

From a practical point of view, a decision should be made to choose the type of data, 305-day or TD milk records, with the Animal model program in order to obtain an accurate genetic evaluation for the dairy cattle. Considering the heritability estimates obtained from this study, the highest h^2 of single TD milk records reached 0.33 in the third and 0.22 in the second TD, whereas the corresponding estimate for

305-day milk records was only 0.08. These results indicate that use of TD milk records, especially the third or second TD records, would give more selection response than what could be obtained by 305-day milk records.

Product-moment and rank correlations among estimates of sires and among estimates of cows breeding values for TD and 305-day milk records are presented in tables 4 and 5. The product-moment and rank correlations between breeding values of sires calculated from TD and 305-day milk records were relatively high. For sires, the values ranged from 0.42 to 0.83 and 0.53 to 0.88. For cows, the values ranged from 0.49 to 0.77 and 0.45 to 0.79. These results agree with the findings of Ptak and Schaeffer (1993) and Gaur and Raheja (1996) who observed high product-moment and rank correlations between estimated breeding values of sires for TD and total milk yield.

Table 4. Product-moment (above diagonal) and rank (below diagonal) correlations between estimates of sires breeding values calculated from 305-day and single test day (TD) milk yield records of first lactation Holstein cattle

Trait	305-day	TD1	TD2	TD3	TD4	TD5	TD6	TD7	TD8	TD9	YD10
305-day		0.61	0.75	0.69	0.71	0.72	0.77	0.82	0.83	0.62	0.42
TD1	0.62		0.77	0.57	0.58	0.49	0.49	0.53	0.59	0.53	0.33^{NS}
TD2	0.72	0.69		0.87	0.72	0.65	0.66	0.64	0.63	0.46	0.26^{NS}
TD3	0.72	0.56	0.88		0.80	0.69	0.73	0.70	0.61	0.41	0.32^{NS}
TD4	0.75	0.61	0.71	0.80		0.94	0.86	0.84	0.74	0.52	0.30^{NS}
TD5	0.73	0.54	0.60	0.65	0.92		0.92	0.82	0.70	0.47	0.20^{NS}
TD6	0.79	0.54	0.66	0.69	0.81	0.87		0.89	0.81	0.63	0.33^{NS}
TD7	0.85	0.59	0.69	0.73	0.84	0.82	0.90		0.93	0.71	0.47
TD8	0.88	0.60	0.69	0.67	0.76	0.73	0.86	0.95		0.85	0.57
TD9	0.74	0.64	0.51	0.45	0.54	0.50	0.61	0.67	0.77		0.73
TD10	0.53	0.39*	0.35*	0.37*	0.36*	0.34*	0.37*	0.46	0.49	0.70	

All correlation coefficients were significant at $p<0.01$, except for some rank correlations (*) of TD10 and TD1 to TD6 which were significant at $p<0.05$; NS = not significant.

Table 5. Product-moment (above diagonal) and rank (below diagonal) correlations between estimates of cows breeding values calculated from 305-day and single test day (TD) milk yield records of first lactation Holstein cattle

Trait	305-day	TD1	TD2	TD3	TD4	TD5	TD6	TD7	TD8	TD9	TD10
305-day		0.49	0.56	0.59	0.69	0.69	0.75	0.77	0.77	0.69	0.60
TD1	0.45		0.62	0.37	0.43	0.36	0.38	0.36	0.37	0.35	0.26
TD2	0.58	0.81		0.90	0.46	0.41	0.39	0.35	0.34	0.31	0.22
TD3	0.66	0.48	0.78		0.60	0.50	0.47	0.42	0.40	0.36	0.28
TD4	0.68	0.40	0.53	0.76		0.90	0.75	0.69	0.65	0.56	0.41
TD5	0.67	0.33	0.46	0.60	0.88		0.87	0.74	0.69	0.58	0.39
TD6	0.75	0.35	0.47	0.60	0.73	0.85		0.89	0.79	0.70	0.50
TD7	0.79	0.33	0.45	0.57	0.67	0.72	0.89		0.91	0.75	0.60
TD8	0.79	0.32	0.43	0.55	0.63	0.68	0.77	0.90		0.87	0.65
TD9	0.71	0.34	0.42	0.51	0.56	0.57	0.67	0.73	0.85		0.76
TD10	0.65	0.27	0.32	0.42	0.42	0.40	0.49	0.58	0.62	0.74	

* All correlation coefficients were significant at $p<0.05$

Breeding values have been estimated for 305-day and single TD milk records by several researchers (Ptak and Schaeffer, 1993; Swalve, 1995; Jamrozik *et al.*, 1997; Strabel and Szwaczkowski, 1998). The rank correlations between values based on single TD and those estimated from 305-day milk records within both sires and cows were mostly positive and high. This finding indicates that there is a change in ranking. This observation is in agreement with many published papers (Swalve, 1995; Dalal *et al.*, 1999; Kaya *et al.*, 2003). Swalve (1995) reported that a comparison of both sets of breeding values indicated only minor changes in sire rank, but more drastic changes in reranking for individual cows. Because changes in rank for cows seemed to be associated with lactation curves that deviated greatly from the standard lactation curve.

In general, it can be stated that high product-moment and rank correlations were obtained between adjacent test days and the correlations decreased as interval between test days increased. This result is in agreement with the results from the study by Singh and Acharya (1969) and Dalal *et al.* (1999).

CONCLUSION

It can be concluded that single TD milk records could be used for selecting animals for milk production. The higher heritability estimates of TD3 and TD2 suggest that selection on early tests may become more advantageous if reduced generation interval is taken into account.

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تقدير العمق الوراثى والقيم التربوية بإستخدام سجلات يوم الإختبار الفردية لموسم الحليب الأول فى أبقار الهولشتين

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أُستخدم فى الدراسة ١٠٩٤٥ سجلاً فردياً ليوم الإختبار الشهرى لعدد ١١٦٣ بقرة هولشتين فى الموسم الأول، وكان الهدف من الدراسة هو تقدير العمق الوراثى والقيم التربوية بإستخدام سجلات يوم الإختبار الفردية مُقارنةً بالسجلات الخاصة بإنتاج ٣٠٥ يوم. وتم تقدير مكونات التباين بإستخدام طريقة DF-RML . ويُمكن تلخيص أهم النتائج المُتحصل عليها فيما يلى:

١- حققت قيم العمق الوراثى لصفة إنتاج اللبن المُقدرة بإستخدام سجلات يوم الإختبار الفردية قيماً أعلى من تلك المحسوبة بإستخدام سجلات ٣٠٥ يوم (ما عدا سجلات يوم الإختبار الأول والسادس والتاسع).

٢- كانت أعلى قيمة للعمق الوراثى هى تلك المُقدرة بإستخدام سجلات يوم الإختبار الفردية للشهر الثانى والثالث.

٣- كانت قيم مُعامل الإرتباط ومُعامل إرتباط الرتب بين القيم التربوية المُقدرة بإستخدام سجلات يوم الإختبار الفردية وتلك المُقدرة بإستخدام سجلات ٣٠٥ يوم موجبة ومعنوية.

٤- نستنتج من النتائج إمكانية إجراء إنتخاب مُبكر بإستخدام سجلات يوم الإختبار للشهر الثانى أو الثالث.