UDK 637.07.

MILK RECORDING METHODS: EFFECTS ON PHENOTYPIC VARIATION OF LACTATION RECORD

R. Aleandri, A. Tondo

1. Introduction

All countries are moving towards low-cost milk data collection. This aim is essentially reached when the Recording Officer goes to byres as less as possible. The risk of reducing the number of observed milkings (i.e. increasing the number of estimated milkings) is the loss of accuracy in the calculation of the whole lactation curve. Automation of milking parlours (electronic lactometers) and usage of automatic milking systems (robots) will solve the problem of milk production, not fat and protein (not yet). During the last 5 years (1998-2002), Italy has passed from 22% to 30% of farms utilising AT method. Other official milk recording methods are available in order to reduce costs.

The aim of the work is to provide an evaluation of accuracy level both for the test day and the calculation of lactation curve using different milking methods.

2. Controlled population and milk recording methods

In Italy there have been 24.394 recorded dairy herds in 2002, with 1.340.118 recorded dairy cows. Official ICAR approved milk recording methods have been codified in Italy as follows (CTC resolution, newsletter n32 - 29/11/99):

Verification Performer	cod	n.contr. milkings	cod	Verification rate	cod	Milk sample	cod	Milking estimate	cod	n. of milkings	cod
Officer	A	All	b*	Every 4 weeks	4	From 1 milking	U	Doubling	Y	one	1
Breeder	B	One	T	Every 6 weeks	6	From all milkings	P	By coefficients	F	two	2
Breeder and Officer	C							Tank comparison	K	>2	3
								By the system (lactometer)	J	robot	R

*= blank

The distribution of dairy herds and cows in Italy by milk recording method is the following:

Table 1. - MILK RECORDING METHOD DISTRIBUTION OF DAIRY HERDS AND COWS - ITALIAN SITUATION - YEAR 2002

| Recording method	DAIRY CATTLE			
	N. HERDS	N. COWS	% HERDS	% COWS
A4P2	6.736	483.938	28	36
A4U2	3.959	445.954	16	33
A6P2	6.120	120.148	25	9
A6U2	251	9.770	1	1
ATU1	7.328	280.308	30	21
TOTAL	24.394	1.340.118		

The prevailing milk recording method for dairy cattle is still A4 (44% of herds and 69% of cows). In the last 7 years the trend is towards a drop of the overall number of recorded herds (-9% from 1996 to 2002) with a growth of the number of recorded cows (+14% from 1996 to 2002). The average number of cows per herd has passed from 44 to 55, following a constant growing trend.

Table 2. - RECORDED HERDS AND COWS 1996-2002.

Year	Italy			Trend of average number of cows per herd - Italy
	N. herds	N. cows	Aver. n. of cows	
1996	26.688	1.173.089	43,96	
1997	26.630	1.199.814	45,05	
1998	26.141	1.199.114	45,87	
1999	25.962	1.242.090	47,84	
2000	25.584	1.264.907	49,44	
2001	24.976	1.290.423	51,67	
2002	24.394	1.340.118	54,94	

Source: AIA

Trend of average number of cows per herd - Italy
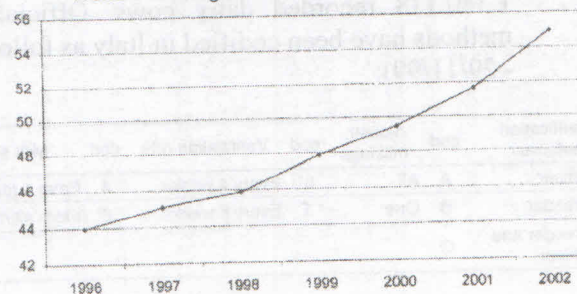
Most of the European countries have a trend towards a drop of the overall number of recorded herds (Source: ICAR): Switzerland, Austria, Netherlands, Denmark, Belgium, France and Germany have a decrease of herds. Not all countries make up this loss with an increase of the number of cows, as it is the case of Germany, Switzerland and Netherlands (see table 3).

Table 3. - NUMBER OF RECORDED HERDS AND COWS IN EUROPEAN COUNTRIES WITH MORE THAN 1.000.000 COWS + USA

| YEAR	FRANCE			NETHERLANDS			GERMANY			USA		
	HERDS	COWS	Av. num.	HERDS	COWS	Av. num.	HERDS	COWS	Av. num.	HERDS	COWS	Av. num.
1998	69.546	2.694.521	38,74	24.675	1.302.117	52,77	92.099	3.845.050	41,75	38.920	4.446.460	114,25
1999	69.520	2.740.692	39,42	23.640	1.293.329	54,71	89.110	3.741.016	41,98	34.820	4.182.171	120,11
2000	68.911	2.757.817	40,02	22.640	1.235.501	54,57	83.176	3.669.222	44,11	33.539	4.287.085	127,82

Source: ICAR; France Contrôl Laitier

Table 4. - STOCK VARIATION IN EUROPEAN COUNTRIES WITH MORE THAN 1.000.000 COWS + USA

YEAR	HERDS					COWS				
	FRANCE	N.LANDS	GERMANY	ITALY	USA	FRANCE	N.LANDS	GERMANY	ITALY	USA
1998	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
1999	99,96	95,81	96,75	99,33	89,47	101,71	99,33	97,29	103,58	94,06
2000	99,09	91,75	90,31	97,87	86,17	102,35	94,88	95,43	105,49	96,42

Source: ICAR; France Contrôl Laitier

Recorded herds trends in European countries with more than 1.000.000 cows + USA
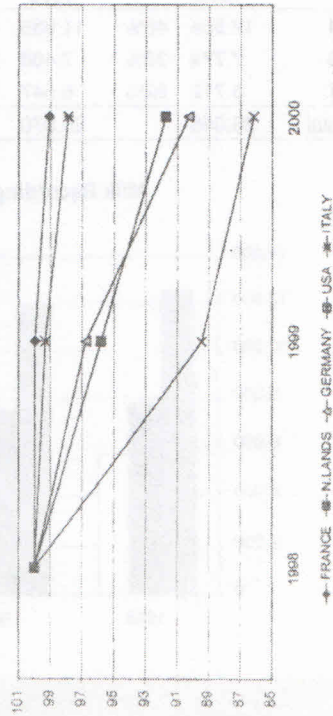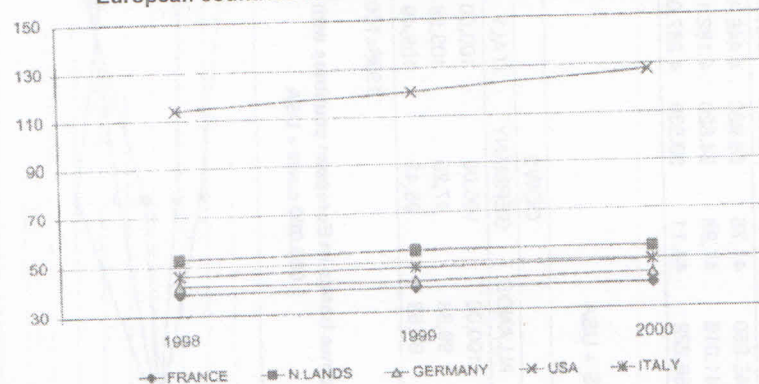
Note: year 1998=100

Recorded cows trends in European countries with more than 1.000.000 cows + USA
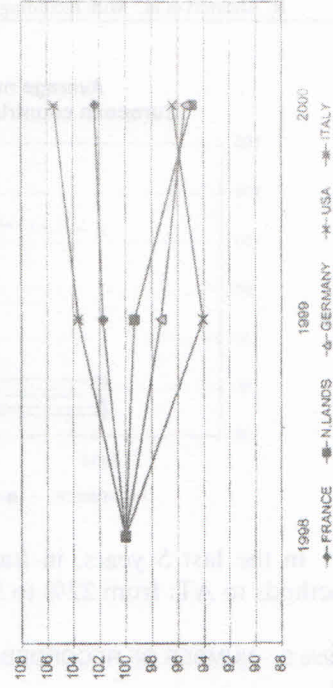
1998=100

Average number of cows per herd trends In
European countries with more than 1.000.000 cows + USA

— FRANCE   — N.LANDS   —△— GERMANY   —✖— USA   —✱—ITALY

In the last 5 years, in Italy there has been a shift from A4/A6 recording methods to AT: from 22% to 30% of herd using AT method (see Table 5).

Table 5. - NUMBER OF RECORDED HERDS TRENDS BY MILK RECORDING METHOD - ITALY

	1998		1999		2000		2001		2002	
A4	12.554	48%	11.855	46%	11.345	45%	10.912	44%	10.695	44%
A6	7.779	30%	7.468	29%	6.992	27%	6.799	27%	6.371	26%
AT	5.712	22%	6.547	25%	7.152	28%	7.224	29%	7.328	30%
Total	26.045		25.870		25.489		24.935		24.394	

Milk Recording Methods - N. of herds - Last 5 years

▪ A4   ▪ A6   ☐ AT
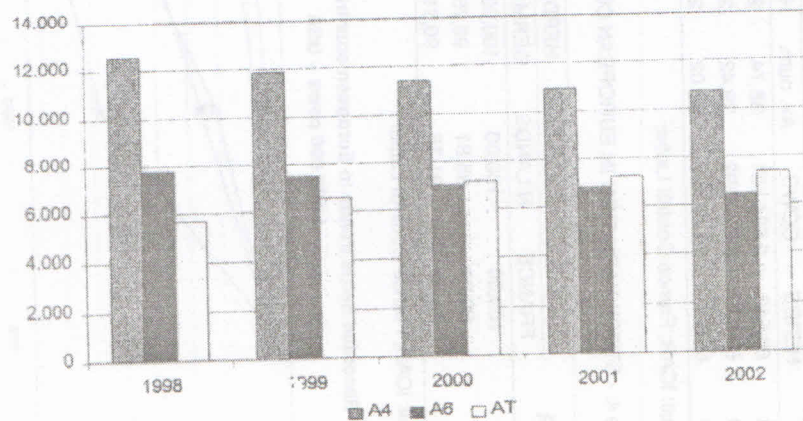
Milk Recording Methods - % of herds - Last 5 years
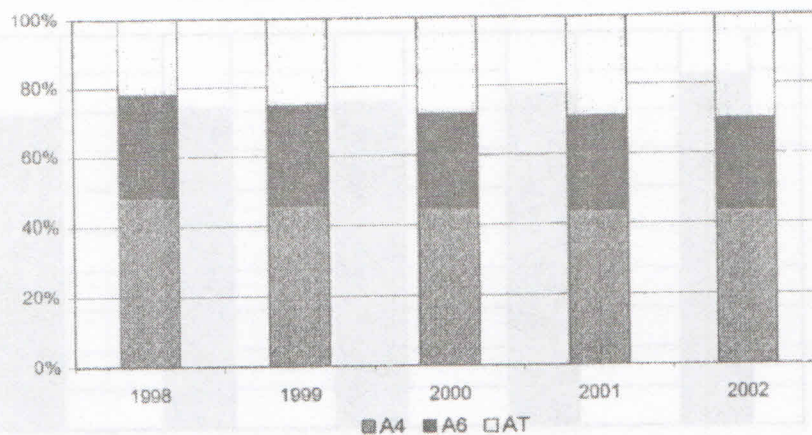
Table 6. - NUMBER OF RECORDED COWS TRENDS BY MILK RECORDING METHOD - ITALY

	1998		1999		2000		2001		2002	
A4	917.293	77%	908.100	73%	898.738	71%	893.773	69%	929.892	67%
A6	141.480	12%	140.781	11%	136.592	11%	146.433	11%	129.918	10%
AT	139.169	12%	191.999	15%	228.354	18%	249.865	19%	280.308	23%
Total	1.197.942		1.240.880		1.263.684		1.290.071		1.340.118	

Milk Recording Methods - N. of cows - Last 5 years
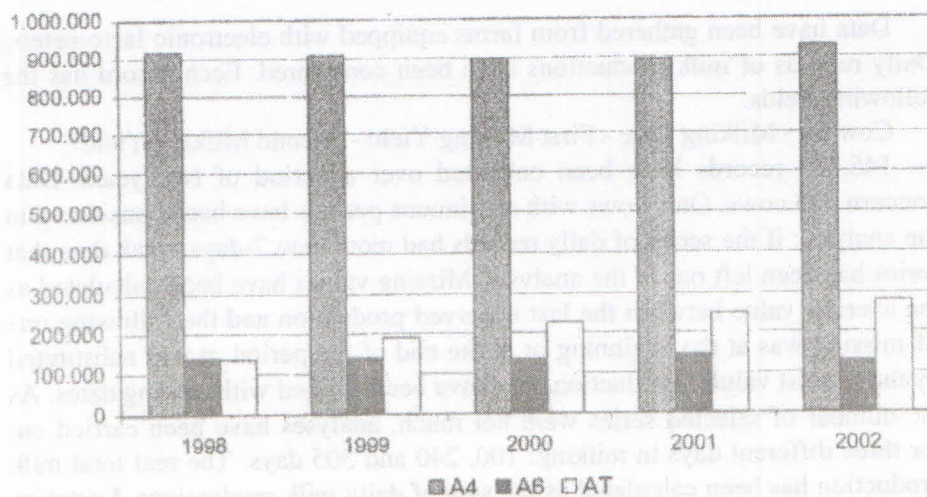
Milk Recording Methods - % of cows - Last 5 years
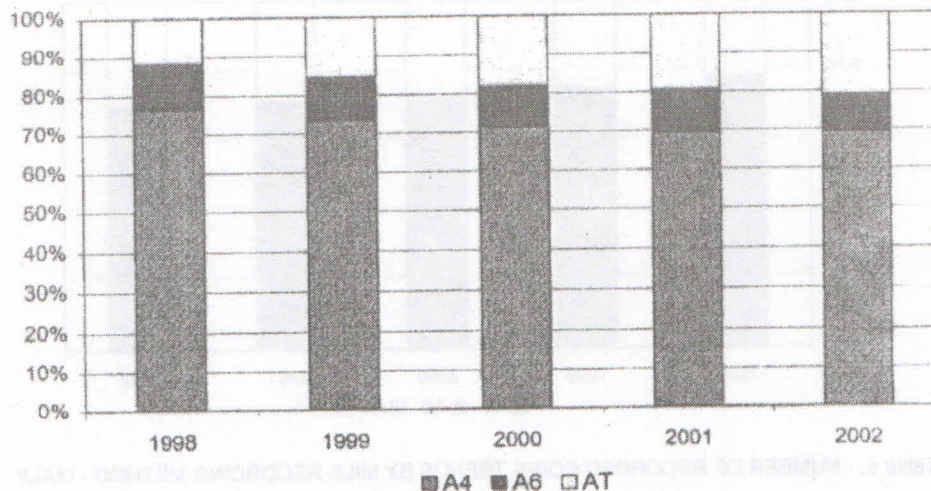
3. Accuracy of milk recording methods

The accuracy of the test day estimate and the accuracy of the lactation curve estimate will be discussed separately.

3.1 Lactation curve estimate

Data have been gathered from farms equipped with electronic lactometers. Daily records of milk productions have been considered. Each record has the following fields:

Cow ID - Milking Date - First Milking Yield - Second Milking Yield

146.306 records have been collected over a period of two years. Data concern 833 cows. Only cows with continuous periods have been considered in the analysis: if the series of daily records had more than 7-days break then that series has been left out of the analysis. Missing values have been calculated as the average value between the last observed production and the following one (if missing was at the beginning or at the end of the period, it was substituted by the nearest value). Production data have been merged with calving dates. As the number of selected series were not much, analyses have been carried out for three different days in milking: 100, 240 and 305 days. The real total milk production has been calculated as the sum of daily milk productions. Lactation

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curve estimates have been calculated with the interpolation method. The result of the selection is the following:

171 cows with 100 days in milking, 66 cows with 240 days in milking, 30 cows with 305 days in milking,

The following milk recording methods have been verified (coding is referred to the table at the beginning of the paper):

A4 = AT4J (these two methods return the same information)

AT4

A6 = AT6J (these two methods return the same information)

AT6

BJ0 - data collected every day (i.e. real production)

BJ1 - data collected one day per week

BJ2 - data collected one day every 4 weeks (i.e. 4-weeks interval)

A simulation of different methods has been carried out with the available series.

The estimated total production value (100, 240 or 305 days) depends on which are the sampled days. The value considered as representative of the estimate is the average and the standard deviation of calculated values.
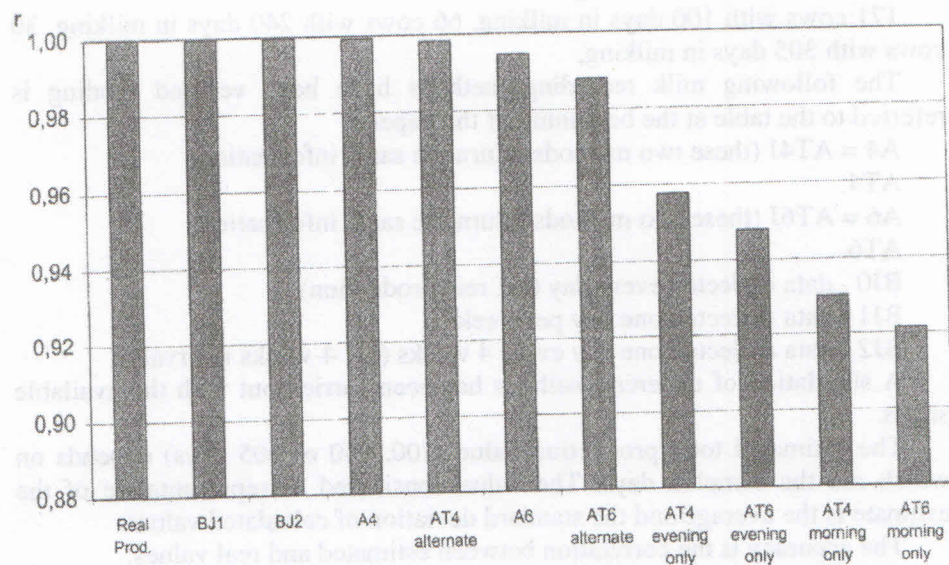
The accuracy is the correlation between estimated and real values.

In graphs 1, 2 and 3 accuracies of different milk recording methods are shown, 100, 240 and 305 days respectively. Graphs 4, 5 and 6 show the error term of the estimates (real - estimated values).
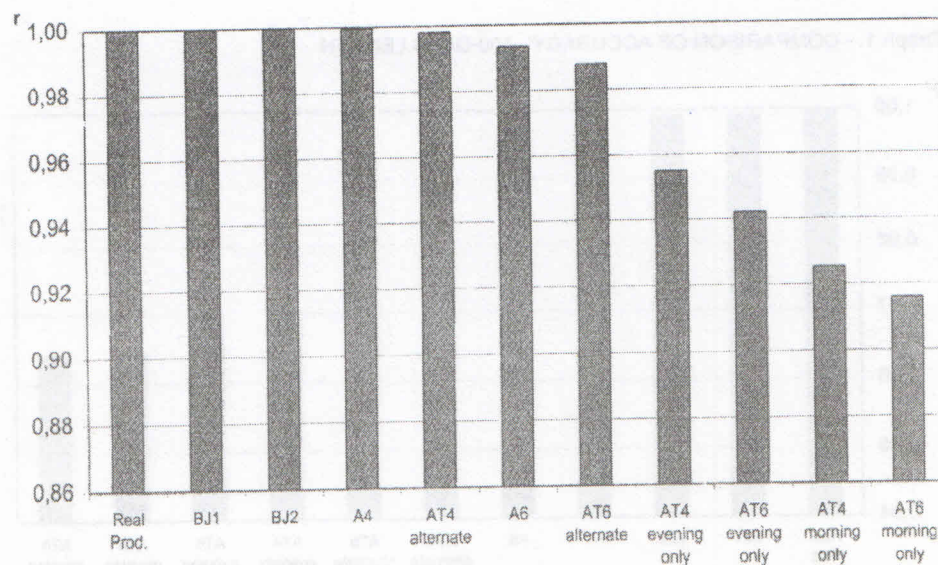
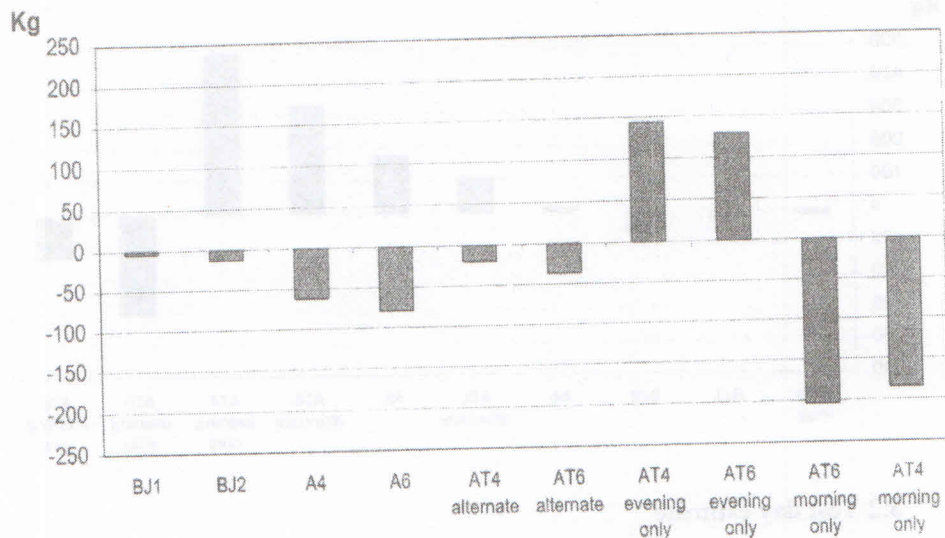Graph 1. - COMPARISON OF ACCURACY - 100-DAYS LENGTH
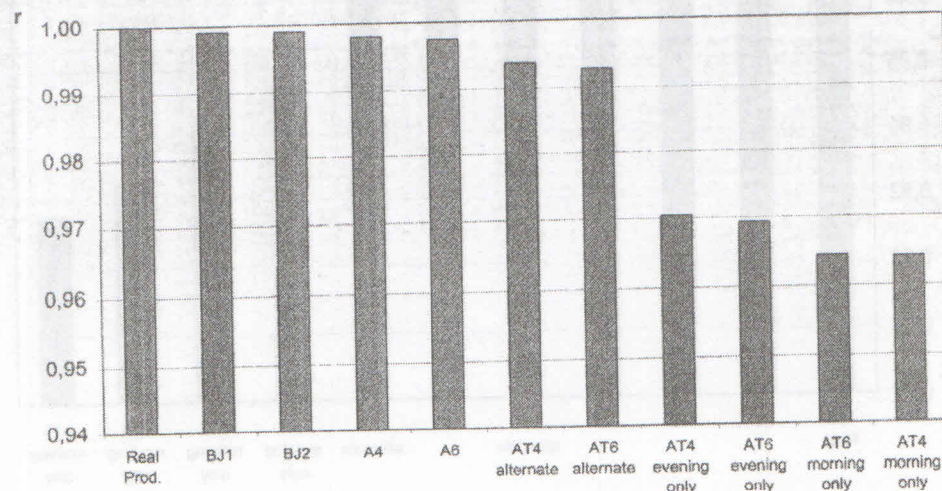
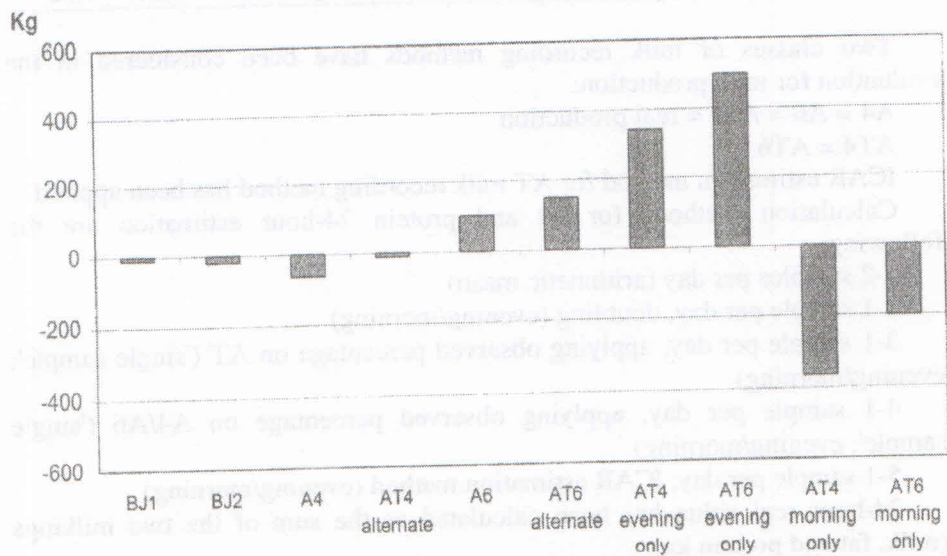Graph 2. - COMPARISON OF ACCURACY - 240 DAYS LENGTH

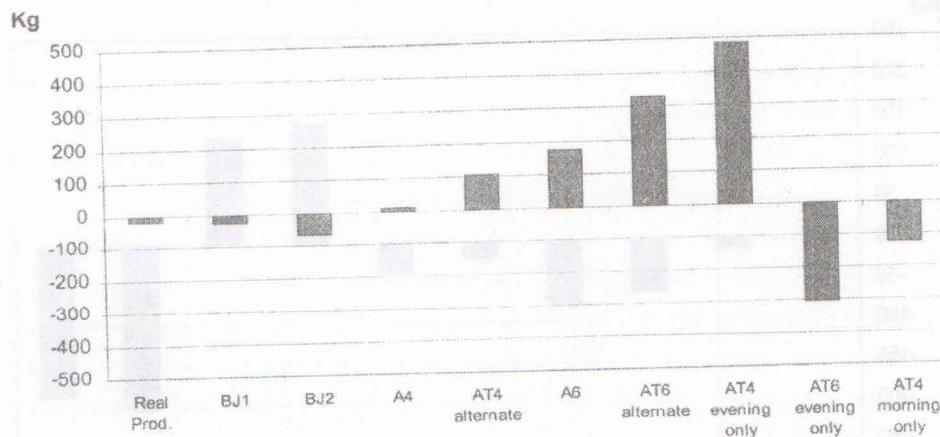Graph 3. - COMPARISON OF ACCURACY - 305 DAYS LENGTH

Graph 4. - ERROR COMPARISON -100 DAYS LENGTH (METHODS ARE IN ACCURACY DESCENDING ORDER)

Graph 5. - ERROR COMPARISON - 240 DAYS LENGTH (METHODS ARE IN ACCURACY DESCENDING ORDER)

Graph 6. - ERROR COMPARISON - 305 DAYS LENGTH (METHODS ARE IN ACCURACY DESCENDING ORDER)

3.2 Test day estimate

15.539 daily records have been used. Each record has the following fields:

		First milking				Second milking			
Cow ID	Date	Milk kg.	Fat %	Prot %	time	Milk kg.	Fat %	Prot %	Time

Two classes of milk recording methods have been considered in the evaluation for milk production:

A4 = A6 = ATJ = real production

AT4 = AT6

ICAR estimation method for AT milk recording method has been applied.

Calculation methods for fat and protein 24-hour estimation are the following:

1-2 samples per day (arithmetic mean)

2-1 sample per day, doubling (evening/morning)

3-1 sample per day, applying observed percentage on AT ('single sample'; evening/morning)

4-1 sample per day, applying observed percentage on A4/A6 ('single sample'; evening/morning)

5-1 sample per day, ICAR estimation method (evening/morning)

24-hour real value has been calculated as the sum of the two milkings (milk, fat and protein kg).

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Here is a brief description of calculation methods for fat and protein.

1-2 samples per day, arithmetic means - arithmetic average of morning and evening fat and protein kg. This method has been used in order to consider the case when the test tubes are not proportionally filled but 50% filled.

2-1 sample per day, doubling - fat and protein kg are multiplied by 2, either morning or evening kg.

3-1 sample per day, applying observed percentage on AT ('single sample') - the percentage of fat and protein, either morning or evening, is applied to the estimated 24-hours milk production (ICAR coefficients estimate).

4-1 sample per day, applying observed percentage on A4/A6 ('single sample') - the percentage of fat and protein, either morning or evening, is applied to the real 24-hours milk production.

5 - 1 sample per day, ICAR estimation method – 24-hours fat and protein kg are estimated by the application of coefficients (ICAR method[1]).

Table 7 shows errors (Kg) between real and estimated values of test day.

Table 7. - DEVIATION FROM REAL VALUE OF FAT AND PROTEIN

FAT ERROR

Code of milking recording method	MEAN	STD DEV	MIN	MAX
1	-0,000181	0,012064	-0,1764	0,22425
2 - MORNING	-0,033591	0,139702	-1,11357	0,96638
2 - EVENING	0,033591	0,139702	-0,96638	1,11357
3 - MORNING	-0,014705	0,133697	-1,01193	0,989378
4 - MORNING	0,005578	0,104346	-0,77748	0,8588
3 - EVENING	-0,006242	0,14429	-0,95544	1,079282
4 - EVENING	-0,005939	0,114365	-0,96728	0,90216
5 - MORNING	-0,007932	0,124063	-0,75552	1,031001
5 - EVENING	0,014918	0,156787	-0,56561	0,982422

PROTEIN ERROR

| Code of milking recording method	MEAN	STD DEV	MIN	MAX
1	-0,000096	0,00362	-0,08991	0,06695
2 - MORNING	-0,033749	0,081749	-0,5745	0,67938
2 - EVENING	0,033749	0,081749	-0,67938	0,5745
3 - MORNING	-0,016728	0,076845	-0,56676	0,704919
4 - MORNING	0,001394	0,03048	-0,37392	0,29458
3 -EVENING	-0,002344	0,087119	-0,57041	0,56186
4 - EVENING	-0,001588	0,033382	-0,40338	0,456
5 - MORNING	-0,010082	0,074991	-0,57211	0,697107
5 - EVENING	0,004685	0,102013	-0,49283	0,558137

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[1] ICAR guidelines - Section 2.1.4: "The AM/PM milkings and the T and C Methods".

Graphs 7, 8, and 9 show correlations between real 24-hour value and estimations, milk, fat and protein estimates. Graphs 10,11 and 12 show the error term (real - estimated values).
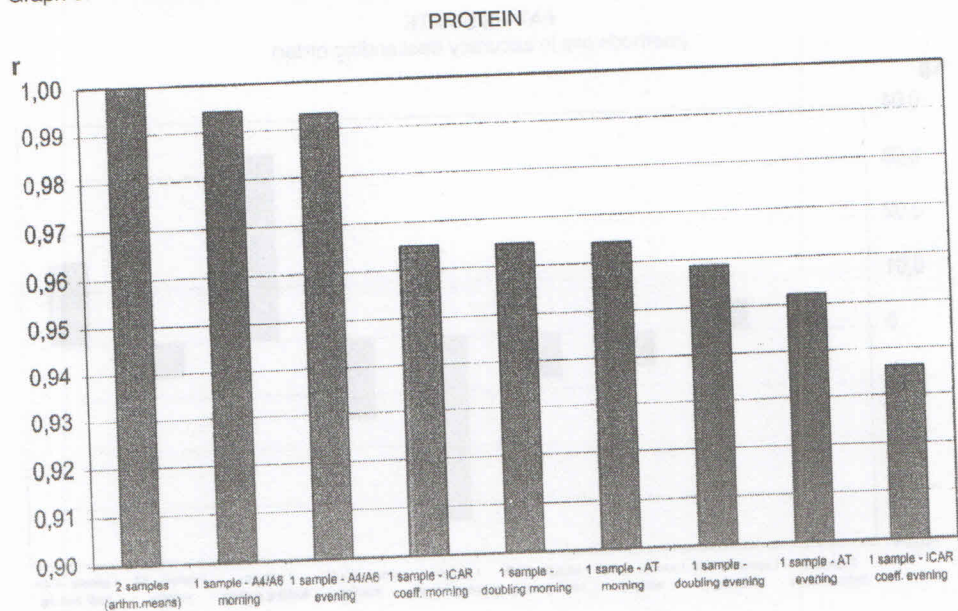
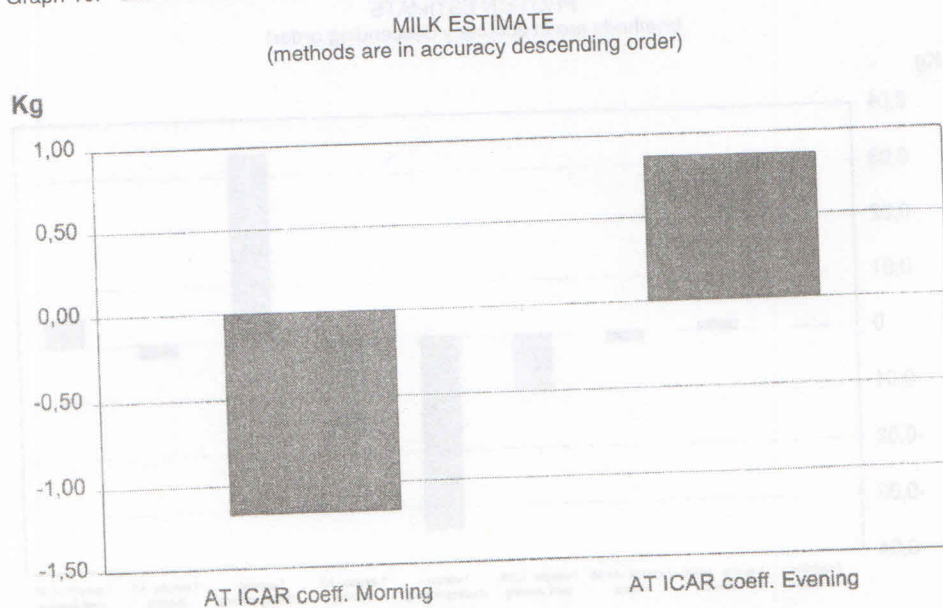Graph 7. - COMPARISON OF ACCURACY - DAILY RECORDING METHODS

MILK
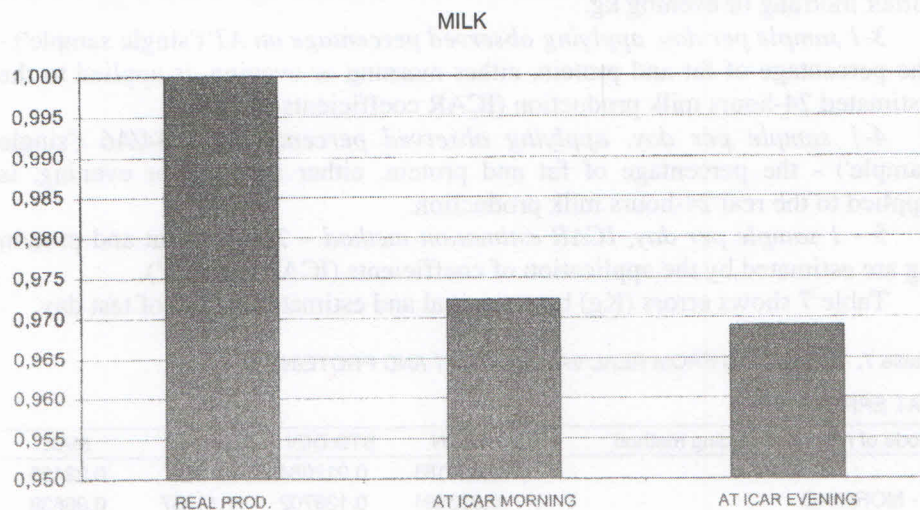
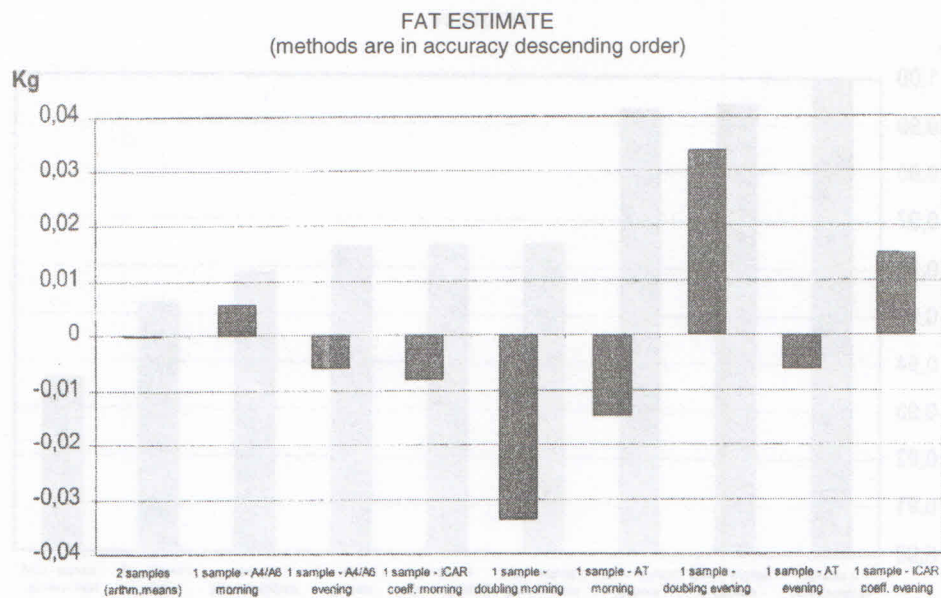Graph 8. - COMPARISON OF ACCURACY - DAILY RECORDING METHODS

FAT
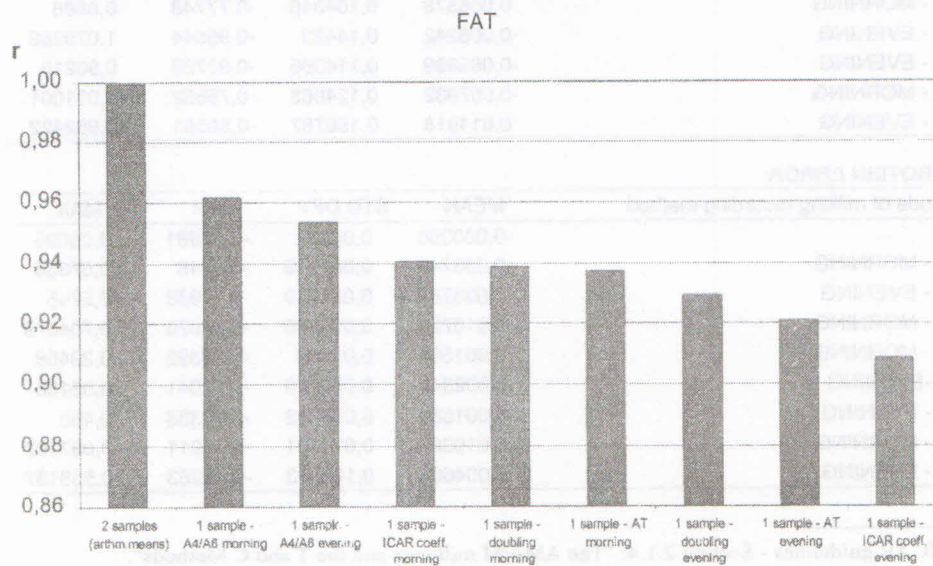
Graph 9. - COMPARISON OF ACCURACY - DAILY RECORDING METHODS

PROTEIN

Graph 10. - ERROR COMPARISON - DAILY RECORDING METHODS

MILK ESTIMATE
(methods are in accuracy descending order)

Graph 11. - ERROR COMPARISON - DAILY RECORDING METHODS

FAT ESTIMATE
(methods are in accuracy descending order)

Kg

Graph 12. - ERROR COMPARISON - DAILY RECORDING METHODS

PROTEIN ESTIMATE
(methods are in accuracy descending order)

Kg

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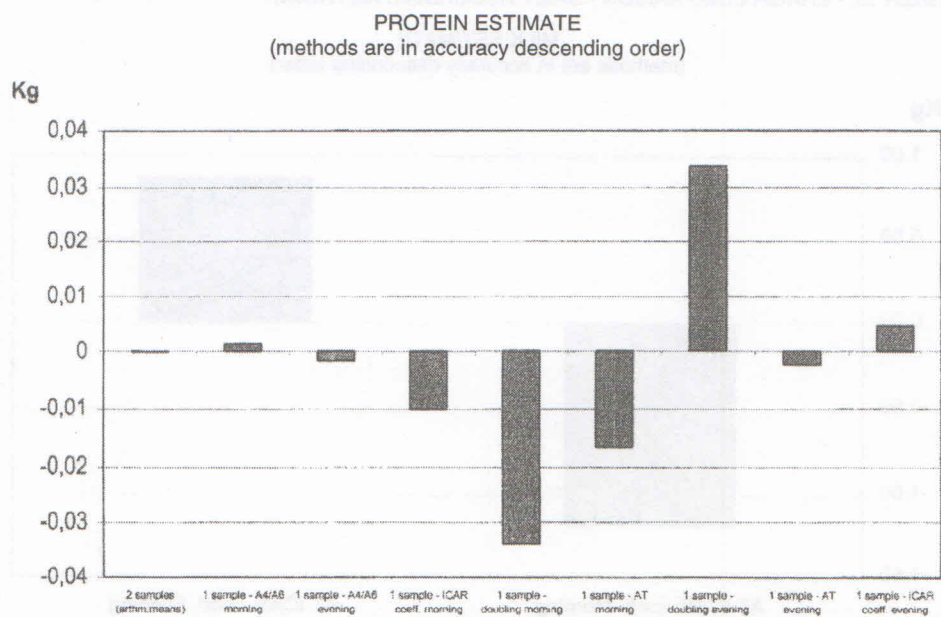
MILK Modelling

The following model has been verified:

$$y = \mu + DRM_i + Month\ of\ Calving + Parity + DIM + e$$

where:

DRM_i = Daily Recording Method

Month of Calving = 1, ...,12

Parity = 1,2,3+

DIM = Days In Milking (1 month classes)

e = error term

y = (real 24-hour milk - estimated 24-hour milk)

Results:

All considered factors are significant in order to explain the y variability, y means are significantly different among them.

FAT and PROTEIN Modelling

$$y = \mu + DRM_i + Parity + DIM + e$$

where:

DRMi = Daily Recording Method

Parity = 1,2, 3+

DIM = Days In Milking (1 month classes)

e = error term

y = (real 24-hour fat/protein - estimated 24-hour fat/protein)

Results:

All considered factors are significant in order to explain the y variability, y means are significantly different among them.

4. *Conclusions*

All milk recording methods have good accuracy with respect to the real milk, fat and protein production. When the total milk yield is considered (lactation curve) all methods have an accuracy greater then 98%. The exiguous number of curves urges to gather new data for farther analyses. With regard to the test day data, different methods have different level of accuracy even though all of them are higher than 92% for protein and 91% for fat. One suggestion is that if 2 milkings are observed (i.e. milk yield is the real one - A4/A6/ATJ method) and only one sample is taken, the best fat and protein estimate is the so called 'single sample' (marked with 4 and 5 in the test day coding), that is fat and protein percentage of the sample is applied to the daily

milk yield. Milk results on test day suggest a loss of about 3% accuracy when method shifts from 2 milkings observed (A4/A6) to 1 milking observed (AT).

In Italy, about 190.000 recorded cows live in a herd equipped with electronic lactometers (source: AIA). It is then possible, in these herds, to apply ATJ milk recording methods, that is the recording method where one milking is official officer assisted (with milk sample) and the remaining milking is system acquired. The accuracy of the daily estimate with this method is 1.00; 0.95; 0.99 for milk, fat and protein respectively. In a short time, then, all cows in herds equipped with electronic lactometers could adopt the most accurate of AT methods and the lowest-cost of not-B methods, that is the ATU1J method (see methods description at the beginning of the paper). At the moment, in Italy, 15% of controlled cows population can already be controlled with ATJ milk recording method. This percentage is bound to grow in the next years as technology will spread.

A change from A4 to AT recording method do not reduce accuracy of a great deal, so herds without electronic lactometers can change their recording methods to AT if the AM/PM alternation is carried out.

Recording methods with 6 weeks interval (A6/AT6) can be also applied to herds where official controls are particularly hard to carry out without a big reduction of accuracy with recpect to 4-weeks interval methods.

BIBLIOGRAPHY

1. ICAR guidelines (30 May 2002 approval), Section 2.1 - *The AM/PM milkings and the T and C Methods.*

2. Central Technical Committee resolution, newsletter n.32 - 29/11/99.

METODE MJERENJA MLIJEKA: DJELOVANJE NA FENOTIPSKU VARIJACIJU MJERENJA LAKTACIJE

Sažetak

Sve metode mjerenja mlijeka imaju dobru točnost u odnosu na stvarnu proizvodnju mlijeka, masnoće i bjelančevina. Kad razmatramo ukupan prinos mlijeka (krivulja laktacije) sve metode imaju točnost veću od 98%. Neznatan broj krivulja nameće potrebu sakupljanja novih podataka za dalje analize, u vezi s podatkom dana testiranja razne metode imaju različitu razinu točnosti iako su sve više od 92% za bjelančevine i 91% za masnoće. Jedan je prijedlog da ako se promatraju 2 mužnje (tj. prinos mlijeka je stvaran - metoda A4/A6/AT) i uzme se samo jedan uzorak, najbolja procjena masnoće i bjelančevina je tzv. "jedan uzorak" (ocijenjen s 4 i 5 u šifriranju dana testiranja) tj. postotak masnoće i bjelančevina uzorka primjenjuje se na dnevni prinos mlijeka. Rezultati

mlijeka na dan testiranja ukazuju na gubitak oko 3% točnosti kad se metoda praćenja pomakne od 2 mužnje (A4/A6) na jednu mužnju (AT).

U Italiji oko 190000 mjerenih krava živi u stadu opremljenom elektronskim laktometrima (izvor: AIA). Tada je moguće, u tim stadima, primijeniti ATJ metode mjerenja gdje jednu mužnju prati službena osoba (s uzorkom mlijeka) a ostalo se mlijeko dobiva sustavom za mužnju.

Točnost dnevne procjene pomoću ove metode je 1.00; 0.95; 0.99 za mlijeko, masnoću i bjelančevine. Tako se u kratkom vremenu za sve krave u stadu opremljenom elektronskim laktometrima mogu primijeniti najtočnije AT metode i najjeftinije ne-B metode, a to je ATUIJ metoda (pogledati opis metoda na početku članka).

U ovom času, u Italiji, 15% populacije kontroliranih krava može se već kontrolirati ATJ metodom mjerenja mlijeka. Ovaj postotak mora rasti sljedećih godina jer će se tehnologija razvijati.

Promjena od metode mjerenja od A4- na AT ne smanjuje točnost u većoj mjeri, pa stada bez elektronskog laktometra mogu promijeniti metode mjerenja na AT ako se provede AM/PM.

Metode mjerenja s razmakom od 6 tjedana (A6/AT6) mogu se također primijeniti na stada gdje se službena kontrola teško provodi, bez velikog smanjenja točnosti u odnosu na metodu razmaka od 4 tjedna.

Primljeno: 15. 10. 2003.