

Extension Factors for Incomplete Lactations of Serra-da-Estrela Sheep¹

F. J. DELGADO
Escola Superior Agraria
3000 Coimbra, Portugal

T. G. MARTIN
Department of Animal Sciences
Purdue University
West Lafayette, In 47907

ABSTRACT

Data for 6537 lactations of 2335 Serra-da-Estrela ewes representing 41 flocks (1966 to 1985) were obtained from the Milk Recording Scheme conducted by the Portuguese Ministry of Agriculture. The suckling period averaged 32 d, and ewes were milked for approximately 200 d after the suckling period. Individual test day yields for 1548 lactations of 600 ewes from 32 flocks (1975 to 1985) were used to define the shape of the lactation curve. A third-order polynomial and an exponential function were equally accurate in describing the shape of the lactation curve in the postsuckling period. A considerable number of incompletely recorded lactations occur, and, with extension factors, these incomplete lactations could be used in genetic evaluation. Factors based on both partial lactation yield and last test day yield were developed. Use of these factors should be restricted to partial lactations of at least 75 d with 2 test days. An alternative of recording only postweaning yield was proposed. (Key words: extension factor, incomplete lactation, sheep)

Abbreviation key: MPY = milking period yield, MRS = Milk Recording Scheme, PLY = partial lactation yield, SPY = suckling period yield, TLY total lactation yield.

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INTRODUCTION

A high value cheese is produced from sheep's milk in the Serra-da-Estrela region of Portugal. The local breed of dairy sheep, the Serra-da-Estrela, is the principal breed of dairy sheep in Portugal. In order to promote higher yield per ewe, the Ministry of Agriculture initiated a Milk Recording Scheme (MRS) in 1945. Lambs nurse the ewes until weaning at an average age of 32 d. Ewes are then milked for approximately 200 d.

The MRS weighing of milk begins in August and ends on June 20 when ewes are taken to mountain pasture for the summer. The lambing season is concentrated in September and October when 56% of the lambings occur. However, about 20% of the lambings occur after December, and those ewes have incompletely recorded lactations. This causes a considerable loss of lactation data that could be used in the estimation of breeding values. The objectives of this study were 1) to derive estimates of parameters that describe lactation characteristics of the Serra-da-Estrela breed and 2) to develop factors that could be used to extend incomplete lactations and adjust lactations of variable duration to a standard length.

DATA SOURCE AND ANALYSIS

Data were obtained from the MRS of the Serra-da-Estrela breed. The general data set consisted of 6537 lactations of 2335 ewes from 41 flocks during 1966 to 1985. Total lactation yield (TLY, as calculated by MRS), age at lambing, litter size, and days of lactation (postpartum) were recorded. A least squares model that included main effects of flock, year, and month of parturition was used to derive estimates of means and standard deviations for these traits.

The test day data set consisted of data on 9966 individual test days for 1661 lactations of 644 ewes from 32 flocks during 1975 to 1985. Data for each test day included daily yield and days postpartum, and data for each lactation included TLY, age at lambing, litter size, days of lactation, 150-d yield, and length of suckling period. The lactation data were analyzed by the model just described.

The TLY, as estimated by MRS, consists of suckling period yield (SPY) and milking period yield (MPY).

$$\widehat{\text{SPY}} = \frac{d_1 \times T_1}{M}$$

where

M = Montanaro (12) factor (Table 1),
 d_1 = days postpartum at first test day, and
 T_1 = first test day yield.

Yield in later periods is estimated by back projection. If the second test day is d_2 and second test day yield is T_2 , MRS calculates second period yield (Y_2) as

$$\hat{Y}_2 = (d_2 - d_1)T_2$$

and TLY as SPY plus MPY

$$\widehat{\text{TLY}} = \widehat{\text{SPY}} + \sum_{i=2}^L \hat{Y}_i.$$

This method of calculation places excessive weight on first test day yield, produces downward biased estimates of MPY, and is subject to error in estimating SPY.

Based on reports concerning the shape of lactation curves of dairy cows (8, 9, 13), water buffalo (14), and sheep (10), two equations were derived for each of four age groups of ewes (1, 2, 3 to 5, and >5 yr). Within lactation, test day milk yield (T) was expressed as a function of days postpartum (d) by 1) the third-order polynomial, $T = a + b_1d + b_2d^2 + b_3d^3$, where a describes the intercept and b_1 , b_2 , and b_3 are regression coefficients and 2) an exponential function, $\hat{T} = Ae^{bd}$, where A is the intercept, e is the base of natural logarithms, and b is a decay function. The exponential function was fitted as $\log T = \log A + bd$.

The expected shape of the lactation curve was one that peaked around wk 3 of lactation (5, 12). In these data, the number of very early test day yield records was small because the average suckling period was 32 d. Only 15% of first test days occurred in the interval (16 to 25 d postpartum) when the peak was expected. Consequently, the gamma function was not investigated in this study. Accuracies of the equations were compared by estimating within-lactation correlations between actual test day yield and predicted test day yield and standard errors of estimate of predicted individual test day yields.

Methods of extending incomplete lactation records have been evaluated (1, 15, 16). Based on lactation curves estimated from the data, extension factors based on both partial lactation yield (PLY) and last test day were developed for application to MRS records.

RESULTS AND DISCUSSION

Analysis of variance of MRS data on TLY included in the general and test day data sets yielded estimates of means and standard deviations in Table 2. Lactation length was in excess of 200 d and highly variable. Lactation length was influenced by month of lambing ($P < .01$); longest lactations were associated with August to October parturition. Ewes lambing later in the season had shorter lactations because of the June 20 termination of testing. Suckling period also was highly variable and longest for ewes lambing in the fall ($P < .01$). Increased length of suckling period greatly increased the probability of error associated with estimating SPY.

Polynomial and exponential equations were fitted, within lactation, to the test day data for each of four age groups of ewes. The appropriate age group function and lactation constant were used to estimate each test day yield. Standard errors of estimate ranged from 39 to 49 g, which represented errors less than 6%. The correlations and standard errors of estimate (Table 3) were very similar for both functions and across age groups.

The equation, across all ages, for the polynomial was

$$\hat{T} = 1259 - 6.50d + .0183d^2 - .00003d^3;$$

TABLE 1. Montanaro (12) factors (M) for estimating suckling period yield (SPY) from first test day yield.

Interval	Daily yield for	Average	Factor M ¹	SPY to day n ²
	days n - 4 to n	daily yield to day n - 5		
	(g)			(kg)
1-5	726			3.6
6-10	829	726	1.14	7.3
11-15	869	778	1.12	11.6
16-20	852	808	1.06	16.1
21-25	816	819	1.00	20.4
26-30	771	818	.94	24.6
31-35	680	811	.84	28.3
36-40	635	792	.81	31.4
41-45	586	772	.77	34.2
46-50	570	752	.76	37.5
51-55	531	733	.74	39.5
56-60	481	715	.68	42.4

¹Column 2 divided by column 3.

²n × column 2/1000 (M).

all terms accounted for significant ($P < .001$) variation. However, the parameters varied greatly among ages (i.e., b_1 from -3.6 to -9.6). The integral of that function between d 0 and 200 was 158.6 kg, which was slightly greater than TLY means shown in Table 2.

The across ages exponential equation was

$$T = 1212e^{-.0055d}$$

The equations were consistent across age groups of ewes ($b = -.0053$ to $-.0061$), and estimated parameter values differed ($P < .01$) from zero in all age groups (Table 4).

The integral of this function was 147.0 kg for 200-d TLY. This value was essentially

equal to the MRS means (Table 2). The exponential equation was chosen as the basis for development of extension factors for incomplete lactations.

Using the four age group equations in Table 4, integrals of Ae^{bd} were evaluated between 0 to 60 d, 0 to 65 d, and succeeding intervals increasing by 5-d increments (0 to 70, 0 to 75, etc.) to 0 to 200 d in order to obtain estimates of cumulative yield to 60, 65, . . . , 195, and 200 d. Two standard lactation lengths were chosen (150 and 200 d) for development of multiplicative extension factors. Extension factors were estimated as the ratio (integral to a standard length:integral to an incomplete point).

TABLE 2. Least squares means and standard deviations of lactation traits derived in analyses of the general and test day data sets.

Trait	General			Test day		
	(n)	\bar{X}	SD	(n)	\bar{X}	SD
Age lambing, mo	6537	45.9	22.7	1548	45.8	21.9
Litter size	3377	1.16	.37	1659	1.25	.43
Lactation length, d ¹	6537	212.3	63.5	1661	220.6	39.6
Lactation yield, kg ²	6537	147.9	74.3	1661	145.8	66.5
150-d Yield, kg ²				1661	112.7	53.1
Suckling period, d ¹				1654	32.4	19.2

¹Days postpartum.

²No adjustment for lactation length or length of suckling period.

TABLE 3. Standard errors of estimates (grams) of predicted test day yield and correlations between actual test day yield and test day yield predicted by the polynomial and exponential functions in four age groups of ewes.

Age group	Function			
	Polynomial		Exponential	
	SE	r	SE	r
1 yr	45	.68	44	.70
2 yr	42	.73	41	.75
3 to 5 yr	39	.77	39	.77
>5 yr	41	.75	41	.75
All ages	41	.75	40	.76

In virtually every case, comparable extension factors for different age groups of ewes, within a given standard length lactation, were equal at the second decimal digit. The third digit was retained, and extension factors were averaged across age groups of ewes to develop the multiplicative extension factors (Table 5) based on PLY.

Yield on the last test day (T_L) has been shown to be more efficient than PLY as an estimator of remaining yield (1, 15, 16). In the case of MRS records used in this study, any error in estimating SPY would be magnified by use of multiplicative factors for PLY. Exponential curves were based on test days in the declining phase of lactation, and extrapolation from last test day would be subject to less error. Then TLY would be estimated as

$$\widehat{TLY} = PLY + c(d_S - d_L)T_L$$

where

- c = extension factor,
- d_S = days in a standard lactation,
- d_L = day of last test, and
- T_L = last test day yield.

Factors (c) were derived for each age group curve and averaged to obtain the values in Table 5.

The exponential equation provided an adequate description of the postweaning lactation curve of Serra-da-Estrela dairy sheep. Because the equation does not predict a postlambing yield peak, it cannot be utilized to estimate SPY. In one review (4), several methods of estimating milk yield during the suckling pe-

riod were described, but none was completely satisfactory. The Montanaro (12) yields (Table 1; d 15 to 60) were used to fit an exponential curve with an exponential regression of $-.0137$. The corresponding postweaning value found in this study was $-.0055$. Assuming $-.0055$ to be the appropriate value to estimate yield 30 to 60 d postpartum, use of the Montanaro factors to estimate 60 d SPY would overestimate 30- to 60-d yield by 55% and bias the estimate of 200-d yield upward by approximately 10%. Daily milk yield may decline as much as 30% at time of transition from suckling to milking (11).

The TLY is composed of SPY plus MPY. If these two are considered to be separate traits, the function of SPY is the production of a lamb for market or as a flock replacement. The function of MPY is production of milk for making cheese. Total production of the ewe is composed of weight of lamb weaned and yield of milk. Following this concept, lactation yield should be expressed as MPY. This recommendation to MRS is in agreement with an official proposal of the International Committee for Animal Recording (2) that SPY be excluded in reporting sheep lactation records. Research reports on sheep lactation yields of the La-caune breed in France (3), the Massese breed in Italy (7), and 10 breeds in the US (6) were based on estimates of lactation yield that excluded SPY.

The MPY should be standardized, relative to parturition date, with regard to both beginning and ending times. Based on the mean and variation for length of suckling period (Table 2), it would be logical to express yield as milk yielded between 30 and 200 d postpartum. When lambs are weaned later than 30 d, and the lactation is terminated prior to 200 d post-

TABLE 4. Estimates of parameters of the exponential equation for four age groups of ewes.

Age group	A	b	SE
1 yr	1160	$-.0061^*$.0003
2 yr	1202	$-.0055^*$.0003
3 to 5 yr	1253	$-.0055^*$.0002
>5 yr	1137	$-.0053^*$.0002
All ages	1212	$-.0055^*$.0002

*Differs from zero ($P < .001$).

TABLE 5. Factors for extension of incomplete lactations of Serra-da-Estrela ewes based on partial lactation yields and last test day yields.

Lactation length	Factors for adjustment of yields			
	Partial yields to		Last test day yields to	
	150 d	200 d	150 d	200 d
(d)				
60	1.99	2.36	.789	.697
65	1.86	2.21	.799	.706
70	1.75	2.08	.809	.714
75	1.66	1.96	.819	.723
80	1.57	1.86	.830	.732
85	1.50	1.78	.841	.741
90	1.44	1.70	.852	.750
95	1.38	1.63	.863	.760
100	1.33	1.57	.874	.769
105	1.28	1.51	.886	.779
110	1.24	1.46	.898	.789
115	1.20	1.42	.910	.799
120	1.16	1.38	.923	.809
125	1.13	1.34	.935	.819
130	1.10	1.30	.948	.830
135	1.07	1.27	.960	.841
140	1.05	1.24	.974	.852
145	1.02	1.21	.989	.863
150	1.00	1.19		.874
155		1.16		.886
160		1.14		.897
165		1.12		.909
170		1.10		.921
175		1.08		.934
180		1.06		.946
185		1.04		.959
190		1.03		.972
195		1.01		.986
200		1.00		

partum, the lactation would need to be extrapolated to estimate both the early and late periods. Following the reasoning presented earlier, it would be logical to express the early period as a function of first test day yield and the late period as a function of last test day yield.

$$\widehat{MPY} = PLY + c_1 (d_1 - 30)T_1 + c_2(200 - d_L)T_L.$$

The c_2 adjustment factors are in column 4 of Table 5. The c_1 factors for 35, 40, 45, 50, 55, and 60 d, respectively, are 1.012, 1.027, 1.042, 1.056, 1.071, and 1.087.

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