FIRST DRAFT

Report on:

Milk Recording Accuracy and It's Impact on Genetic Evaluations

by:

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95-1276/HW/CS

1. Terms of reference

The International Committee for Animal Recording (ICAR) has established with the support of INTERBULL a working group in order to consider the impact of:

a. Test interval and number of tests included in accumulated lactation yield for milk, fat and protein;
b. The accuracy of volume and composite determination at each test for each trait;
c. The availability of other data, like health data, which may influence to some extend milk, fat and/or protein yield per test;

on accuracy of genetic evaluations for milk production traits for bulls and cows.

This study may result in guidelines which may be adopted by ICAR in the design of milk recording services for dairy farmers.

This report is a first draft.

Up to now the study of the working group has concentrated around the estimation of the relationship between recording frequency and accuracy of breeding value estimation for milk production traits. Therefore genetic correlations were estimated between 305-day cumulative yields, obtained by different recording frequency. Results of this analysis is presented in this paper.

2. Material and Methods

The data set consisted of estimates phenotypic and genetic variances and covariances among test day yields and the phenotypic means for these test day yields, known at a 4-weekly interval, for milk, fat and protein yield. The estimates were obtained from the study by Ouweltjes (1990) and were based on first lactation test day yields of Black and white heifers, calved between April 1983 and March 1986. The estimates are summarized in appendix A.

Variances were estimated for 305-day milk, fat and protein yield, computed from test day records, taken at a 4-weekly, 8 weekly and 12 weekly interval. Genetic correlations among these 305-day yields (milk, 4 weekly with milk, 8 weekly, etc.) were assessed as well as heritabilities.

305-Days yield was modelled as:

$$Y_{305w} = b_w' \, p$$

where Y_{305w} : 305-day yield based on a w-weekly (4, 8 or 12) recording scheme;
b_w : weighting vector for the w-weekly recording scheme;
l : vector with production levels (means) for 4 weekly recording scheme.

$b_w = \text{diag}\ (\ d_w\ p'\ )\ /\ 1$

where d_w : vector with number of days for w-weeks recording scheme;
p : vector with yields for the 4-weekly recording sheme.

Phenotypic variances and covariances were calculated by:

$(co)var\ (Y305_{w1}, Y305_{w2}) = b_{w1}'\ P\ b_{w2}$

where P : 4-weekly phenotypic variance/covariance matrix between test day yields.

Then $var\ (Y305_4, Y305_4)$ was calculated by $b_4'\ P\ b_4$
and $cov\ (Y305_4, Y305_8)$ was calculated by $b_4'\ P\ b_8$.

For computation of genotypic variances and covariances the genotypic variance/covariance matrix G was taken instead of P.

Heritabilities and phenotypic and genotypic correlations were calculated by:

$$h_w^2 = \frac{\sigma^2_{a_w}}{\sigma^2_{p_w}} \qquad r_{p_{w1w2}} = \frac{cov_p(Y305_{w1}, Y305_{w2})}{\sigma_{p_{w1}} \cdot \sigma_{p_{w2}}} \qquad r_{g_{w1w2}} = \frac{cov_g(Y305_{w1}, Y305_{w2})}{\sigma_{a_{w1}} \cdot \sigma_{a_{w2}}}$$

where h_w^2 : heritability of Y305d for w-weekly recording scheme;
σ_a^2 : genetic variance for Y305d;
σ_p^2 : phenotypic variance;
r_p : phenotypic correlation between Y305d yield for w1 weekly scheme and Y305d yield for w2 weekly scheme;
r_g : genotypic correlation.

Heritabilities and correlations give estimates for accuracy of selection on 305-day yield for w-weekly intervals on population level. However, there may be great differences in 305-day yield at cow level, whether 8 or 12 weekly recording frequency is considered instead of 4 weekly. Therefore, variances were estimated for the differences between 305-day yield for 8 weekly with 4 weekly, for 12 weekly with 4 weekly recording frequency.

Therefore,

$var\ (\ Y305_{w1} - Y305_{w2}\ )$ was calculated by

$var\ (Y305_{w1}) + var\ (Y305_{w2}) - 2*cov\ (Y305_{w1}, Y305_{w2})$.

The vector b_w reflects the number of days, considered in computation of 305 day yield and the level of test day yield (see above). For level the phenotypic averages were taken. b_w Vectors were based on the d_w vectors, defined as:

$$
\begin{array}{lcl}
d_4' & = & [\ 30\ \ 30\ \ 30\ \ 30\ \ 30\ \ 30\ \ 30\ \ 30\ \ 30\ \ 30\ ] \\
d_{8a}' & = & [\ \ 0\ \ 60\ \ \ 0\ \ 60\ \ \ 0\ \ 60\ \ \ 0\ \ 60\ \ \ 0\ \ 60\ ] \\
d_{8b}' & = & [\ 60\ \ \ 0\ \ 60\ \ \ 0\ \ 60\ \ \ 0\ \ 60\ \ \ 0\ \ 60\ \ \ 0\ ] \\
d_{12a}' & = & [\ \ 0\ \ \ 0\ \ 90\ \ \ 0\ \ \ 0\ \ 90\ \ \ 0\ \ \ 0\ \ 125\ \ \ 0\ ] \\
d_{12b}' & = & [\ \ 0\ \ 90\ \ \ 0\ \ \ 0\ \ 90\ \ \ 0\ \ \ 0\ \ 125\ \ \ 0\ \ \ 0\ ] \\
d_{12c}' & = & [\ 90\ \ \ 0\ \ \ 0\ \ 90\ \ \ 0\ \ \ 0\ \ 125\ \ \ 0\ \ \ 0\ \ \ 0\ ]
\end{array}
$$

This results therefore in 6 different vectors b_w, which are summarized in appendix B.

3. Results and discussion

Variance/covariance matrices for a 4 weeks recording scheme compared with a 8 and 12 weeks recording scheme are given for milk, fat and protein yield in table 1,2 and 3.

Genetic standard deviation is 630 kg for 4 weekly 305 day milk yield, 610 - 647 kg for 8 weekly 305 day milk yield and 618 - 680 for 12 weekly 305 day milk yield. The higher variation in genetic standard deviation for 12 weekly 305 day milk yield is caused by varying interval between calving and the first test.

Genetic standard deviations are around 25 kg fat in all cases and approximately 17 kg protein.

Table 1 Phenotypic and *genotypic* variance/covariance matrix between $Y305_4$ and $Y305_{8 \text{ and } 12}$ for **milk yield (kg)** (*1000). Results for the different b_{8ab} and b_{12abc} vectors are separated by a slash.

	recording scheme (week)		
	4	8	12
4	899 *393*	884 / 917 *382 / 405*	882 / 954 / 950 *377 / 424 / 422*
8		888 / 956 *372 / 419*	
12			929 / 1070 /1105 *367 / 459 / 466*

Table 2 Phenotypic and *genotypic* variance/covariance matrix between $Y305_4$ and $Y305_{8 \text{ and } 12}$ for **fat yield (kg)**. Results for the different b_{8ab} and b_{12abc} vectors are separated by a slash.

	recording scheme (week)		
	4	8	12
4	1632 *624*	1572 / 1695 *588 / 662*	1568 / 1669 / 1742 *594 / 645 / 669*
8		1572 / 1822 *557 / 704*	
12			1698 /1865 /2139 *577 / 668 / 738*

Table 3 Phenotypic and *genotypic* variance/covariance matrix between $Y305_4$ and $Y305_{8 \text{ and } 12}$ for **protein yield (kg)**. Results for the different b_{8ab} and b_{12abc} vectors are separated by a slash).

	recording scheme (week)		
	4	8	12
4	927 283	911 / 945 *273 / 295*	927 / 960 / 969 *288 / 299 / 292*
8		925 / 995 *264 / 308*	
12			1022 /1086 /1160 *298 / 319 / 310*

Heritabilities, genetic and phenotypic correlations are given in table 4, 5 and 6. Heritabilities of $Y305_{4,8 \text{ and } 12}$ vary around .41 for milk production which is in accordance with values found for 305 day productions of Dutch heifers (Van der Lugt, 1994). For fat yield and protein yield the heritabilities vary around .36 and .29 respectively. Genetic correlations between $Y305_{4,8 \text{ and } 12}$ are approximately 1.

Table 4 Heritabilities (diagonal), phenotypic (above diag.) and genetic (below diag.) correlations between $Y305_4$ and $Y305_{8 \text{ and } 12}$ for milk yield (kg). Results for the different b_{8ab} and b_{12abc} vectors are separated by a slash.

	recording scheme (week)		
	4	8	12
4	0.437	0.989 / 0.989	0.965/0.973/0.953
8	0.998 / 0.999	0.419 / 0.438	
12	0.993 / 0.999 /0.987		0.395/0.429 /0.422

Table 5 Heritabilities (diagonal), phenotypic (above diag.) and genetic (below diag.) correlations between $Y305_4$ and $Y305_{8 \text{ and } 12}$ for fat yield (kg). Results for the different b_{8ab} and b_{12abc} vectors are separated by a slash.

	recording scheme (week)		
	4	8	12
4	0.383	0.981 / 0.983	0.942 /0.957 /0.932
8	0.998 / 0.998	0.354 / 0.387	
12	0.989 /0.999 /0.986		0.340 /0.359 /0.345

Table 6 Heritabilities (diagonal), phenotypic (above diag.) and genetic (below diag.) correlations between $Y305_4$ and $Y305_{8 \text{ and } 12}$ for protein yield (kg). Results for the different b_{8ab} and b_{12abc} vectors are separated by a slash.

	recording scheme (week)		
	4	8	12
4	0.305	0.984 / 0.984	0.952 /0.957 /0.935
8	0.998 / 0.999	0.285 / 0.309	
12	0.991 /0.994 /0.987		0.292 /0.294 /0.267

Table 7 Phenotypic and genetic variances for ($Y305_{8,12}$-$Y305_4$) for milk fat and protein yield (kg). Results for the different b_{8ab} and b_{12abc} vectors are separated by a slash.

recording scheme (week)			
recording scheme	genetic		phenotypic
milk			
8 - 4	1493 / 1581		19596 / 20533
12 - 4	5490 / 3509 /14752		63523 / 60408 / 104620
fat			
8 - 4	5 / 5		61 / 63
12 - 4	14 / 3 / 23		193 / 158 / 287
Protein			
8 - 4	1 / 1		30 / 31
12 - 4	5 / 4 / 9		96 / 93 / 149

In Table 7 variances are presented for ($Y305_{8,12}$ - $Y305_4$) for milk, fat and protein yield. For 305 day milk yield, the genetic standard deviation (GSD) of the difference between 8 and 4 weekly recording frequency is app. 40 kg, which is about 6 %, using the GSD for milk yield of 630 kg. The GSD for the difference between 12 and 4 weekly recording frequency varies between 60 and 120 kg, depending on the interval between calving and the first test. Phenotypic standard deviations are all higher.

GSD for the difference for 305 day fat (8 weekly - 4 weekly) is app. 2 kg, which is about 8% of the mean (25 kg). This is higher for the difference between 12 weekly and 4 weekly. For protein the GSD of the difference between 8 weekly and 4 weekly is 1 kg, which is about 5 %.

The results presented in table 1 - 7 depend mainly on the used variance and covariance matrices between test day yields. Plans are undertaken to estimate these parameters on greater data sets and for different populations in order to reach a better basis for conclusions.

4. Some preliminary conclusions

Based on this first analysis, the next statements can be made:

a. Genetic correlations between 305 day yield, calculated from a 4 weekly, 8 weekly or a 12 weekly recording frequency is very high. This will almost not affect bull rankings, if milk recording frequency is changed from 4 to 8 or 12 weekly.

b. Genetic Standard deviations for the difference between 305 day yield computed from a 4 weekly scheme or computed from a 8 or 12 weekly scheme are around 5% for milk and protein and around 8% for fat, which shows that individual cows may rank quite different if recording frequency increases.

c. Interval in days between calving and the first test influence genetic parameters. This shows the necessity for use of methods to compute 305 day yields, where account is taken for the time in lactation of the fist test day yield.

5. Literature

Ouweltjes, W. (1990) Onderzoek naar de efficiëntie van melkcontrolesystemen met verschillende frequenties. NRS Rapport.

Van der Lugt, A.W., L.L.G. Janss and J.A.M. Van Arendonk (1994). Estimation of variance components in large animal models using gibbs sampling. Paper 5th WCGALP.

APPENDIX A Data for milk yield

Table	Milk yield productions, standard deviations and heritabilities for test days.		
test day	productions	standard deviation	heritability
15	21.0	4.3	.31
45	21.4	4.1	.41
75	20.6	4.0	.39
105	19.5	3.8	.35
135	18.5	3.7	.37
165	17.7	3.7	.36
195	16.8	3.8	.30
225	15.8	3.8	.26
255	14.6	3.8	.22
285	13.3	4.0	.17

P = phenotypic variance/covariance matrix between test day yields

18.490	12.517	9.288	8.333	7.319	7.000	6.536	5.882	5.065	3.784
	16.810	13.776	11.373	10.012	9.557	9.036	8.102	6.855	5.248
		16.000	12.920	10.952	10.212	9.728	8.816	7.448	5.760
			14.440	11.810	10.545	9.964	8.953	7.653	5.928
				13.690	11.637	10.264	9.280	8.014	6.216
					13.690	11.810	9.983	8.577	6.808
						14.440	11.985	9.819	7.904
							14.440	11.841	9.120
								14.440	12.160
									16.000

G = genetic variance/covariance matrix between test day yields

5.732	5.908	5.143	4.683	4.257	4.146	3.837	3.062	2.475	1.658
	6.892	6.427	5.784	5.436	5.304	4.863	4.070	3.322	2.381
		6.240	5.504	5.453	5.324	4.835	4.211	3.339	2.554
			5.054	4.908	4.791	4.492	3.877	3.246	2.447
				5.065	4.996	4.638	4.143	3.370	2.635
					4.928	4.528	4.130	3.324	2.673
						4.332	3.952	3.339	2.678
							3.754	3.246	2.780
								3.177	2.851
									2.720

Data Fat yield

Table	Fat yield, genetic parameters for test days.		
test day	productions (kg)	standard deviation	heritability
15	.912	.23	.26
45	.886	.19	.34
75	.852	.18	.31
105	.818	.17	.24
135	.789	.17	.26
165	.766	.16	.25
195	.741	.16	.22
225	.716	.16	.21
255	.687	.17	.22
285	.652	.18	.17

P = phenotypic variance/covariance matrix between test day yields

0.0529	0.0288	0.0182	0.0160	0.0145	0.0129	0.0114	0.0107	0.0102	0.0087
	0.0361	0.0253	0.0191	0.0165	0.0143	0.0131	0.0119	0.0116	0.0096
		0.0324	0.0226	0.0181	0.0153	0.0138	0.0127	0.0122	0.0100
			0.0289	0.0217	0.0169	0.0152	0.0144	0.0139	0.0116
				0.0289	0.0212	0.0174	0.0160	0.0156	0.0132
					0.0256	0.0202	0.0169	0.0160	0.0135
						0.0256	0.0202	0.0177	0.0150
							0.0256	0.0215	0.0161
								0.0289	0.0236
									0.0324

G = genetic variance/covariance matrix between test day yields

0.0138	0.0126	0.0107	0.0086	0.0081	0.0071	0.0060	0.0052	0.0052	0.0040
	0.0123	0.0109	0.0087	0.0085	0.0074	0.0062	0.0055	0.0057	0.0044
		0.0100	0.0080	0.0080	0.0071	0.0059	0.0053	0.0055	0.0044
			0.0069	0.0070	0.0063	0.0057	0.0053	0.0054	0.0045
				0.0075	0.0069	0.0062	0.0059	0.0062	0.0053
					0.0064	0.0058	0.0055	0.0059	0.0050
						0.0056	0.0054	0.0057	0.0051
							0.0054	0.0057	0.0051
								0.0064	0.0051
									0.0055

Data protein yield

Table	Genetic parameters for test day yield		
test day	productions (kg)	standard deviation (kg)	heritability
15	.684	.15	.17
45	.667	.13	.29
75	.656	.13	.29
105	.642	.13	.24
135	.624	.13	.23
165	.606	.13	.18
195	.586	.13	.16
225	.562	.13	.15
255	.533	.13	.18
285	.495	.14	.10

P = phenotypic variance/covariance matrix between test day yields

0.0225	0.0127	0.0084	0.0078	0.0070	0.0066	0.0060	0.0059	0.0057	0.0044
	0.0169	0.0127	0.0101	0.0090	0.0085	0.0078	0.0073	0.0068	0.0055
		0.0169	0.0130	0.0105	0.0096	0.0090	0.0083	0.0076	0.0060
			0.0169	0.0128	0.0106	0.0098	0.0091	0.0083	0.0066
				0.0169	0.0132	0.0108	0.0100	0.0090	0.0073
					0.0169	0.0132	0.0108	0.0095	0.0078
						0.0169	0.0132	0.0105	0.0086
							0.0169	0.0132	0.0096
								0.0169	0.0137
									0.0196

G = genetic variance/covariance matrix between test day yields

0.0038	0.0041	0.0037	0.0033	0.0029	0.0026	0.0023	0.0020	0.0020	0.0011
	0.0049	0.0048	0.0042	0.0040	0.0035	0.0032	0.0029	0.0030	0.0019
		0.0049	0.0044	0.0040	0.0036	0.0033	0.0031	0.0033	0.0022
			0.0041	0.0037	0.0033	0.0032	0.0030	0.0031	0.0022
				0.0039	0.0034	0.0031	0.0030	0.0031	0.0022
					0.0030	0.0028	0.0027	0.0029	0.0020
						0.0027	0.0026	0.0028	0.0020
							0.0025	0.0027	0.0020
								0.0030	0.0023
									0.0020

APPENDIX B

Table 1 Milk yield (kg) weight vectors b for 4, 8 and 12 weeks recording scheme based on 4 weeks recording system resulting in two and three different vectors for 8 and 12 weeks respectively.

test day	recording scheme					
	4 weeks	8 weeks		12 weeks		
		a	b	a	b	c
15	35.2	0	70.3	0	0	105.5
45	35.8	71.6	0	0	107.5	0
75	34.5	0	69.0	103.5	0	0
105	32.6	65.3	0	0	0	97.9
135	31.0	0	61.9	0	92.9	0
165	29.6	59.3	0	88.9	0	0
195	28.1	0	56.3	0	0	117.2
225	26.5	52.9	0	0	110.2	0
255	24.4	0	53.0	101.8	0	0
285	26.0	48.2	0	0	0	0

Table 2 Fat yield (kg) weight vectors b for 4, 8 and 12 weeks recording scheme based on 4 weeks recording system resulting in two and three different vectors for 8 and 12 weeks respectively.

test day	recording scheme					
	4 weeks	8 weeks		12 weeks		
		a	b	a	b	c
15	35.0	0	70.0	0	0	105.0
45	34.0	68.0	0	0	102.0	0
75	32.7	0	65.4	98.1	0	0
105	31.4	62.8	0	0	0	94.2
135	30.3	0	60.5	0	90.8	0
165	29.4	58.8	0	88.2	0	0
195	28.4	0	56.7	0	0	118.5
225	27.5	54.9	0	0	114.5	0
255	26.4	0	57.1	109.8	0	0
285	29.2	54.2	0	0	0	0

Table 3 **Protein yield (kg)** weight vectors b for 4, 8 and 12 weeks recording scheme based on 4 weeks recording system resulting in two and three different vectors for 8 and 12 weeks respectively.

test day	recording scheme					
	4 weeks	8 weeks		12 weeks		
		a	b	a	b	c
15	33.9	0	67.8	0	0	101.7
45	33.0	66.1	0	0	99.1	0
75	32.5	0	65.0	97.5	0	0
105	31.8	63.6	0	0	0	95.4
135	30.9	0	61.8	0	92.7	0
165	30.0	60.0	0	90.1	0	0
195	29.0	0	58.1	0	0	121.0
225	27.8	55.7	0	0	116.0	0
255	26.4	0	57.2	110.0	0	0
285	28.6	53.1	0	0	0	0