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# Losses of precision associated with simplified designs of milk recording for dairy ewes

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Simplified designs of milk yield recording based on the yield of a single monthly milking, adjusted or not for interval between milkings and for production level, were simulated and evaluated for 3173 ewe-test-day records belonging to 155 lactations of Churra dairy ewes. Losses of precision associated with simplified methods were evaluated by comparing estimated lactation yields with those observed both in a reference plan, where the two daily milkings were recorded at weekly intervals, and in the official A4 milk recording (monthly records of the two daily milkings). Estimates of lactation yields were less precise when the usual monthly designs were compared with a weekly sampling of both a.m. and p.m. milkings. The losses of precision were high at 9·4–36·2% including the A4 plan. The yield from only the milking period was more predictable than milk yield from the whole lactation (suckling and milking periods) and should consequently be adopted in dairy ewes. All options with one daily milking every month were more accurate when the corresponding plan was based on, or began with, the a.m. milking (loss of precision 14·9–15·8%). There was no evidence of improvement in sampling accuracy by adjusting for the preceding interval between milkings or production level. For practical and economic reasons, the design alternating a.m. and p.m. milkings every month, without adjustment, is suggested for ovine milk recording.

**Keywords:** Milk recording designs, simplification, test-day records, dairy ewes.

Abbreviation Key: A1 = twice-a-day weekly recording design, A4 = standard twice-a-day monthly recording.

Ovine milk is important in Mediterranean countries, some of which have well-established milk recording schemes. Normal husbandry in these countries traditionally includes a lamb suckling period of approximately one month and a milking period that begins after lambs are weaned. 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 (Carriedo et al. 1995). Because the cost of monthly recordings of two daily milkings (A4) is too high for sheep compared with individual outputs (Barillet et al. 1987), simplified procedures based on monthly recordings of only one daily milking (a.m. or p.m.) are of particular interest. Conversely, the advantages of simplified procedures have to be balanced against any associated losses of precision.

Because of a lack of more accurate information on this topic, evaluation of simplified plans reported in the literature has usually been made on the basis of monthly a.m. and p.m. measures for cows (Schaeffer & Rennie, 1976; Smith & Pearson, 1981; Wiggans, 1981; Lee & Wardrop, 1984; Hargrove & Gilbert, 1984; Delorenzo & Wiggans, 1986; Anderson et al. 1989), goats (Bouloc et al. 1991), and dairy ewes (Gabiña et al. 1986). The latter authors found errors of 2·7–5·3% when comparing simplified designs with the A4 standard plan in Latxa flocks for a 12-h interval between milkings. However, no information is available on losses of precision when lactational recordings that are more accurate than A4 were used as a comparative basis, for instance the twice-a-day weekly recording design (A1). In fact the use of test-day weekly observations would be more accurate than A4 method to evaluate actual ewe lactational yields and would allow more reliable estimates of the losses of precision associated with simplified methods.

This study simulated various strategies of simplifying milk recording, compared milk yield estimated from the supervised plans with estimates from the A4 and A1 standard

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plans, and assessed the possibilities for their use for dairy ewes. Lactation yield standardized to 120 d (L120) and to the milking period only (L30–120) were estimated and analysed.

## Materials and Methods

### *Experimental data*

A total of 3173 test-day records for milk yield from 155 Churra ewe lactations were obtained weekly from weeks 2–22 *post partum*. During the suckling period (34·2 ± 0·60 d *post partum*) lambs stayed continuously with the ewes except for the milk recording days. This recording was carried out beginning at week 2 *post partum*; before each milking, the lambs were separated from their mother for, respectively, 16 and 8 h before the corresponding a.m. (09.00) and p.m. (17.00) milkings to provide the appropriate period for milk secretion. Milkings were recorded on consecutive days to avoid an excessive period of inanition for lambs, which might later affect mammary health. Before separation from the lambs, the ewes were milked to remove residual milk. This method was similar to that used after weaning and allowed the milk yield in the suckling period to be estimated. After weaning, the ewes were milked twice a day at 09.00 and 17.00. Testing was carried out one day a week on both milkings.

Ewes belonged to the experimental flock of the University of León (Spain). They were always machine-milked, and were permanently housed with similar environmental, handling, and feeding conditions throughout the experiment.

### *Procedures*

Different testing designs were simulated from the available individual data and categorized as follows:

1. Monthly recording of the two daily milkings (A4). Individual daily milk yield (Y) was calculated from the associated a.m. production ($I_{a.m.}$) and p.m. production ($I_{p.m.}$) as

   $A4;\ Y = I_{a.m.} + I_{p.m.}$

2. Monthly recording of one fixed milking a day (AF), adjusted for the entire flock's production (AFAp) or for the interval preceding the current milking (AFAi), depending on whether the milking is a.m. or p.m. Individual daily milk yields were estimated from measurements on one milking as

   $AFAp_{a.m.};\ Y = (F'/F_{a.m.}) \times I_{a.m.}$
   $AFAp_{p.m.};\ Y = (F'/F_{p.m.}) \times I_{p.m.}$

   $AFAi_{a.m.};\ Y = (24/16) \times I_{a.m.}$
   $AFAi_{p.m.};\ Y = (24/8) \times I_{p.m.}$

   where F is the flock's production at the corresponding milking, F′ is a day's total production, and 16 and 8 are the p.m.–a.m. and a.m.–p.m. intervals in hours, respectively.

3. Monthly alternate recording without adjustment (AT), beginning with the a.m. milking ($AT_{a.m.}$) or the p.m. milking ($AT_{p.m.}$). Individual daily milk yields were estimated from measurements on one milking as

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

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

4. Monthly alternate recording adjusted for the flock's production (ATAp) or for the interval preceding the current milking (ATAi), and beginning with the a.m. milking ($ATAp_{a.m.}$ and $ATAi_{a.m.}$) or the p.m. milking ($ATAp_{p.m.}$ and $ATAi_{p.m.}$). Individual daily milk yields were estimated from measurements on one milking as

   $ATAp_{a.m.};\ Y = (F'/F_{a.m.}) \times I_{a.m.}$ for odd test-days
   $= (F'/F_{p.m.}) \times I_{p.m.}$ for even test-days

   $ATAp_{p.m.};\ Y = (F'/F_{p.m.}) \times I_{p.m.}$ for odd test-days
   $= (F'/F_{a.m.}) \times I_{a.m.}$ for even test-days

   $ATAi_{a.m.};\ Y = (24/16) \times I_{a.m.}$ for odd test-days
   $= (24/8) \times I_{p.m.}$ for even test-days

   $ATAi_{p.m.};\ Y = (24/8) \times I_{p.m.}$ for odd test-days
   $= (24/16) \times I_{a.m.}$ for even test-days

   where F is the flock's production at the corresponding milking, F′ is a day's total production, and 16 and 8 are the p.m.–a.m. and a.m.–p.m. intervals in hours, respectively. Some formulae require flock production. For this study, values of F′ were computed as the sum of the individual milk productions for the entire flock (all ewes in lactation).

The various designs of milk recording are summarized 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 period between days 31 and 75 *post partum* which, under Spanish regulations, is the designated period within which to carry out the first test-day. Milk yields per lactation were estimated and adjusted to a 120-d standard period (L120) and to the milking period only (L30–120) using the Fleischmann method, according to the following formula:

$$Y = I_1 . Y_1 + \sum_{i=2}^{i=4} I_i \frac{Y_i + Y_{i-1}}{2}$$

**Table 1.** Test-day recording plans: reference and simplified designs

| Test day | Periodicity (d) | Recorded milkings |
|---|---|---|
| A1[1] | 7 | a.m.+p.m. |
| A4[1] | 30 | a.m.+p.m. |
| AF | | |
| $AFAp_{a.m.}$ | 30 | a.m. |
| $AFAp_{p.m.}$ | 30 | p.m. |
| $AFAi_{a.m.}$ | 30 | a.m. |
| $AFAi_{p.m.}$ | 30 | p.m. |
| AT | | |
| $AT_{a.m.}$ | 30 | Alternate a.m.[2]–p.m. |
| $AT_{p.m.}$ | 30 | Alternate a.m.–p.m.[2] |
| $ATAp_{a.m.}$ | 30 | Alternate a.m.[2]–p.m. |
| $ATAp_{p.m.}$ | 30 | Alternate a.m.–p.m.[2] |
| $ATAi_{a.m.}$ | 30 | Alternate a.m.[2]–p.m. |
| $ATAi_{p.m.}$ | 30 | Alternate a.m.–p.m.[2] |

[1] Reference methods
[2] Milking the test day started with

**Table 2.** Arithmetic means of lactational milk yield records ($\overline{X}$, litres), standard deviations (SD) losses of precision ($1-R^2$) and coefficients of regression (b) for the simplified test-day modalities with regard to the A1 option

| | L120 | | | | L30–120 | | | |
|---|---|---|---|---|---|---|---|---|
| Test day | $\overline{X}$ (l) | SD | $1-R^2$ (%) | b | $\overline{X}$ (l) | SD | $1-R^2$ (%) | b |
| A1 | 142 | 30·9 | — | — | 100 | 24·6 | — | — |
| A4 | 137 | 32·8 | 18·1 | 0·852 | 97 | 24·1 | 9·4 | 0·974 |
| $AFAp_{a.m.}$ | 140 | 34·8 | 23·0 | 0·783 | 99 | 25·5 | 15·8 | 0·889 |
| $AFAp_{p.m.}$ | 141 | 38·1 | 34·6 | 0·662 | 99 | 27·1 | 23·5 | 0·792 |
| $AFAi_{a.m.}$ | 131 | 32·6 | 23·2 | 0·835 | 93 | 24·1 | 15·7 | 0·941 |
| $AFAi_{p.m.}$ | 150 | 40·6 | 36·2 | 0·610 | 105 | 28·7 | 25·6 | 0·741 |
| $AT_{a.m.}$ | 154 | 37·4 | 23·2 | 0·752 | 103 | 25·7 | 15·5 | 0·877 |
| $AT_{p.m.}$ | 121 | 31·9 | 28·6 | 0·825 | 90 | 24·3 | 17·3 | 0·920 |
| $ATAp_{a.m.}$ | 141 | 34·4 | 22·9 | 0·795 | 99 | 24·8 | 14·9 | 0·913 |
| $ATAp_{p.m.}$ | 140 | 37·5 | 31·7 | 0·683 | 99 | 26·9 | 19·9 | 0·820 |
| $ATAi_{a.m.}$ | 133 | 32·5 | 23·9 | 0·834 | 95 | 23·9 | 15·3 | 0·951 |
| $ATAi_{p.m.}$ | 149 | 40·2 | 33·1 | 0·634 | 103 | 28·1 | 22·0 | 0·772 |

where $Y$=lactational milk yield; $I_1$=interval between lambing and first test-day; $Y_1$=milk yield of first test-day; $Y_i$=milk yield of test-day $i$; and $I_i$=interval in days between test-days $i-1$ and $i$.

### *Statistical analysis*

Lactation yields (L120 and L30–120) estimated for all simplified designs (X) were compared with those from the A1 and A4 reference options (Y) by means of linear regression between Y and X according to the model Y=a+bX+E, where a=intercept, b=slope or coefficient of regression, and E=random error. Loss of precision of the simplified method was estimated as $1-R^2$ and expressed as a percentage. The analyses were carried out by the Statistical Analysis System program (SAS, 1999) using GLM and Regression procedures.

## Results and Discussion

Averages and standard deviations for total milk yield (L120 and L30–120) together with losses of precision resulting from comparison between simplified designs and the A1 design used as reference, are in Table 2. As shown in Table 2, losses of precision between estimated and observed milk yields were much higher for L120 (18·1–36·2%) than for L30–120 (9·4–25·6%). The reason was probably that the Fleischmann method estimated the milk yielded during the suckling period from the first test-day yield, multiplying that yield by the number of days from lambing to first test-day. Such an estimate would induce an important error because this period coincides with the rising phase and peak of the lactation curve (Fuertes et al. 1998; Izquierdo et al. 1969). A larger number of test-day observations in this suckling period would make herd handling more complicated and would not be feasible in practice. For this reason, the difficulty associated with estimating actual milk production during the suckling period prevents L120 estimates from being a true measure of whole lactation yield. Further indication of the improved accuracy when information from the milking period only was used were the higher coefficients of regression for this period (0·741–0·974) in comparison with whole lactation (0·610–0·852) (Table 2). Such results indicate that in dairy ewes L30–120 is predicted better and is therefore to be maintained instead of L120, according to rules of ICAR (1992).

Milk production was estimated more accurately with information from both milkings (loss of precision for A4 plan, 9·4%; Table 2). Estimating milk yield with information from only one fixed milking ($AF_{a.m.}$ or $AF_{p.m.}$) was more accurate when the a.m. milking was considered. Losses of precision were 15·8% ($AFAp_{a.m.}$) and 15·7% ($AFAi_{a.m.}$) for $AF_{a.m.}$ methods, and 23·5% ($AFAp_{p.m.}$) and 25·6% ($AFAi_{p.m.}$) for $AF_{p.m.}$ methods. Computing milk yield by adjusting for milking interval was as accurate as by adjusting for the production level. These results accord with the highest postweaning monthly within-lactation correlations found for a.m. milkings (0·537) *v.* p.m. milkings (0·430) in Churra ewes for an interval between milkings similar to that in our study (Fuertes et al. 1998). When the a.m.–p.m. interval was shorter than the p.m.–a.m. interval, prediction was better from the a.m. milking than from the p.m. milking, as reported for other species (Schaeffer & Rennie, 1976; Lee & Wardrop, 1984; Bouloc et al. 1991).

In the alternate recordings (Table 2), plans beginning with a.m. milking (14·9–15·5%) also allow better prediction than those beginning with p.m. (17·3–22·0%). When the two daily milkings are alternated, variation in a.m.–p.m. production would be compensated from one test day to another, provided the number of test-days is sufficient. Thus, when the alternate methods without adjustment

**Table 3.** Losses of precision ($1-R^2$) and coefficients of regression (b) for the simplified test-day modalities relative to the A4 option

| | L120 | | L30–120 | |
|---|---|---|---|---|
| Test day | $1-R^2$ (%) | b | $1-R^2$ (%) | b |
| $AFAp_{a.m.}$ | 7·5 | 0·900 | 6·3 | 0·917 |
| $AFAp_{p.m.}$ | 18·5 | 0·786 | 17·2 | 0·805 |
| $AFAi_{a.m.}$ | 7·8 | 0·972 | 6·6 | 0·967 |
| $AFAi_{p.m.}$ | 20·1 | 0·726 | 18·7 | 0·757 |
| $AT_{a.m.}$ | 8·0 | 0·843 | 7·2 | 0·898 |
| $AT_{p.m.}$ | 11·0 | 0·979 | 8·2 | 0·947 |
| $ATAp_{a.m.}$ | 8·4 | 0·926 | 7·3 | 0·931 |
| $ATAp_{p.m.}$ | 14·8 | 0·809 | 11·3 | 0·843 |
| $ATAi_{a.m.}$ | 7·9 | 0·975 | 7·8 | 0·969 |
| $ATAi_{p.m.}$ | 16·8 | 0·751 | 13·3 | 0·795 |

were used, the losses of precision were similar or even lower (15·5 and 17·3%) than for corrected methods (14·9–22·0%). The highest regression coefficients of the simplified methods corresponded to $ATAi_{a.m.}$ method (b=0·951), for which the loss of precision in comparison with A1 method was 15·3%. These results indicate greater accuracy when the simplified recordings began with the a.m. milking rather than with the p.m. milking, as found by Gabiña et al. (1986). Thus, given the importance of the first test-day in dairy ewes, these authors proposed the supervision of both a.m. and p.m. milkings in the first visit before adopting a simplified recording plan in subsequent visits, with the aim of increasing the precision of lactational recordings.

Table 3 shows a comparison of all of the schemes with A4 method, where the information on the two daily milkings are available. In all cases deviations between estimated and observed milk yields were noticeably lower than those for the comparison on the basis of A1 recording. For L30–120, the lowest losses of precision and the highest coefficients of regression were obtained for $AFAp_{a.m.}$ (6·3% and 0·917), $AFAi_{a.m.}$ (6·6% and 0·967), $AT_{a.m.}$ (7·2% and 0·898), $ATAp_{a.m.}$ (7·3% and 0·931), $ATAi_{a.m.}$ (7·8% and 0·969), and $AT_{p.m.}$ (8·2% and 0·947), in accordance with the results in Table 2. These errors were even greater than those found by Gabiña et al. (1986) who compared simplified methods with A4 method in Latxa ewes for a 12-h interval between milkings. However, if we take into account that A1 method is much more accurate than A4 to estimate the precision of simplified methods, and that in Churra ewe flocks the interval between milking is similar to that in our study, then the errors we found (Table 2) will be closer to actual fact. Consequently, errors ⩾15% must be assumed when only 4 out of 180 milkings are recorded throughout lactation.

In conclusion, errors were associated with simplified plans, including the A4 one, in relation to weekly information. Results showed that milk yield throughout lactation was better represented by L30–120 than by L120. Additionally, when only one milking was measured, milk yield was predicted with greater accuracy from the recording plans beginning with, or based exclusively on, the a.m. milking than from the other strategies. There were no statistical grounds to support an improvement in sampling accuracy by adjusting for the preceding interval or production level. The monthly alternate plan without adjustment is preferable for both practical and economic reasons.

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