Adequacy of genetic evaluation of dairy cows for milk yield using different testing schemes

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ABSTRACT

Alternative milk recording schemes, as alternate a.m.-p.m. (AT) procedures, have been proposed in order to reduce recording costs per cow thereby increasing the number of cows and young bulls that can be tested. The objective of this paper is to compare predicted breeding values using alternative recording schemes for estimating lactation yields, specifically for dams of sires. Over 4 million test day records for milk yield of 306,148 Italian Friesian cows collected in 649 herds in the province of Milan (Italy) between 1990 and 1997 were used. The simulation of alternative testing schemes was carried out using A4 single milking data. The alternative schemes to estimate daily milk yield from AM and PM data, were: a) alternate scheme using a doubling; b) alternate scheme using a correction for milking interval applying (MI) direct or inverse factors; c) non-alternate scheme using a correction for MI applying inverse factors; d) random scheme using a correction for MI applying inverse factors. A mixed model procedure to estimate breeding values was used. The rank correlation between EBV with A4 method and other testing schemes resulted around 99% at the population level and around 89% with regard to the top 1% of cows. About 10% of cows ranked with A4 method were excluded from the list of the top 1% when alternative testing schemes were applied. A negligible effect on the reduction of selection intensity for the dams of sires path was found.

Key words: Alternate am-pm testing scheme, Single milking, Breeding values, Dairy cattle.

RIASSUNTO

ADEGUATEZZA DELLA VALUTAZIONE GENETICA DI BOVINI PER LA PRODUZIONE DEL LATTE UTILIZZANDO DIFFERENTI METODI DI CONTROLLO FUNZIONALE PER LA STIMA DELLA PRODUZIONE NELLA LATTAZIONE

I metodi di controllo funzionale per il latte, quali il metodo alternato (AT), sono stati proposti per ridurre i costi di controllo per vacca e per aumentare il numero di vacche e giovani tori sottoposti ai controlli funzionali ed alle prove di progenie. Obiettivo di questa ricerca è di confrontare gli indici genetici stimati utilizzando diversi metodi di controllo funzionale per la stima della produzione di latte nella lattazione, con particolare riferimento alle madri di toro. Sono stati analizzati oltre 4 milioni di singoli controlli funzionali per la produzione di latte di 306,148 vacche di razza Frisona italiana, raccolti in 649 allevamenti della provincia di Milano tra il 1990 ed il 1997. Sono stati simulati diversi metodi di controllo funzionale a partire dalle singole mungiture di controlli funzionali di tipo A4. Per tutti gli allevamenti considerati sono stati considerati diversi metodi di stima della produzione giornaliera di latte a partire dalla mungitura della mattina (AM) o della sera (PM) come segue: a) metodo AT utilizzando il semplice raddoppio della singola mungitura; b) metodo AT utili-
Introduction

The milk recording system is the basis for genetic evaluation and improvement of dairy cattle. Several milk recording methods are officially defined by the International Committee for Animal Recording systems (ICAR, 2003). Testing plans based on weighing and sampling two milkings within 24 h at 4-wk (A4 method) is the standard method in most countries (ICAR, 2003). However, during the last few decades the cost per cow recorded became increasingly expensive, and modifications of testing schemes have been proposed in order to reduce the costs of milk recording (Everett and Wadell, 1970a; Everett and Wadell, 1970b; Putman and Gilmore, 1970; Hargrove and Gilbert, 1984; Buttazzoni and Baiocco, 1993). The alternate a.m.-p.m. testing scheme (AT), based on an alternate recording of a.m. (AM) and p.m. (PM) milking weights on consecutive test days, has been proposed as an alternative scheme of the A4 testing plan (Ormiston et al., 1967; Putman and Gilmore, 1968; McDaniel, 1969; Putman and Gilmore, 1969; Wiggans, 1981).

Several advantages can be hypothesized when using recording schemes based on a correct application of AT method for official testing plans. First of all, the greater number of herds served by each supervisor can effectively reduce recording costs per cow and fewer visits in a herd by supervisors have less disturbing effects on the milking routine. Moreover, the reduction of recording costs per cow may allow an increase in the number of young bulls involved in progeny testing programs and this can theoretically enhance the rate of genetic gain achievable from selection programs (Schaeffer and Rennie, 1976). Therefore, the recording system should not only be evaluated by reducing costs, but should also consider consequences on the reliability of recorded data for management and breeding purposes (Duda and Aumann, 1997; Wilmink et al., 1997). In this regard a validation of AT methodology is needed in order to evaluate the effects of the AT method on genetic evaluations. Liu et al. (2000) showed that the use of estimated daily yields from morning or evening milking has a lesser impact on estimated breeding values of bulls than cows when the test-day model is used for genetic evaluation in dairy cattle. However, the same authors concluded that use of estimated daily yields is less reliable for estimating breeding value than use of true daily yields. Moreover, as genetic evaluations that use lactation yield data are still popular (Interbull, 2000) in many countries, the impact of the AT method on estimated breeding values is needed.

The purposes of the present study are: i) to compare estimated breeding values (EBV) for milk yield using different testing schemes; ii) to evaluate bias and accuracy of EBV under different testing schemes; iii) to evaluate the effect of different testing schemes on the ranking of top cows.

Material and methods

The data used were 4,150,214 test day records for milk yield of 306,148 Italian Friesian cows reared in 649 herds registered in the province of
Milan (Italy). Calving years ranged from 1991 to 1994. Test day records were measured on a 28-d basis and consisted of PM, AM, initial time of milking, months of lactation and parity of the cow. The records from lactation with less than 10 test-days, records of cows with incorrect or missing date of birth, test-day records collected prior to 8 days in milk, test-day observations with daily milk interval lower than 9 or greater than 15 h and records from herds with less than 10 cows were removed from the data file. Moreover, the first lactation registered per cow was considered, hence, for all cows this was assumed to be only one record, thus no repeatability model was applied for genetic evaluation. After editing procedures, records from 50,464 cows from 565 herds were available. The following were computed for each cow:

i) 305-d lactation yield using both AM and PM, according to the customary A4 official procedure (ICAR, 2003);

ii) daily milk yield (DMY) according to the following methods:
   a) doubling AM or PM
   b) dividing AM or PM by inverse factors (IMF), as proposed by Cassandro et al. (1995)
   c) dividing AM and PM by incorrect IMF. In this case an error of 1-h milking interval (e.g., an adjustment factor for a 10-h milking interval was used when true milking interval was 11-h) was assumed, in order to evaluate the effect of incorrect records on the milking interval.

iii) 305-d lactation yield according to the following methods:
   a) alternate testing scheme using doubling or IMF or incorrect IMF;
   b) non-alternate testing scheme using IMF applied to only AM or only PM;
   c) mixed testing scheme, assuming a random mixed use among herds of the aforementioned testing schemes. The same proportion of herds for each different testing scheme was guaranteed. This scheme was aimed to simulate a possible field condition, where 305-d lactation yields within herds are estimated using alternate testing schemes in some herds and non-alternate testing schemes in other herds.

iv) EBV, predicted with a single trait animal model procedure using PEST program (Groeneveld, 1996) and applying, for each 305-d lactation milk yield estimated with the aforementioned testing schemes, the following linear mixed model, in agreement with National Table 1. Description of the data file 1.

| Item 2 | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| DMY, kg mean | 31.8 | 34.1 | 32.6 | 30.8 | 29.0 | 27.3 | 25.5 | 23.6 | 21.6 | 18.9 |
| SD    | 8.0  | 7.9  | 7.4  | 6.9  | 6.4  | 6.1  | 5.8  | 5.6  | 5.5  | 5.9  |
| PM, kg mean | 15.2 | 16.2 | 15.4 | 14.6 | 13.7 | 12.9 | 12.1 | 11.2 | 10.2 | 9.0  |
| SD    | 4.0  | 4.0  | 3.8  | 3.6  | 3.3  | 3.1  | 3.0  | 2.8  | 2.8  | 2.9  |
| AM, kg mean | 16.6 | 17.9 | 17.2 | 16.2 | 15.3 | 14.4 | 13.4 | 12.4 | 11.4 | 9.9  |
| SD    | 4.3  | 4.2  | 4.0  | 3.7  | 3.5  | 3.3  | 3.1  | 3.0  | 3.0  | 3.3  |
| DIM, d mean | 21   | 54   | 87   | 120  | 153  | 186  | 218  | 252  | 285  | 317  |
| SD    | 9    | 11   | 13   | 14   | 15   | 16   | 15   | 15   | 15   | 15   |

1 50,464 cows
2 DMY = Daily milk yield; PM = p.m. milking weight; AM = a.m. milking weight; DIM = days in milk.
Breeders Association of Italian Friesian cows (Interbull, 2000):

\[ Y_{ijkl} = HYS_i + P_j + b \times AGE_{ijkl} + a_k + e_{ijkl} \]

where:

- \( Y_{ijkl} \) = an observation of 305-d lactation milk yield;
- \( HYS_i \) = fixed effect of herd-year-season \( i (i=1, \ldots, 4,041) \);
- \( P_j \) = fixed effect of parity \( j (j = 1: 23,565 \text{ records}; 2: 11,749 \text{ records}; 3: 6,852 \text{ records}; 4: 3,939 \text{ records}; 5: 2,230 \text{ records}; 6: 2,129 \text{ records}) \);
- \( b \) = linear regression coefficient;
- \( AGE_{ijkl} \) = age at calving (linear covariate);
- \( a_k \) = random effect of animal \( k (k = 1, \ldots, 87,141 \text{ animals} + 6 \text{ phantom groups, grouped on birth year and country origin}) \);
- \( e_{ijkl} \) = random effect of error \( \sim N(0, \sigma^2e) \).

The comparison among testing methods were assessed through:

i) correlation analysis for 305-d lactation milk yield and EBV computed between alternative schemes and the A4 scheme;

ii) bias of estimate for 305-d lactation yield and EBV, computed as mean of difference between estimates from an alternative scheme and the A4 scheme;

iii) accuracy of estimate for 305-d lactation yield.

Table 2. Rank correlations, bias and accuracy of estimated 305-d lactation yield for different testing schemes in comparison with A4 method\(^1\).

| Testing scheme | Rank correlation\(^2\) | Bias\(^3\) Kg | Accuracy\(^4\) | Maximum bias |
|----------------|------------------------|---------------|---------------|--------------|
|                | %                      |               |               | Negative     | Positive     |
| ALTERNATE\(^5,6\) |                        |               |               |              |
| Doubling       |                        |               |               |              |
| first a.m.     | 99.32                  | 44            | 181           | -1270        | 1285         |
| first p.m.     | 99.32                  | -44           | 184           | -1194        | 1386         |
| Inverse factors|                        |               |               |              |
| first a.m.     | 99.35                  | -8            | 176           | -1324        | 1112         |
| first p.m.     | 99.32                  | -7            | 182           | -1261        | 1350         |
| Incorrect inverse factors |            |               |               |              |
| first a.m.     | 99.35                  | 531           | 212           | -903         | 1871         |
| first p.m.     | 99.32                  | 539           | 223           | -642         | 2107         |
| NON-ALTERNATE  |                        |               |               |              |
| Inverse factors|                        |               |               |              |
| all a.m. records | 98.26                  | 19            | 293           | -1801        | 1748         |
| all p.m. records | 98.01                  | -34           | 328           | -1974        | 2212         |
| MIXED\(^7\)    | 98.37                  | 116           | 285           | -1326        | 1601         |

\(^1\) 50,464 cows with average 305-d lactation yield of 8,555 kg (SD 1,618 kg), using A4 method.
\(^2\) Rank correlation between A4 and alternative methods for average 305-d lactation yield.
\(^3\) Mean difference between A4 and alternative methods for average 305-d lactation yield.
\(^4\) Standard deviation of the difference between A4 and alternative methods for average 305-d lactation yield.
\(^5\) Inverse factors = factors computed from regression equations of PM:DMY or AM:DMY on the milking interval, and incorrect inverse factors = factors computed for values of the milking interval 1h lower than the true milking interval (Cassandro et al., 1995).
\(^6\) first a.m. (or p.m.) = the first available record for a cow from an a.m. (or p.m.) milking.
\(^7\) Mixed testing scheme is a mixed use among herds of A4, alternate and non-alternate testing schemes.
and EBV, computed as standard deviation of difference between estimates from an alternate scheme and the A4 scheme; iv) frequency of cows ranked at top 1% and top 10% of the population using the A4 scheme that dropped out from the top rank when alternate testing schemes were used for estimating 305-d lactation yield.

The potential impact of different testing schemes on intensity of selection was evaluated comparing the mean of difference between breeding values of alternative testing schemes with the A4 method (ICAR, 2003) on top 1% and 10% of cows (500 and 5000 cows, respectively) ranked for different testing schemes. Data were analyzed using SAS (1985).

Results and discussion

Data characteristics

Descriptive statistics for the data file are reported in Table 1. The means of DMY from the first to the tenth test-day followed a typical lactation curve with the pick of yield around the second

| Table 3. Rank correlations, bias and accuracy of estimated breeding value (EBV) for milk yield of different testing schemes in comparison with A4 scheme. |
|--------------------------------------------------|------------------|------------------|------------------|------------------|
| Testing scheme                                  | Rank correlation | Bias (Kg)       | Accuracy         | Maximum bias     |
|                                                 | %                |                  |                  | Negative Positive|
| ALTERNATE<sup>5,6</sup>                         |                  |                  |                  |                  |
| Doubling                                        |                  |                  |                  |                  |
| first a.m.                                      | 99.05            | 2                | 40               | -265             | 310 |
| first p.m.                                      | 99.00            | -2               | 40               | -309             | 265 |
| Inverse factors                                 |                  |                  |                  |                  |
| first a.m.                                      | 99.03            | 1                | 39               | -270             | 285 |
| first p.m.                                      | 99.00            | -2               | 40               | -316             | 317 |
| Incorrect inverse factors                       |                  |                  |                  |                  |
| first a.m.                                      | 99.04            | 4                | 46               | -271             | 328 |
| first p.m.                                      | 99.00            | 1                | 47               | -309             | 401 |
| NON-ALTERNATE                                   |                  |                  |                  |                  |
| Inverse factors                                 |                  |                  |                  |                  |
| all a.m. records                                | 98.48            | 5                | 52               | -470             | 424 |
| all p.m. records                                | 97.96            | -6               | 58               | -475             | 544 |
| MIXED<sup>7</sup>                               | 99.02            | 1                | 41               | -282             | 281 |

1 87,141 animals with average estimated breeding values of 47 kg (SD 316 kg), using A4 method.
2 Rank correlation between A4 and alternative methods for average EBV for milk yield.
3 Mean difference between A4 and alternative methods for average EBV for milk yield.
4 Standard deviation of the difference between A4 and alternative methods for average EBV for milk yield.
5 Inverse factors = factors computed from regression equations of PM:DMY or AM:DMY on the milking interval, and incorrect inverse factors = factors computed for values of the milking interval 1 h lower than the true milking interval (Cassandro et al., 1995).
6 first a.m. (or p.m.) = the first available record for a cow from an a.m. (or p.m.) milking.
7 Mixed testing scheme is a mixed use among herds of A4, alternate and non-alternate testing schemes.
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Month of lactation. Average milk production at the AM milking was about 11% higher than at the PM milking. Estimated average lactation yield, using the A4 testing scheme, was 8,555 ± 1,618 kg for the 50,464 cows analyzed.

Rank correlation, bias and accuracy of estimated 305-d lactation yield for different testing schemes are presented in Table 2. High rank correlations, ranging from 98.01 to 99.35%, suggest that testing schemes have a negligible impact on the phenotypic ranking of the cow population. Among alternate testing schemes, the doubling showed higher bias and lower accuracy than the IMF method. However, for both methods bias was < 1% of lactation yield calculated by the A4 procedure. Comparable results were obtained by Schaeffer and Rennie (1976), Webb (1980), and Smith and Pearson (1981). A systematic error of 1-h less than the actual milking interval (incorrect IMF) caused an overestimation of 305-d lactation yield > 500 kg and an accuracy around ± 200 kg. Hence, the alternate use of AM and PM to calculate lactation yield gave precise estimates of the 305-d lactation yield. The milking interval through the use of adjustment factors can improve both accuracy and precision of estimates, but if milking interval data are questionable, the simple doubling method seems to assure the most accurate estimate of 305-d lactation yield. A testing scheme based on only the use of AM or PM data

| Table 4. Rank correlations, bias and accuracy of estimated breeding value (EBV) for milk yield on top 1% of cows of different testing schemes in comparison with A4 scheme. |
|---|---|---|---|---|
| Testing scheme | Rank correlation | Bias | Accuracy | Maximum bias |
| | % | kg | | |
| ALTERNATE | | | | |
| Doubling | | | | |
| first a.m. | 88.51 | 11 | 57 | -244 163 |
| first p.m. | 89.89 | -11 | 57 | -163 244 |
| Inverse factors | | | | |
| first a.m. | 89.06 | 2 | 56 | -242 148 |
| first p.m. | 89.29 | -6 | 58 | -159 262 |
| Incorrect inverse factors | | | | |
| first a.m. | 89.05 | 76 | 59 | -136 249 |
| first p.m. | 89.21 | 69 | 64 | -99 401 |
| NON-ALTERNATE | | | | |
| Inverse factors | | | | |
| all a.m. records | 84.10 | 24 | 73 | -224 299 |
| all p.m. records | 81.67 | -28 | 81 | -354 245 |
| MIXED | | | | |
| | 89.87 | 5 | 60 | -220 192 |

1 500 cows with average EBV of 1,181 kg (SD 184 kg), using A4 scheme
2 Rank correlation between A4 and alternative methods for average EBV for milk yield
3 Mean difference between A4 and alternative methods for average EBV for milk yield
4 Standard deviation of the difference between A4 and alternative methods for average EBV for milk yield
5 Inverse factors = factors computed from regression equations of PM:DMY or AM:DMY on the milking interval, and incorrect inverse factors = factors computed for values of the milking interval 1h lower than the true milking interval (Cassandro et al., 1995).
6 First a.m. (or p.m.) = the first available record for a cow from an a.m. (or p.m.) milking.
7 Mixed testing scheme is a mixed use among herds of A4, alternate and non-alternate testing schemes.
(e.g. non-alternate scheme) showed a low average bias, but accuracy of estimates were highest. The two non-alternate testing schemes showed the highest maximum and minimum values. Similar results were obtained by Dickinson and McDaniel (1970), which pointed out that the higher variability of estimates for the non-alternate testing scheme is explained by the imperfect correlation between AM and PM data. At the present, the national recording systems in several countries are changing towards a mixed used of different testing schemes in order to increase the number of recorded dairy herds without increasing costs. Consequently, different milk recording methods are offered by local milk recording associations to register new dairy herds and to permit a choice of some dairy farmers that prefer the AT respect to the A4 method to reduce costs and have less disruption in the milking routine. The results of the mixed testing scheme show the impact on field conditions when the A4 method and alternative testing schemes are used randomly among herds. In this study, the implementation of a mixed scheme exhibited a high accuracy, closer to non-alternate testing schemes, and high bias when compared to different alternate testing schemes. In conclusion, assuming that MI data is not available or not reliable, the systematic use in all herds of the doubling alternating method scheme seems to be the most precise and prudent method to compare cows on phenotypic level for estimating lactation yield.

Comparison of testing schemes on genetic evaluations

Analyses on EBV at the population level, using different testing schemes, are presented in Table 3. Rank correlations appeared high and exceed 98% for all testing schemes. This finding suggests that, at the population level, the effect of recording testing scheme, on genetic evaluation, seems to be negligible. However, the absolute value of the maximum bias ranged between 475 to 544 kg of EBV. Alternate testing schemes performed better in

| Table 5. Frequencies of cows excluded in top 1% and top 10% of A4 method using alternative testing schemes |
|---|---|---|
| Testing scheme | Top 1 % | Top 10 % |
| ALTERNATE\(^1,2\) | | |
| Doubling | | |
| first a.m. | 10.4 | 7.4 |
| first p.m. | 12.6 | 7.8 |
| Inverse factors | | |
| first a.m. | 10.4 | 7.4 |
| first p.m. | 11.4 | 6.4 |
| Incorrect inverse factors | | |
| first a.m. | 10.4 | 7.5 |
| first p.m. | 11.4 | 6.5 |
| NON-ALTERNATE | | |
| Inverse factors | | |
| all a.m. records | 16.0 | 11.6 |
| all p.m. records | 14.0 | 10.6 |
| MIXED\(^3\) | 14.2 | 9.9 |

1 Inverse factors = factors computed from regression equations of PM:DMY or AM:DMY on the milking interval, and incorrect inverse factors = factors computed for values of the milking interval 1h lower than the true milking interval (Cassandro et al., 1995).
2 first a.m. (or p.m.) = the first available record for a cow from an a.m. (or p.m.) milking.
3 Mixed testing scheme is a mixed use among herds of A4, alternate and non-alternate testing schemes.
terms of bias and accuracy when compared to non-alternate schemes. Absolute values of bias for alternate testing schemes ranged between 2 and 4 kg with an accuracy that ranged between 39 and 47 kg. Non-alternate testing schemes showed an absolute value of bias around 5 kg with accuracy close to 60 kg. The systematic error of 1 h less on MI (incorrect IMF) showed a comparable bias with the other alternate schemes showing that systematic errors applied to all animals could be corrected by genetic evaluation procedures. Indeed, the herd effect included on the genetic evaluation model accounts for the systematic 1 h less on MI on cows within herd. The use of a mixed scheme gave results very similar to those obtained using the alternate schemes for all herds. A bias of 1 kg and an accuracy of 41 kg suggest that a random combination of alternative recording schemes with the A4 scheme assure a precise comparison of cows at the genetic level.

However, when only potential dams of sires (top 1% of cows) are analyzed (Table 4), the reliability of alternative testing schemes showed a decreasing of precision in predicting EBV. Rank correlations were 88-89% for alternate and mixed schemes and 82-84% for non-alternate schemes. These low rank correlations suggest a sensible re-ranking of top cows that might affect the selection of dams of sires. The alternate schemes, with adjustment factors for differences on milking interval, evidenced the lowest bias and accuracy among alternate schemes. On the contrary, the incorrect inverse factors method showed the highest bias and lowest accuracy suggesting, also in this case, that the doubling method may be preferable if milking interval data is questionable. The non-alternate testing scheme reported the lowest accuracy in absolute evidencing the benefit of alternate testing schemes to predict EBV on lactation yield. The use of a mixed scheme, gave EBV predictions comparable to those obtained using alternate schemes in terms of bias and accuracy, and to assure the genetic evaluations of top cows recorded in herds tested with alternative testing schemes.

Table 6. Differences for milk yield EBV between A4 and alternative testing schemes.

| Testing scheme | Top 1 % | Top 10 % |
|----------------|---------|----------|
| A4 average EBV kg | 1609 | 1181 |
| Difference from A4 method: | | |
| ALTERNATE | | |
| Doubling | | |
| first a.m. | -13 | -8 |
| first p.m. | -13 | -9 |
| Inverse factors | | |
| first a.m. | -13 | -8 |
| first p.m. | -14 | -8 |
| Incorrect inverse factors | | |
| first a.m. | -13 | -8 |
| first p.m. | -14 | -8 |
| NON-ALTERNATE | | |
| Inverse factors | | |
| all a.m. records | -15 | -16 |
| all p.m. records | -25 | -20 |
| MIXED | | |
| -19 | -9 |

1 Inverse factors = factors computed from regression equations of PM:DMY or AM:DMY on the milking interval, and incorrect inverse factors = factors computed for values of the milking interval 1 h lower than the true milking interval (Cassandro et al., 1995).
2 first a.m. (or p.m.) = the first available record for a cow from an a.m. (or p.m.) milking.
3 Mixed testing scheme is a mixed use among herds of A4, alternate and non-alternate testing schemes.
The effect of testing schemes on change in ranking of top cows in the population is reported in Table 5. In the present study, the percentage of cows excluded by the top 1% (500 cows) ranged between 10.4 and 16.0%, whereas on the top 10% (5,000 cows) it ranged from 6.4 to 11.6%. Hence, the results showed that a number of cows from 52 to 80 on the top 1% and from 320 to 580 on the top 10% are improperly ranked. Therefore, a perceptible number of cows can be excluded on list of the elite cows because due to a change from A4 to AT schemes. Higher re-ranking occurred for mixed scheme respect to AT schemes. Also in this case, the non-alternate scheme was the worst scheme tested. However, it is very important to estimate the reduction on absolute value of EBV of top cows when the A4 method is changed with alternative testing schemes. This reduction can be assumed as an estimation of a reduction in selection intensity using the AT with respect to the A4 method. In the present study, the selection intensity reduction ranged from -13 to -25 kg (from -0.8 to -1.5% on average of 1,609 kg) for the top 1% of cows and from -8 to -20 kg (from -0.7 to 1.7% on average of 1,181 kg) for the top 10% of cows (Table 6). The effect of different testing schemes on selection intensity of a breeding plan is not available in the literature but Liu et al. (2000) reported that for the same amount of data information, in terms of number of lactations and number of tests per lactation, reliability of cow EBV will be lower when a cow is in the AT rather than in the standard A4 testing scheme. Results of this study suggest that the potential impact on reduction of selection intensity for the dams of sires path seem to be negligible when alternative testing schemes are used in comparison with the A4 method, but further research is needed to support this conclusion with regard to milk composition traits and also with lactations in progress.

**Conclusions**

This research confirms that alternative testing schemes might be applied to estimate reliable lactation yield even when milking interval is questionable and a doubling of a.m. or p.m. milking weight is used to estimate daily milk yield. The use of non-alternate testing schemes resulted the worst of the all testing schemes analyzed. The mixed testing schemes used in this study shows an accuracy comparable with that observed for alternate testing schemes. At the population level, the rank correlations of animals’ performances using different testing schemes were around 99% for both phenotypic and genetic ability suggesting a low re-ranking. However, on the elite cows (top 1%) the rank correlations were about 89%, suggesting a sensible re-ranking of potential dams of sires. About the 10% of cows were excluded on list of the top 1% of the A4 method when alternative testing schemes were applied. However, the impact on the reduction of selection intensity for the dams of sires path seem to be negligible when alternative testing schemes are used in comparison to the A4 method. A high reduction in costs related to milk recording systems is expected when using alternative testing schemes (Everett, R.W., Wadell, L.H., 1970a, Everett, R.W., Wadell, L.H., 1970b, Hargrove, G.L., Gilbert, G.R., 1984.). These findings seem to be encouraging for adopting alternative testing schemes, also in dairy herds where potential dams of sires are reared for milk yield. However, further studies are needed in order to estimate the impact on genetic response for milk components and also with lactations in progress, which was not analyzed in this study.

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