Genetic and phenotypic analysis of Israeli Holstein milk, fat and protein production as determined by a real-time milk analyzer

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INTRODUCTION

- Milk components vary from milking to milking, depending on the time between milkings, DIM, season, the cow's age and parity and health.
- Although nearly all countries with modern milk recording systems rely on once monthly analysis, this may not closely represent the average or sum of a cow’s performance for that month.
- Recently, real-time analysis of milk components per cow per milking has become more widely available, primarily through the implementation of automatic milking systems.

The daily measurement system

- The DMS (AfiLab system Afimilk, Kibbutz Afikim, Israel) is a real-time individual cow milk analyzer which is implemented per parlor stall.
- Each unit uses near-infrared spectroscopy (**NIR**) for on-line milk analysis (Tsenkova et al., 1999).
- The advantages of an NIR system over other systems are that they are speedy and give nondestructive on-line measurements.
- The DMS provides observations of milk fat, protein, and lactose components.

The daily system - Advantages

The DMS providing data from each milking (three per day) instead of once per month.

Lactation curve estimation and genetic evaluations can be done daily meaning that management decisions regarding each cow can be taken on a daily basis.

The possible use of those results for genetic evaluations can save a lot of money.

The DMS, previous results

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Agreement between milk fat, protein, and lactose observations collected from the Dairy Herd Improvement Association (DHIA) and a real-time milk analyzer

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The results base on approximately 450 cows that measured in 23 different batches, 10,273 observations. Correlations between Bentley ("gold standard") and AfiLab were 0.59, 0.67, 0.46 for fat, protein and lactose percent. Correlation was judged to be moderate. The authors concluded "AfiLab observations were helpful estimators of DHIA observations".

A combination of AfiLab observations for protein and lactose 6 days around the DHIA test day resulted was slightly better agreement with protein and lactose percent but not for fat.

The DMS, previous results

The correlations between the monthly DHIA test day and AfiLab in the Israeli population (171,188 records) were 0.97, 0.66, 0.6, 0.8, 0.91 for kg milk, fat and protein percent and fat and protein kg .

AfiLab					
Protein %	Fat %	Protein Kg	Fat Kg	Milk Kg	DHIA
-0.33	-0.45	0.92	0.79	**0.97**	Milk Kg
-0.13	-0.04	0.74	**0.80**		Fat Kg
-0.14	-0.29	**0.91**			Protein Kg
0.34	**0.66**				Fat %
0.60					Protein %

No “Gold Standard”

- When a new analysis method cannot be compared to a “Gold Standard” method, other alternatives for evaluation must be considered.
- For example, the heritabilities for the new and standard method can be compared. In addition, the ability of the two methods to predict complete lactation production from truncated lactation records can be compared.

Objectives

- Testing the hypothesis that much more frequent, but less accurately analyzed milk components, may give a more representative measure of a cow’s total lactation production.
- To compare heritability's values for milk and milk components in the two methods.
- To calculate genetic and phonotype correlations between the two methods.
- To Predict complete lactation production from partial lactations by the DMS records, and compared to the same statistics derived from monthly test day records.

MATERIALS AND METHODS

Daily records for milk production, and fat and protein concentration collected from January 2014 through January 2016 from 47 large Kibbutz (communal) herds distributed throughout the country with a total of 37,486 cows were analyzed.

All of these farms use “NOA,” a comprehensive program for dairy herd management which was developed and is maintained by the ICBA, and addresses all aspects of dairy farming.

All cows were milked three times daily.

Milk production and fat and protein concentration was recorded for each milking.

Estimation of milk components on monthly test days

- Cows were milked three times daily. Each month on the test day the milk inspector collects samples from 2 out of 3 milkings, which are mixed in proportion to the milk produced by the cow in each of the 2 milkings.
- Visits are arranged so that a different milking is missed in each consecutive visit.
- Milk components are determined in the Central Milk Laboratory of Israel Cattle Breeders Association (ICBA) using a CombiFoss™(Foss, Hillerød, Denmark), and a Bentley FTS+FCM (Bentley Instruments, Inc., Chaska, MN).

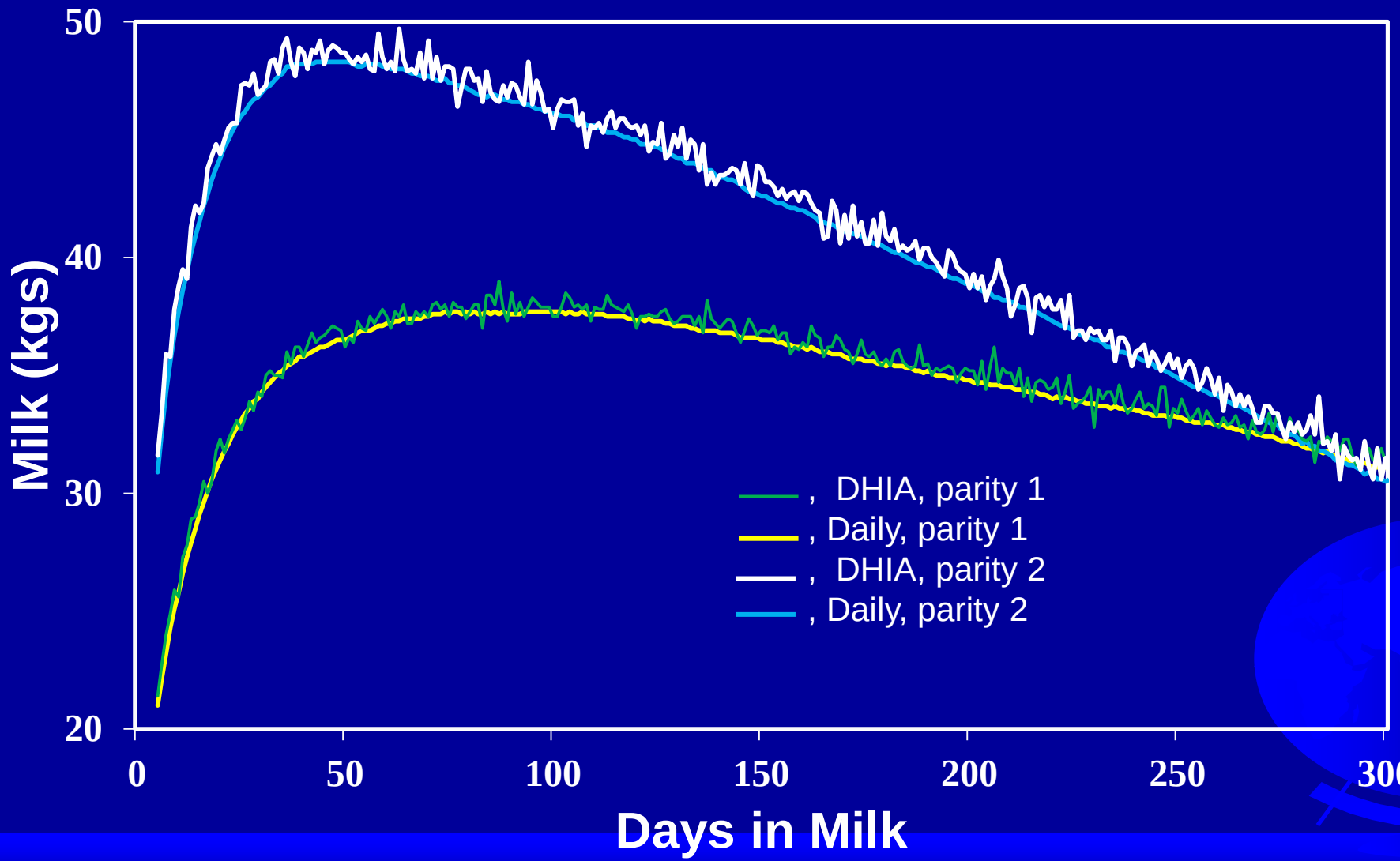
Comparison of daily records

Parity	Trait	Means ± SD		Correlations
		DHIA	Daily	
1	Milk (kg/d)	35.11±6.09	34.98±6.15	0.95
(77,581 records)	Fat (kg/d)	1.25±0.23	1.24±0.21	0.67
	Protein (kg/d)	1.13±0.18	1.14±0.20	0.83
	% fat	3.62±0.58	3.57±0.49	0.62
	% protein	3.25±0.26	3.26±0.24	0.42
2	Milk (kg/d)	41.45±8.78	41.24±8.81	0.96
(58,723 records)	Fat (kg/d)	1.45±0.32	1.44±0.29	0.72
	Protein (kg/d)	1.34±0.24	1.33±0.28	0.87
	% fat	3.55±0.64	3.54±0.54	0.62
	% protein	3.26±0.31	3.24±0.25	0.48

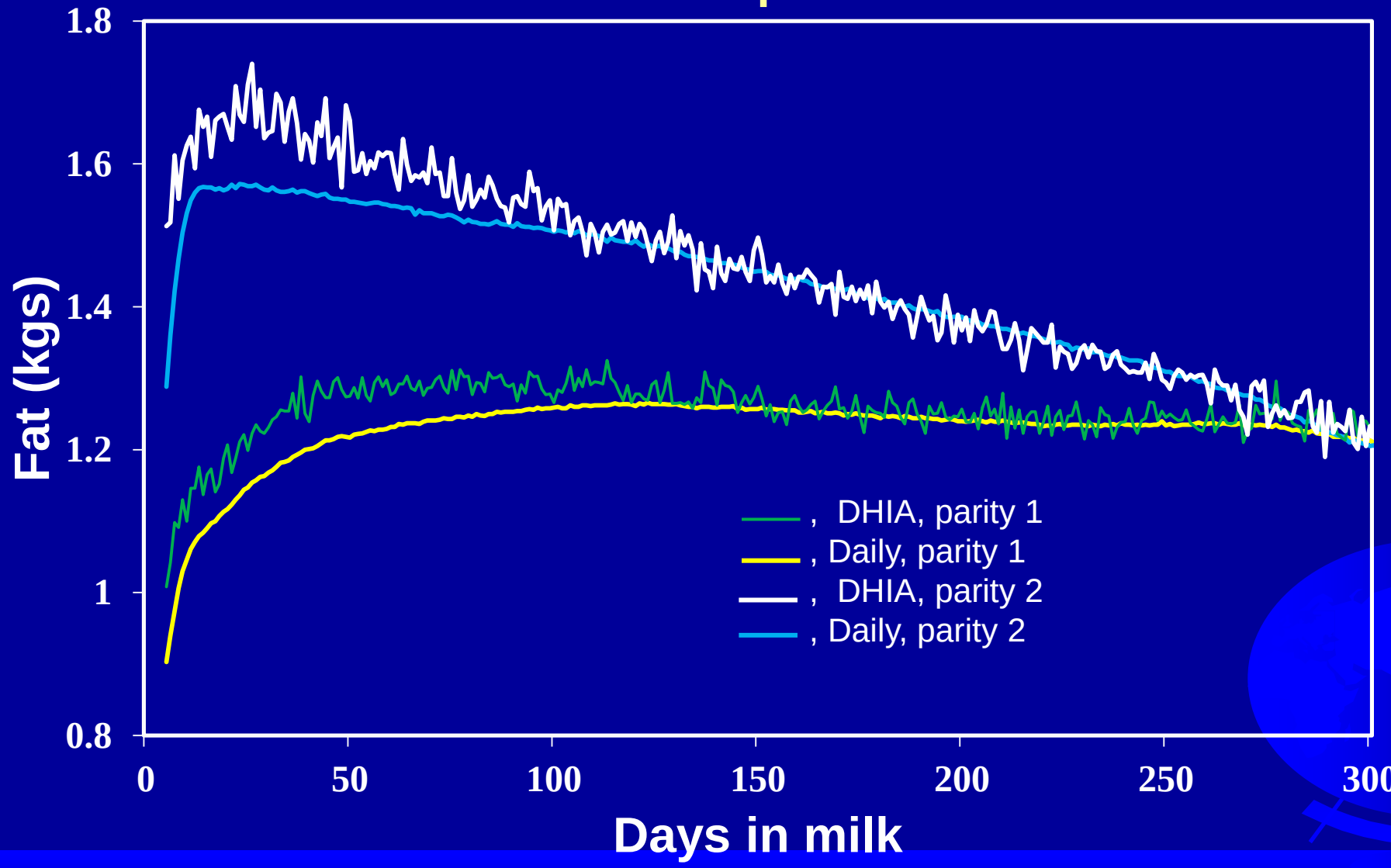
Comparison of 305 d lactations

		Means±SD		
Parity	Trait	DHIA	Daily	Correlations
1	Milk (kg)	10,472±1303	10,440±1293	0.97
(7,953 cows)	Fat (kg)	376±49	369±47	0.77
	Protein (kg)	339±39	340±41	0.90
	% fat	3.61±0.39	3.55±0.30	0.67
	% protein	3.24±0.16	3.26±0.14	0.56
2	Milk (kg)	12,432±1599	12,301±1556	0.97
(6,051 cows)	Fat (kg)	439±63	429±59	0.77
	Protein (kg)	402±47	397±50	0.89
	% fat	3.55±0.42	3.50±0.33	0.65
	% protein	3.24±0.17	3.23±0.15	0.57

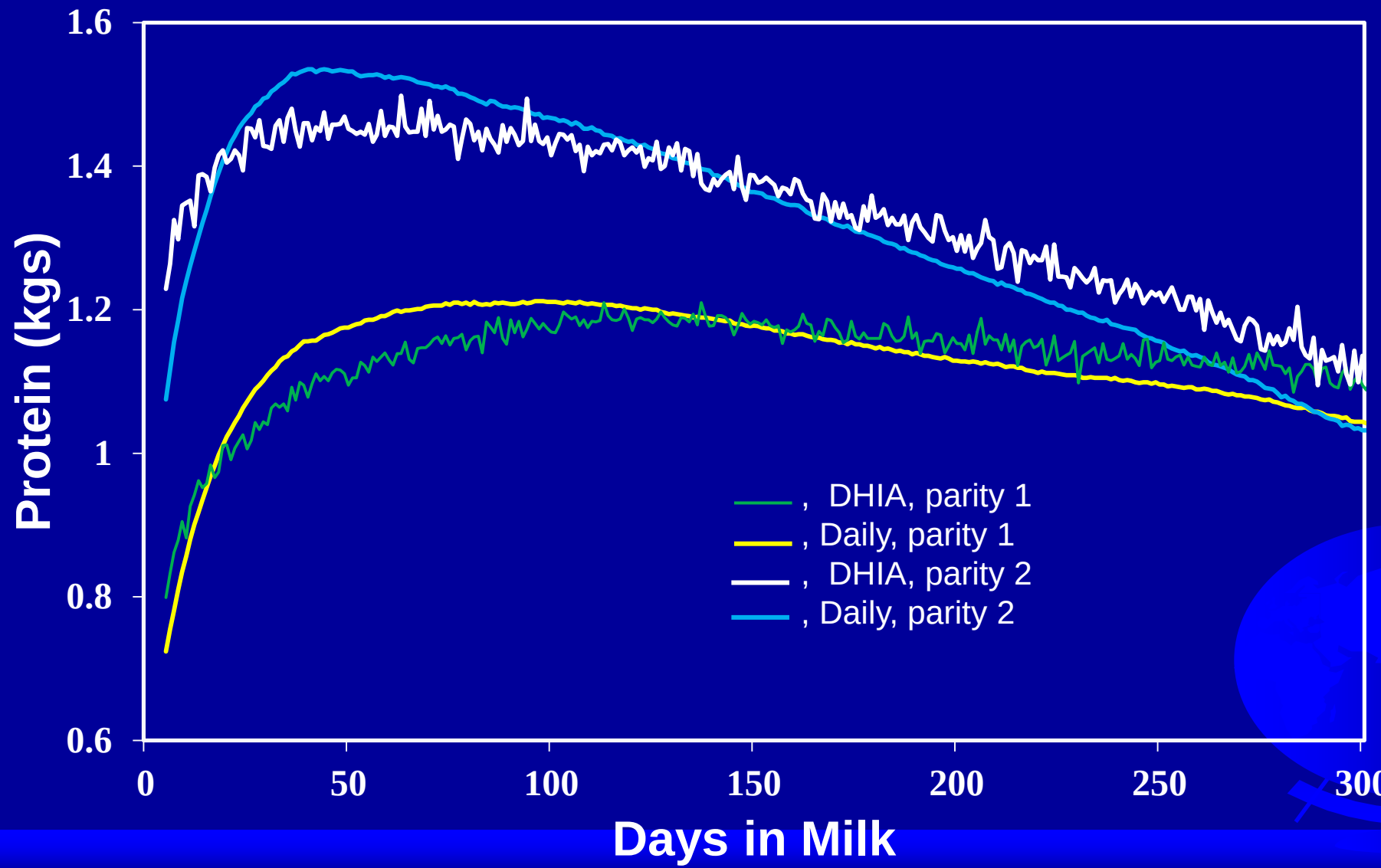
First and second parity lactations curves for milk production



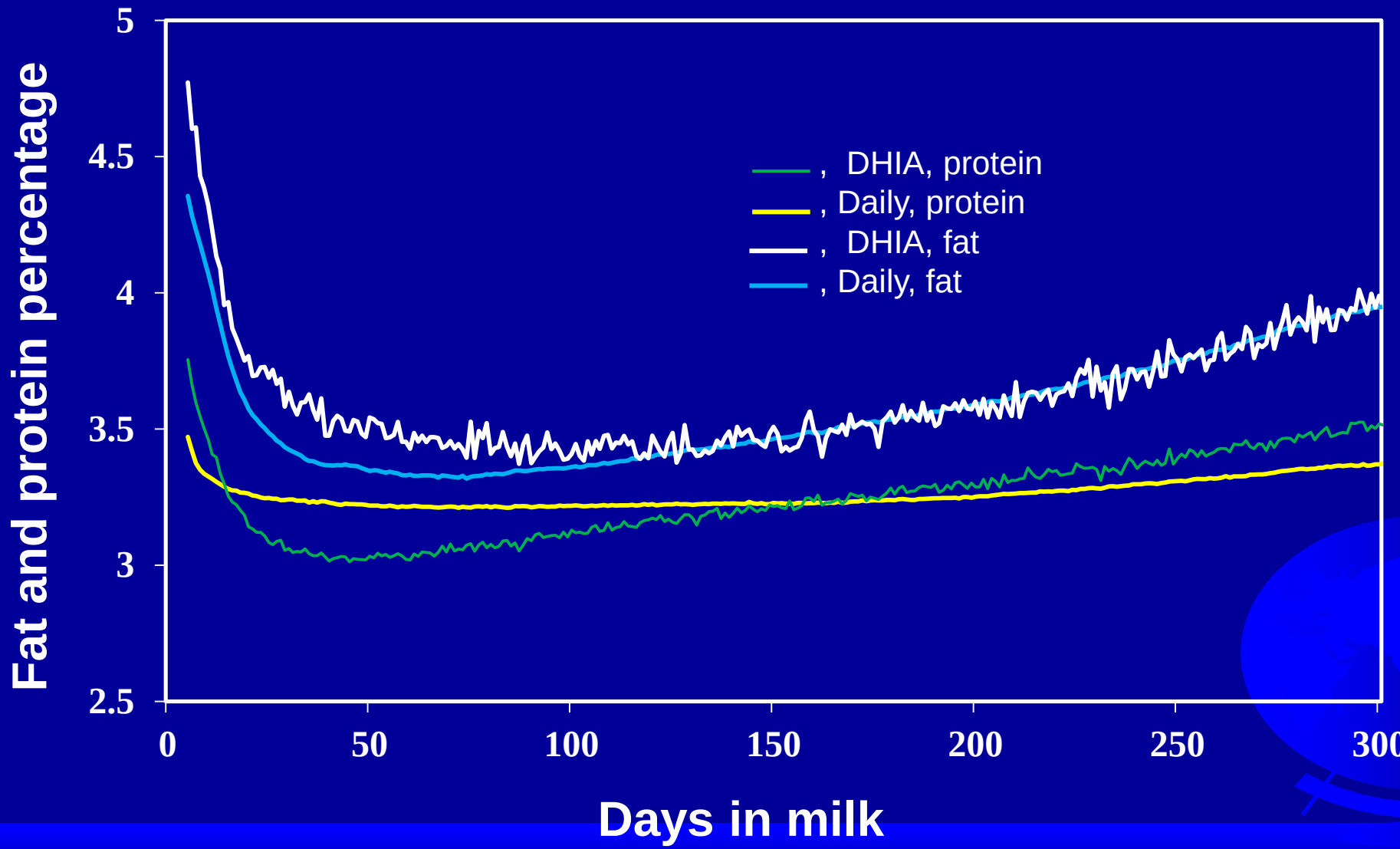
First and second parity lactations curves for fat production



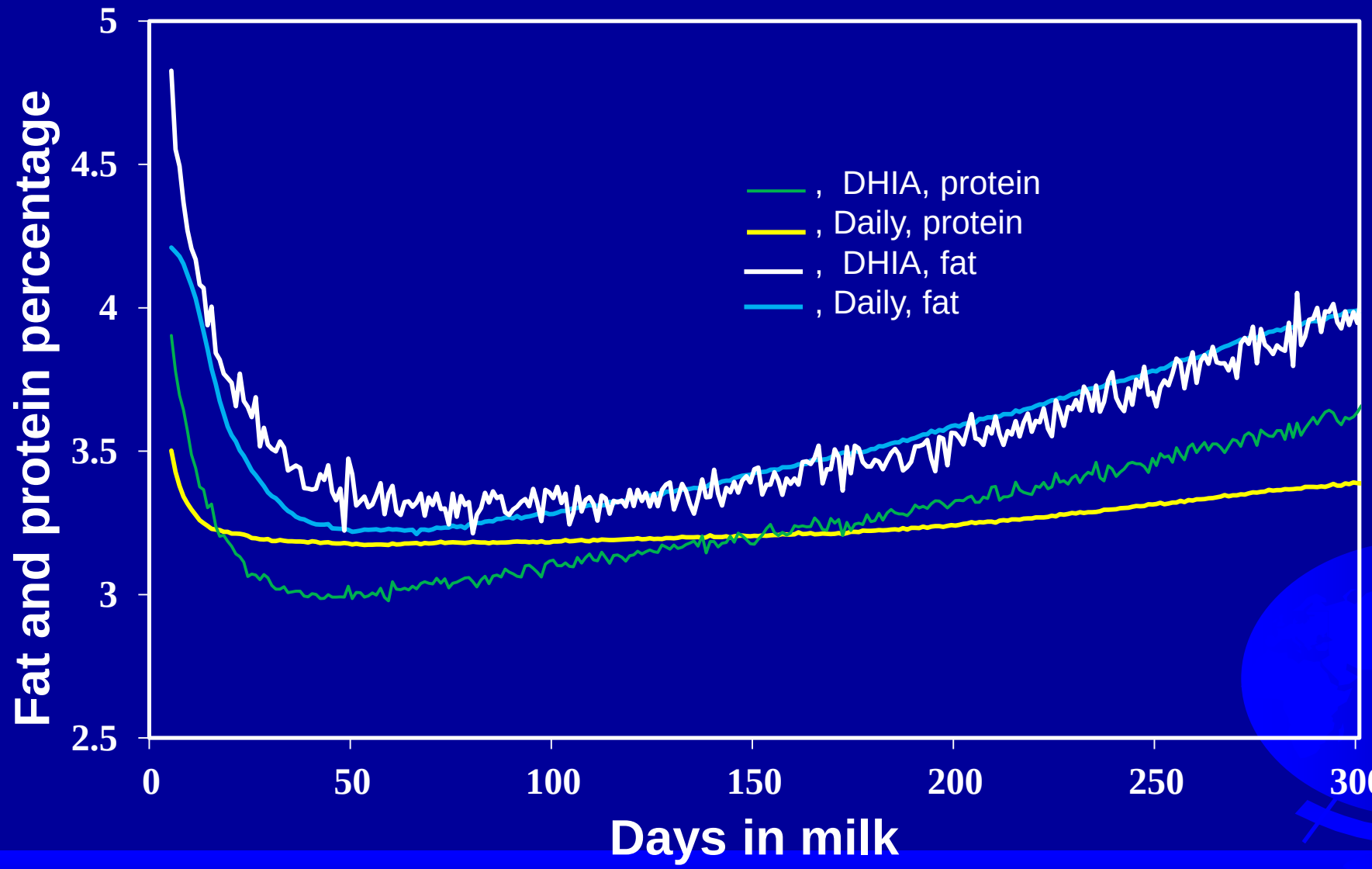
First and second parity lactations curves for protein production



First parity lactation curves for fat and protein percentage



Second parity lactation curves for fat and protein percentage



Heritabilities and genetic and environmental correlations among 7,866 first parity 305 d lactations computed from the DHIA and DMS records.

Trait	Heritabilities		Correlations	
	DHIA	Daily	genetic	environmental
Milk (kg)	0.33	0.35	1.00	0.96
Fat (kg)	0.23	0.31	0.59	0.70
Protein (kg)	0.27	0.32	0.86	0.87
% fat	0.48	0.57	0.70	0.66
% protein	0.55	0.46	0.56	0.52

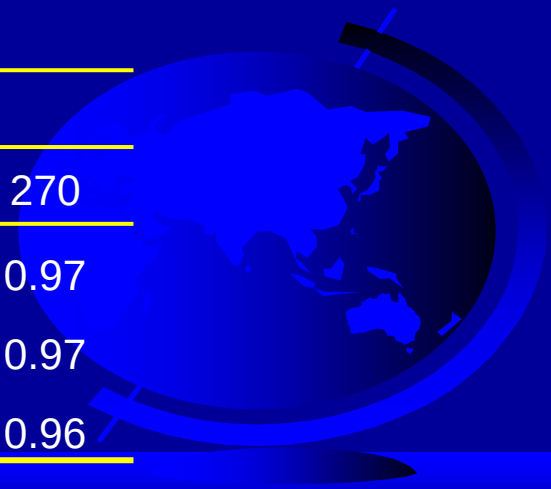
Heritabilities were higher for the Daily records for all traits, except for % protein.

Both genetic and environmental correlations were relatively low, except for milk.

Phenotypic correlations among complete and extended 7,892 first parity lactations computed from the last DHIA test day and the last two weeks of DMS records.

Factors based on last monthly date prior to truncation									
Trait	Mean days in milk at truncation								
	37.4	60.0	94.1	121.0	153.2	181.4	212.7	241.5	266.5
Milk	0.69	0.76	0.78	0.88	0.91	0.93	0.95	0.95	0.96
Fat	0.67	0.75	0.79	0.87	0.91	0.93	0.95	0.95	0.96
Protein	0.70	0.76	0.78	0.87	0.90	0.92	0.94	0.94	0.95

Factors based on last 2-week Daily recordings									
Trait	Mean days in milk at truncation								
	30	60	90	120	150	180	210	240	270
Milk	0.74	0.84	0.88	0.91	0.93	0.95	0.96	0.96	0.97
Fat	0.77	0.84	0.89	0.92	0.94	0.95	0.96	0.96	0.97
Protein	0.72	0.83	0.87	0.90	0.93	0.94	0.95	0.95	0.96



Genetic correlations among complete and extended 7,892 first parity lactations computed the last two weeks of DMS records.

Factors based on last 2-week Daily recordings									
Trait	Mean days in milk at truncation								
	30	60	90	120	150	180	210	240	270
Milk	0.74	0.91	0.95	0.97	0.98	0.98	0.98	0.98	-
Fat	0.79	0.91	0.94	0.98	0.98	0.98	0.97	0.98	-
Protein	0.73	0.92	0.94	0.97	0.98	0.97	0.97	0.97	-

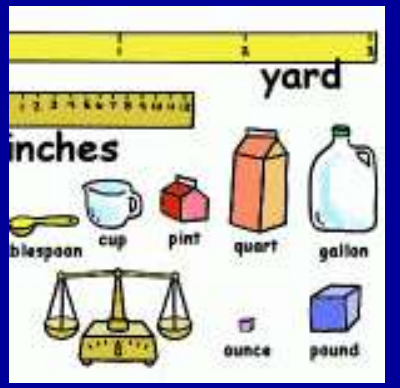
The daily genetic correlations were higher than the phenotypic correlations for all 3 traits at all truncation points.

With only 30 DIM genetic correlations ranged from 0.73 to 0.79 for the 3 traits.

General conclusions

- Daily results underestimated fat production prior to 125 DIM, but were nearly equal to the monthly results after 125 DIM.
- Daily results overestimated protein percentage prior to 150 DIM, and underestimated protein percentage in the second half of the lactation.
- First parity heritabilities were higher for DMS lactations for all traits, except for protein percentage.
- DMS partial lactations with < 150 DIM predicted future lactation more accurately than the corresponding DHIA partial lactations.

Further considerations



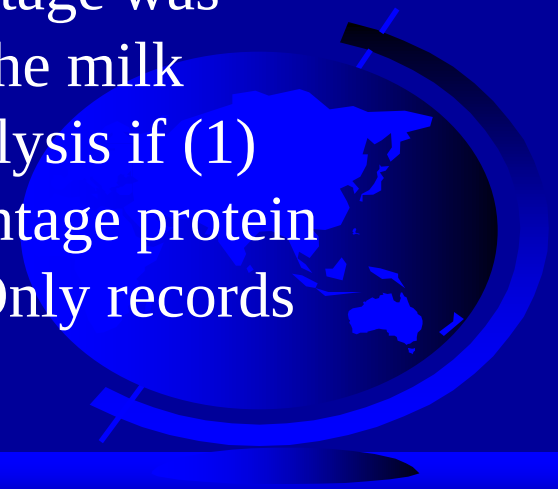
- Further study is required in order to compare results of individual cows on multiple lactations, and to determine the optimum interval between calibrations for DMS meters.

- A current study is dealing with the optimum interval between calibrations for DMS meters.

Thank you

MATERIALS AND METHODS

Calibration of the automatic recording units against the standard ICBA milk recording system was done at least once for each six-month period, and at least 7 cows were used for calibration of each unit. Daily milk production was the sum of production for the 3 milkings beginning with the morning milking of each day. Daily fat and protein percentage was computed as the means of the 3 milking records weighted by the milk production of each milking. Records were included in the analysis if (1) DIM > 4 and < 306, (2) percentage fat >1.0 and < 8, (3) percentage protein >1.0 and < 7 and (4) daily milk production > 5 and < 80 kg. Only records that met all 4 criteria were retained.



AfiLab vs. monthly records, basis for comparison

- Production on the test days and complete lactation production as estimated by the ICBA monthly test days records and the AfiLab daily records were compared.
- Lactation curves for all 5 milk production traits were compared.
- Heritabilities were estimated for first parity milk, fat and protein production and fat and protein percentage.
- Predictors of complete lactation production from partial lactations were computed by the AfiLab records, and compared to the same statistics derived from monthly test day records.

Conclusions with respect to daily production

- Differences between the means were very small for all traits, but this is partially a function of the calibration of the meters.
- Overall the SD for the two methods were quite similar. The biggest difference was for fat percentage.
- The correlations for fat and protein production were higher than for fat and protein percentage.

Conclusions with respect to 305 d lactation production

- ICBA mean fat production and percentage were higher than the corresponding AfiLab means in both parities.
- All correlations between the lactations were higher than the correlations between the records for daily production.
- Correlations for first and second parity were nearly identical for all traits.
- As found for the daily records, correlations were higher for fat and protein production, as compared to fat and protein percentage.
- Correlations for fat and protein production were 0.77 and ~0.9 in both lactations.

Conclusions with respect to the lactations curves for the production traits

- For milk production the curves by the two methods are very similar for both parities, except that the ICBA curves display more random variation, due to the lower number of records on each date.
- For both parities ICBA graphs for fat were higher prior to 125 DIM, but very similar from 125 through 305 DIM.
- For both parities the AfiLab records overestimate protein production in the early part of the lactation, and underestimate production after 150 DIM.

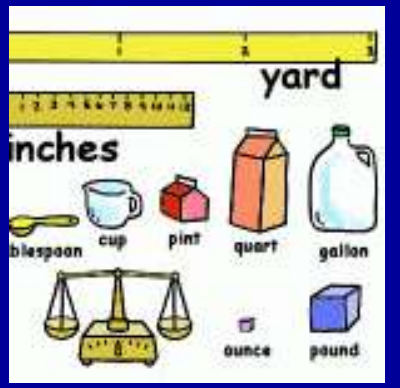
Conclusions with respect to the lactations curves for fat and protein concentration

- The Afilab results underestimate fat percentage in the early part of the lactation, but are very similar to the ICBA results after 125 DIM.
- The AfiLab results overestimate protein percentage in the first part of the lactation, but underestimate protein percentage after 150 DIM.
- These results can be partially explained by the finding of Kaniyamattam and De Vries (2014) that "AfiLab slightly overestimated low Bentley components and underestimated high Bentley components."

Conclusions from extended lactations

- The AfiLab phenotypic correlations are higher than the ICBA correlations for all 3 traits at all 9 truncation points, even though DIM at truncation was lower for the AfiLab records.
- The AfiLab genetic correlations were higher than the phenotypic correlations for all 3 traits at all truncation points (not shown).
- With only 30 DIM genetic correlations ranged from 0.73 to 0.79 for the 3 traits.

Further considerations



- In the last two decades several countries have replaced lactation models with test day models for routine genetic evaluation of milk production traits The main advantages of these models are that they are able to more correctly weight complete vs. incomplete lactations.
- If daily recording becomes widespread, it would seem that test day models would no longer be appropriate, and new methods must be developed to accurately weight partial vs. complete lactations for genetic evaluations.
- Further study is required in order to compare results of individual cows on multiple lactations, and to determine the optimum interval between calibrations for AfiLab meters.