Greener Journal of Biological Sciences
Vol. 3(3), pp. 099-107, April, 2013
ISSN: 2276-7762; ICV: 5.99

DOI Link: http://doi.org/10.15580/GJBS.2013.3.021413460
http://gjournals.org/GJBS

Impact of Simplified Methods of Monthly and Twice Monthly Milk Recording on Genetic Parameter Estimates and Genetic Evaluation in Dairy Ewes Under a Low Input Production System

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ARTICLE INFO

Article No.: *021413460*
Type: *Research*
DOI: *10.15580/GJBS.2013.3.021413460*

Submitted: *14/02/2013*
Published: *28/04/2013*

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Keywords:
dairy ewes, genetic parameters, genetic evaluation, simplified milk recording

ABSTRACT

Sicilo-Sarde dairy flock test-day data were analyzed: 1) to check predicting ability of four alternate methods (AT) of milk recording, based on information from a single milking, two of them adjusted for the weight of the recorded milking in daily milk production (ATa) and two other usual methods without adjustment (ATu), and 2) to study their impact on the genetic estimates. Number of bimonthly test-day observations was 8219 (4323 monthly test-days), carried out between 1999 and 2009 from 303 ewes. Suitability of the simplified methods were evaluated by comparing their associated genetic estimates with those observed both in a reference plan, where the 2 daily milkings were recorded at two-weekly intervals (A_2), and in the official A_4 milk recording (monthly recording of the 2 daily milkings). Estimated milk yields were similar to those observed with the reference methods. They showed similar evolutions through the milking period. Phenotypic correlations between estimated and observed traits were high and positive, and their genetic correlations were equal to unity. Heritability and repeatability estimates associated to simplified methods were close to those obtained with reference methods, with the values from the adjusted methods being slightly higher than those from the usual methods. The Ranking of animals based on their genetic values was not affected by using the simplified recording plans. For practical and economical reasons, the simplified designs alternating a.m. and p.m. milkings are suggested for ovine milk recording. In such a case, the adjusted alternate methods (ATa) should be used rather than the usual alternate methods (ATu) without adjustment.

INTRODUCTION

Throughout the world, twice daily milking is the most frequent milking schedule of dairy ewes and milk production is recorded approximately once every 30 d or, sometimes, once every 15 d in some experimental flocks (Othmane, 2004). However, costs of supervised recording of the two daily milkings are especially high in dairy ewes compared to other dairy species (Othmane and Trabelsi, 2007) and ovine milk recording simplification is still a necessity. For this very reason, several studies have been carried out on this topic (Gabiña et al., 1986; Barillet et al., 1987; Gonzalo et al., 2003; Othmane et al., 2006; Othmane and Trabelsi, 2007); evaluating and suggesting simplified milk recording designs, based on recording only one milking a day, with high phenotypic precision levels. In such cases, daily milk production has to be estimated from the available information on only the recorded milking. Estimation of daily milk yield as a basis for flock management decisions and estimation of lactation yield for use in ewe and ram evaluation are both objectives of milk recording. According to a recent report on milk recording of sheep (Astruc et al., 2010), simplification of milk yield recording has widely spread among ICAR countries (from 53% of recorded ewes in 1988 to 94% in 2010).

Interest of supervised recording of either a.m. or p.m. milk yield lies in reducing costs of milk recording. Potential benefits of simplified plans relative to standard twice-a-day monthly recording plan (**A_4**) are numerous (Hargrove and Gilbert, 1984). However, such advantages have to be balanced against any losses of precision associated to simplified testing schemes which are usually subject to some degree of sampling error. Usual alternate a.m.-p.m. testing systems are in use in several countries as a simplified milk recording method for dairy ewes, where the same weight is accorded to a.m. and p.m. milkings when estimating daily milk production from one milking, by using the pair of factors (2, 2), respectively. Investigation after implementation of new factors for the alternate plan in use indicated that the adoption of the pair of factors (1.7, 2.3) may remove by more than 13% the lack of fit associated to old factors (Othmane and Trabelsi, 2007). On the other hand, accuracy of these alternate methods, as simplified milk recording designs, is usually evaluated using lactation data sets where variation in a.m.-p.m. milk production would be compensated from one test-day to another, provided the number of test-days is sufficient (Othmane et al., 2006). This is not the case with test-day data sets that override the use of lactation data sets in many genetic improvement programmes in ewes. In fact, the difference between a.m. and p.m. milking productions should be strongly felt when daily test-day milk production, based on information from the recorded milking in alternate designs without adjustment, is fitted as an independent trait.

This study simulates alternate methods of simplifying milk recording, compares estimates from the simplified monthly and twice monthly plans with estimates from the A_4 standard plan and twice-a-day twice monthly recording plan (**A_2**), respectively, and assesses the impact of their use from a genetic point of view (genetic parameters of milk yield, genetic correlations and animal evaluation).

MATERIALS AND METHODS

Data

Data for milk yield were obtained from the Sicilo-Sarde dairy flock of the Tunisian National Institute of Agricultural Research (INRAT) between 1999 and 2009. All ewes were on the A_2 plan of testing, with the first test-day beginning at week 7 postpartum and the subsequent records obtained at two-weekly intervals thereafter. All ewes were hand milked twice a day at 08:00 and 16:00. From the experimental unit data, other information included date of milk recording, lactation number, date of birth of ewe, lambing date, and lambing type (simple or multiple born lambs). The rest of recorded flocks in the Sicilo-Sarde population are on the standard A_4 plan of testing, and all ewes are milked twice daily. Daily milk production level in the entire population ranges from 0.6 to 0.8 l (Othmane and Trabelsi, 2007).

The data consisted of 8219 test-day observations of individual milk yield obtained from 303 Sicilo-Sarde ewes during the milking period, after weaning of lambs. A test-day observation consisted of two milk yield records from a.m. and p.m. milkings. The mean number of test-days per lactation was 9.33, and each ewe averaged 2.9 lactations. The total number of sheep in pedigree was 446, of which 363 were ewes and 83 were rams. All rams were used for natural service under good pedigree control.

Variables

Individual test-day milk yield was recorded according to the bimonthly (A_2) and monthly (A_4) milk recording systems. Both observed traits were taken as reference measurements. Four estimated traits were then calculated from the corresponding available data set for each design, A_2i and A_4i respectively, where i ranged from 1 to 4 and represented one of the simulated simplified recording designs described below ([i]).

Data processing

Different alternate testing designs were simulated from the available individual data sets (test-day milk yield for the two daily milkings at bimonthly and monthly intervals) and categorized as follows:

1. Bimonthly (A_2) and monthly (A_4) recording of the two daily milkings. Individual daily milk yield (Y) was

calculated from the associated a.m. production ($I_{a.m.}$) and p.m. production ($I_{p.m.}$) as

A_2 and A_4; $Y = I_{a.m.} + I_{p.m.}$

No references are to be made to A_2 or to A_4 in the following four simplified designs, the corresponding formulae being quite the same for both of them.

2. Usual alternate recording without adjustment (ATu), beginning with either the a.m. ($ATu_{a.m.}$) or the p.m. milking ($ATu_{p.m.}$). Individual daily milk yields were estimated from measurements on one milking as

$ATu_{a.m.}$; $Y = 2 \times I_{a.m.}$ for odd test-days [1]
$= 2 \times I_{p.m.}$ for even test-days
$ATu_{p.m.}$; $Y = 2 \times I_{p.m.}$ for odd test-days [2]
$= 2 \times I_{a.m.}$ for even test-days

3. Alternate recording adjusted for the weight of the recorded milking in daily ewe's production (ATa) where estimation of individual daily milk yields was computed by changing the multiplication factors currently in use (2, 2) in [1] and [2] with the pair of factors (1.7, 2.3) for a.m. and p.m. milkings, respectively, recommended by Othmane and Trabelsi (2007) to be associated to the best precision in the same breed. Depending on whether the alternate design begins with a.m. ($ATa_{a.m.}$) or p.m. milking ($ATa_{p.m.}$), individual daily milk yields were estimated from measurements on one milking as

$ATa_{a.m.}$; $Y = 1.7 \times I_{a.m.}$ for odd test-days [3]
$= 2.3 \times I_{p.m.}$ for even test-days
$ATa_{p.m.}$; $Y = 2.3 \times I_{p.m.}$ for odd test-days [4]
$= 1.7 \times I_{a.m.}$ for even test-days

The various designs of milk recording are summarised in table 1. In such simulations, the first test-day corresponded to week 7 post partum. This week was chosen as being the central point of the designated period, under Sicilo-Sarde breed conditions, within which to carry out the first test-day, between days 31 and 75 post partum.

Phenotypic analysis

Data were gathered according to the different levels of the main environmental variables that were thought to affect test day milk yield in the Sicilo-Sarde breed conditions. Effects of variation factors were then estimated using a general linear model including the identified fixed effects (F: lambing type, test-day date, stage of lactation, test-day number, age at lambing) and the residual (e) as random effect:

$$y = \mu + F + e; \quad \mu = \text{flock mean} \qquad ①$$

It is advisable to indicate that, in such a study, it is more important to know whatever the variation factors affect estimated and observed traits in the same way or not rather than the nature or the magnitude of the variation factor effect in itself.

Test-day milk yields estimated for simplified designs (X) were also compared with those from the A_2 and A_4 reference options (Y) by means of phenotypic correlations and linear regressions between Y and X according to the model:

$$Y = a + bX + E \qquad ②$$

where a = intercept; b = slope or coefficient of regression; and E = associated random error.

Analyses were carried out by the Statistical Analysis System program SAS (1992) using GLM, CORR and REG procedures.

Table 1: Test-day recording plans: reference and alternate designs

Test-day		Periodicity (d)		Recorded milkings
		A_2	A_4	
A_2†		15		a.m. + p.m.
A_4†			30	a.m. + p.m.
AT	$ATu_{a.m.}$	15	30	Alternate a.m.‡-p.m.
	$ATu_{p.m.}$	15	30	Alternate a.m.-p.m.‡
	$ATa_{a.m.}$	15	30	Alternate a.m.‡-p.m.
	$ATa_{p.m.}$	15	30	Alternate a.m.-p.m.‡

† Reference methods.
‡ milking the test-day started with.

Genetic analysis

The test-day traits analysed (dependent variables) were milk yield observed with reference methods and milk yield estimated according to the corresponding simplified designs. Genetic parameter estimation and genetic evaluations were carried out using a univariate animal model. Genetic correlations between observed and estimated traits were obtained using a bivariate animal model. Data were analysed with the following repeatability animal model:

$$y = \mu + F' + A_i + PE_i + e \quad ③$$

where

y = dependent variable; μ = population mean; F' = sum of variation factors with significant effects in model ①; A = random additive genetic effect of the individual i; PE_I = random permanent environmental effect on the individual i; and e = random residual effect.
Genetic parameters were estimated by the analytical gradients (AG) REML (Restricted Maximum Likelihood Estimation) procedure (Neumaier and Groeneveld, 1998) using the Variance Component Estimation programs, VCE4 package (Groeneveld, 1998).

RESULTS AND DISCUSSION

Averages, standard deviations and standard errors for test day milk yield estimated from the simplified designs or observed with the A_4 and A_2 designs used as a reference, are in table 2. Test day milk production obtained in Sicilo-Sarde breed raised under a low input production system (one lambing season a year) were lower than those reported in other studies (Othmane et al., 2002a; Gutierrez et al., 2007; Mačuhová et al., 2012) on dairy breeds with more intensive production systems (3 lambing times in two years) and higher milk production level. As a whole, estimated and observed values of test day milk yield were similar ranging from 526 to 586 ml. However, milk production was estimated more accurately with information from adjusted alternate designs ($ATa_{a.m.}$, $ATa_{p.m.}$). These latter showed the lowest standard deviations and standard errors, the nearest to those obtained with the reference method. Such a tendency was maintained for all simplified adjusted designs independently of the comparison basis (A_4 or A_2).

Table 2: Arithmetic means ($\overline{X}$), standard deviations (SD) and standard errors (SE) of the test day milk yields for the simplified test-day designs with regard to the A_4 and the A_2 options

Recording design	n	$\overline{X}$	SD	SE
Monthly designs				
A_4	4323	563	183.6	2.8
$ATu_{a.m.}$	4323	586	272.5	4.1
$ATu_{p.m.}$	4323	540	244.8	3.7
$ATa_{a.m.}$	4323	551	212.9	3.2
$ATa_{p.m.}$	4323	526	197	3
Bimonthly designs				
A_2	8219	562	182.2	2
$ATu_{a.m.}$	8219	571	262.3	2.9
$ATu_{p.m.}$	8219	552	254.9	2.8
$ATa_{a.m.}$	8219	542	206.9	2.3
$ATa_{p.m.}$	8219	533	202.2	2.2

Table 3 shows the effects of variation factors on test-day milk yields. The variation factors contributed in the same way, in nature and intensity (P < 0.001), to the variations in milk yield from simplified and reference milk recording designs for both A_4 and A_2 options. The only exception was the lower significant effect of lambing type on milk yield from recording designs beginning with a.m. milking than on milk from the other bimonthly designs, which can be explained by the low prolificity rate in the breed and mainly by the higher proportion of milk from a.m. milking in daily individual milk yield, the effect of lambing type being usually felt around the lactation peak where milk is abundant after weaning of lambs.

Lactation curves were configured by grouping both monthly and twice monthly data into 2-weak intervals, according to stage of lactation. The least squares means of daily milk yields from the different milk recording designs over a milking period are shown in figs 1 and 2. Because of the suckling period in dairy ewes, lactation curves for milk yield do not always show the typical pattern seen in dairy cows, which is characterized by an initial phase that increases to a maximum, followed by a decreasing phase. Thus, the lactation curve consists only of a decreasing phase. Estimated and observed test-day milk yields showed the same phenotypic behaviour independently of milk recording frequency, monthly (figure 1) or bimonthly (figure 2). They changed in parallel throughout the milking period with values that were very close to each other. This parallelism resulted in a good estimation of observed values suggesting, at this stage, the suitability of simplified recording designs.

The phenotypic correlations among the variables studied are shown in table 4. Correlations were high and positive between milk yield observed with A_4 reference method and those estimated by all the corresponding simplified methods. However, milk yields from the adjusted alternate methods ($ATa_{a.m.}$ and $ATa_{p.m.}$) were more correlated to the observed milk yield than those estimated using usual alternate methods ($ATu_{a.m.}$ and $ATu_{p.m.}$). The same occurred with the milk recording designs with increased frequencies (bimonthly designs). The same magnitudes and the same tendency of correlations were obtained between observed and estimated traits, that is to say an obvious synergy between observed and estimated values. From a phenotypic point of view, the adjusted alternate methods become then the preferred simplified milk recording designs in the event of their adoption for both monthly and bimonthly variants.

Table 3: Statistical significance of the variation factor[1] effects on the estimated and observed test-day milk yields for the monthly and bimonthly recording designs

Recording design	LT	TDD	SL	TDN	AL
		Monthly designs			
A_4	0.08^{NS}	31.34***	7.43***	3.22***	11.33***
$ATu_{a.m.}$	0.05^{NS}	23.37***	8.21***	70.97***	9.62***
$ATu_{p.m.}$	0.07^{NS}	29.25***	4.00***	86.98***	8.14***
$ATa_{a.m.}$	0.01^{NS}	24.97***	8.18***	21.42***	9.63***
$ATa_{p.m.}$	0.31^{NS}	29.10***	4.53***	23.78***	7.76***
		Bimonthly designs			
A_2	11.53***	41.39***	9.12***	2.36***	17.20***
$ATu_{a.m.}$	5.23*	31.66***	7.28***	151.77***	14.97***
$ATu_{p.m.}$	13.01***	35.87***	7.06***	158.07***	10.83***
$ATa_{a.m.}$	5.32*	32.62***	7.09***	40.54***	14.91***
$ATa_{p.m.}$	14.05***	36.06***	7.80***	37.64***	10.64***

[1] LT: lambing type; TDD: test-day date; SL: stage of lactation; TDN: test-day number; AL: age at lambing.
*** P < 0.001, * P < 0.05, ^{NS} P > 0.05.

Table 4: Phenotypic correlations between test-day milk yields estimated by simplified methods and those observed with reference methods

Method	$ATu_{a.m.}$	$ATu_{p.m.}$	$ATa_{a.m.}$	$ATa_{p.m.}$
		Monthly designs		
A_4	0.74***	0.67***	0.87***	0.84***
		Bimonthly designs		
A_2	0.71***	0.69***	0.86***	0.85***

*** Significant (*P* < 0.001).

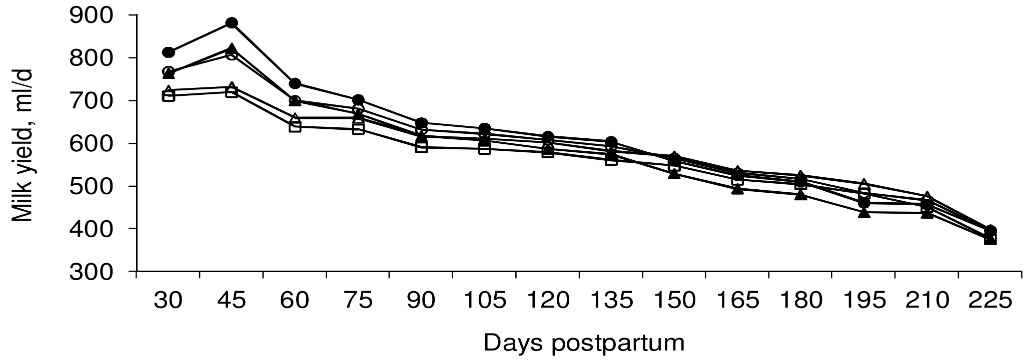

Fig. 1: Changes in milk yield during lactation for A_4 designs: A_4 (○), ATu_{am} (●), ATu_{pm} (△), ATa_{am} (▲) and ATa_{pm} (□)

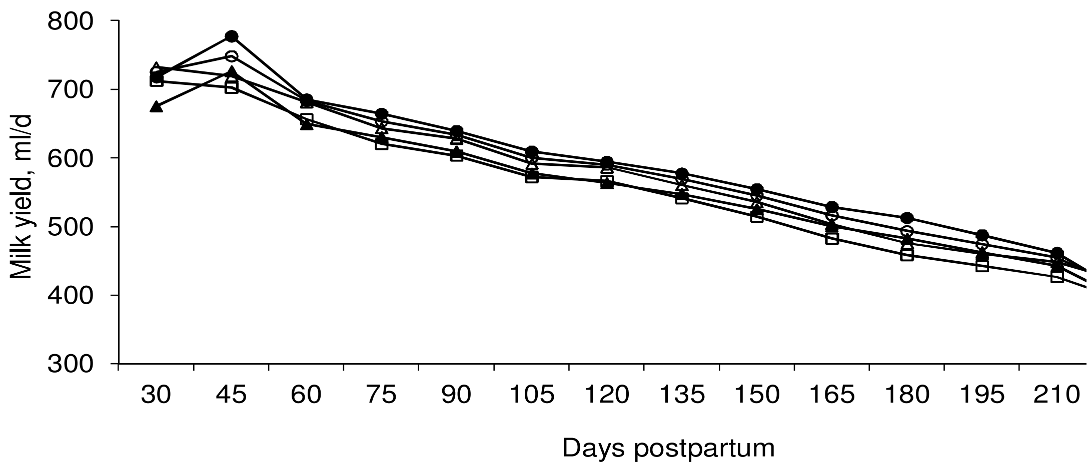

Fig. 2: Changes in milk yield during lactation for A_2 designs: A_2 (○), ATu_{am} (●), ATu_{pm} (△), ATa_{am} (▲) and ATa_{pm} (□)

Results from phenotypic correlations were confirmed by those from the linear regression analysis (tables 5 and 6). Independently of the milk recording frequency (monthly or bimonthly), the highest regression coefficients and the highest associated coefficient of determination (R^2) were obtained with models 3 and 4 where regressors were the adjusted alternate methods ($ATa_{a.m.}$ and $ATa_{p.m.}$), which confirms again the pertinence of their adoption in case of sheep milk recording simplification.

From a genetic point of view, we know of no studies on this topic in dairy ewes. The alternate methods had been reported to be the most efficient simplified milk recording designs to estimate milk yield and composition (Gabiña et al., 1986; Gonzalo et al., 2003; Othmane et al., 2006; Othmane and Trabelsi, 2007; Othmane et al., 2011); but there was no available information on the impact of their adoption on genetic parameters and animal genetic evaluation allowing them to be judged as milk recoding designs for genetic improvement programs. In our study, the genetic variance component estimation showed that the adjusted alternate methods seemed more accurate; they had the lowest residual variances which were the closest to that observed with the reference method in both monthly and bimonthly milk recording designs.

Heritability, permanent environmental variance proportion, and repeatability estimates for observed and estimated test-day milk yields are in table 7. Heritability estimates ranged from 18 to 21.8 for monthly designs (table 7) and were similar to those obtained with the bimonthly designs (17.8 to 21.5). These values were clearly higher to those reported in previous studies (7 and 11) on the same breed (Othmane, 2004; Ilahi and Othmane, 2011a) and fell within the range of results (15 – 23) already published on other dairy sheep breeds (Othmane et al., 2002b; Ilahi and Othmane, 2011b; Marie-Etancelin et al., 2006).

Table 5: Predictive equations of observed monthly (A_4) test-day milk yield (Y) according to the corresponding estimated milk yields (X)

Model	Predictive equation	R^2, %
Model 1	$Y = 0.502\ X_{ATua.m.} + 269$	56
Model 2	$Y = 0.502\ X_{ATup.m.} + 292$	45
Model 3	$Y = 0.751\ X_{ATaa.m.} + 149$	76
Model 4	$Y = 0.78\ X_{ATap.m.} + 153$	70

R^2: Coefficient of determination.

Table 6: Predictive equations of observed bimonthly (A_2) test-day milk yield (Y) according to the corresponding estimated milk yields (X)

Model	Predictive equation	R^2, %
Model 1	$Y = 0.496\ X_{ATua.m.} + 278$	51
Model 2	$Y = 0.496\ X_{ATup.m.} + 288$	48
Model 3	$Y = 0.75\ X_{ATaa.m.} + 154$	73
Model 4	$Y = 0.76\ X_{ATap.m.} + 155$	72

R^2: Coefficient of determination.

Table 7: Heritabilities (h^2), proportions of permanent environmental variance (c^2), their standard error (SE), and repeatabilities (r) for observed and estimated test-day milk yields

Design	n	h^2	SE	c^2	SE	r
			Monthly designs			
A_4	4323	21.8	0.04	10.4	0.03	32.2
$ATu_{a.m.}$	4323	18	0.03	11.2	0.02	29.2
$ATu_{p.m.}$	4323	19.7	0.03	7.3	0.03	27
$ATa_{a.m.}$	4323	18.2	0.03	8.7	0.03	26.9
$ATa_{p.m.}$	4323	20.1	0.04	7.5	0.03	27.6
			Bimonthly designs			
A_2	8219	21.5	0.04	13.4	0.03	34.9
$ATu_{a.m.}$	8219	17.8	0.03	10.5	0.03	28.3
$ATu_{p.m.}$	8219	17.8	0.03	10.8	0.03	28.8
$ATa_{a.m.}$	8219	18.4	0.03	11	0.03	29.4
$ATa_{p.m.}$	8219	18.8	0.03	11.1	0.03	29.9

Heritability and repeatability values estimated from data recorded using the adjusted alternate methods ($ATa_{a.m.}$ and $ATa_{p.m.}$) were slightly higher than those estimated from non adjusted data ($ATu_{a.m.}$ and $ATu_{p.m.}$) and were more close to the reference (A_4 and A_2) values. From a genetic point of view, it can be pointed out that this result is of great interest for sheep breed selection programs based on test-day data. In fact, when the two daily milkings are alternated in lactation models, variation in a.m.-p.m. production would be compensated from one test-day to another, provided the number of test-days is sufficient (Othmane and Trabelsi, 2007). However, such compensation wouldn't be possible for data from test-day models and the adjustment of alternate methods becomes then a necessity in case of adoption of simplified milk recording designs.

Genetic correlations between milk yield from reference methods (A_4 and A_2) and milk yields from the corresponding simplified methods were clearly positive and high, equal to unity. These strong correlations express the strong relationship between observed and estimated traits well, and support the thought that adoption of alternate methods of milk recording in dairy ewes rather than adoption of standard methods may be preferable. Alternate methods are more and more routinely used and are less embarrassing and less expensive for both the breeders and the supervisor when compared to standard methods, where the two daily milkings are to be recorded.

The impact of adoption of the alternate methods of simplifying milk recording on genetic evaluation and ranking of animals was also evaluated. Spearman's rank correlation coefficients allowed us to identify the strength of correlation within breeding value data set for observed and estimated milk yields (table 8). Results showed that rank correlations associated to estimated breeding values compared with reference values were positive and very strong (≥ 0.98) for both the monthly and bimonthly milk recording designs. Such results, together with those of genetic correlations, indicate that the adoption of one method from the proposed simplified designs does not affect the ranking of animals according to their genetic merits, which will lead to the expected genetic gains, provided the existence of an appropriated selection schema. Having that, it is important to indicate that the adoption of the adjusted alternate methods ($ATa_{a.m.}$ and $ATa_{p.m.}$) is still preferred for the highest associated genetic estimates and for their phenotypic accuracy level shown in this study and elsewhere (Othmane and Trabelsi, 2007; Othmane et al., 2011) in the same breed.

Table 8: Spearman's rank correlation coefficients of breeding values from simplified milk recording designs and those from standard milk recording data

Reference	Simplified milk recording designs			
	$ATu_{a.m.}$	$ATu_{p.m.}$	$ATu_{p.m.}$	$ATa_{p.m.}$
A_4	0.9947	0.9943	0.9952	0.9942
A_2	0.9888	0.9752	0.9851	0.9780

Independence margin at significance level 5% associated to the number of studied samples: [-0.0929 ; 0.0929].

CONCLUSIONS

Besides the phenotypic evaluation, this study was the first to evaluate the simplified milk recording designs on their associated genetic estimates compared with those of reference designs. All alternate methods resulted in good prediction of actual milk production when applied to data sets from monthly or twice monthly recordings. However, the adjusted methods allowed better accuracy than the usual alternate methods without adjustment with the same ranking maintained for both monthly and twice monthly frequencies. The adjusted alternate methods ($ATa_{a.m.}$ and $ATa_{p.m.}$) are preferable for their greater accuracy and also for practical and economic reasons and should be then used in Sicilo-Sarde population.

This research was supported by the Tunisian Ministry of Higher Education and Scientific Research (Tunis). Cooperation of the staff of the INRAT Experimental Unit in collecting and verifying the data for this study is also acknowledged gratefully. The experiments comply with the current laws of Tunisia.

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Cite this Article: Bousselmi H and Othmane MH (2013). Impact of Simplified Methods of Monthly and Twice Monthly Milk Recording on Genetic Parameter Estimates and Genetic Evaluation in Dairy Ewes Under a Low Input Production System. Greener Journal of Biological Sciences, 3(3): 099-107, http://doi.org/10.15580/GJBS.2013.3.021413460.