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Research Article

Calculation of Adjustment Factors for Standardizing Lactations to Mature Age and 305-Day and Estimation of Heritability and Repeatability of Standardized Milk Yield of Simmental Cattle Reared on Kazova State Farm

Süleyman ÇİLEK[1], Mehmet Emin TEKİN[2,*]

[1]Suşehri Vocational School, Cumhuriyet University, Sivas - TURKEY

[2]Department of Animal Science, Faculty of Veterinary Medicine, Selçuk Üniversity, Konya - TURKEY

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Abstract: Adjustment factors of lactation milk yield to mature age and 305-day were calculated and heritability and repeatability of milk yield were estimated for Simmental cows reared on Kazova State Farm. A total of 1549 lactation records of Simmental cows reared on Kazova State Farm between 1992 and 2002 were used. The factors for standardizing incomplete lactations to 305-day were estimated by taking 7 calving age groups into consideration (2, 3, 4, 5, 6-8, 9 and 10 years of age and older). The factors for standardizing to mature equivalent estimated by polynomial regression are between the 24th and 143rd month and older.

The repeatability of milk yield was estimated as 0.44 ± 0.028 using intra- class correlation. Heritability of milk yield was estimated using paternal half-sib correlation. Heritability of milk yield for all lactations was estimated as 0.24 ± 0.08. Heritability for first lactation was estimated as 0.30 ± 0.154.

Key Words: Simmental, milk yield, adjustment factors, repeatability, heritability

Kazova Tarım İşletmesinde Yetiştirilen Simental Irkı Sığırların Süt Veriminin Ergin Çağ ve 305 Güne Göre Düzeltme Katsayıları ile Tekrarlama ve Kalıtım Derecelerinin Tahmin Edilmesi

Özet: Bu çalışmada, Kazova Tarım İşletmesinde yetiştirilen Simental ırkı ineklerin süt veriminin 305 gün ve ergin çağa göre düzeltme katsayıları ile tekrarlama ve kalıtım dereceleri tahmin edilmiştir. İşletmede, 1992-2002 yılları arasında yetiştirilen sığırlara ait 1549 laktasyon kaydı kullanılmıştır. Süt verimini 305 güne göre düzeltme katsayıları 7 yaş grubu (2, 3, 4, 5, 6-8, 9, ve 10 yaş ve üzeri) dikkate alınarak hesaplanmıştır. Polinom metodu ile hesaplanan ergin çağa göre düzeltme katsayıları 24. ay ile 143. ay ve daha yukarısı arasındadır.

Süt veriminin tekrarlama derecesi sınıf içi korelasyon metodu ile 0,44 ± 0,028 olarak tahmin edilmiştir. Kalıtım derecesi baba bir üvey kardeşler metodu ile tahmin edilmiştir. Kalıtım derecesi bütün laktasyonlar için 0,24 ± 0,08 olarak; birinci laktasyon için 0,30 ± 0,154 olarak tahmin edilmiştir.

Anahtar Sözcükler: Simmental, süt verimi, düzeltme katsayıları, tekrarlama derecesi, kalıtım derecesi

Introduction

In animal breeding, selection is an important way to improve animal yield. For the accurate selection of bulls and cows that will be given an opportunity to calve in the next generation, yield records must be obtained. Before yield records are used for selection, they must be standardized according to known environmental factors. The most important environmental factors in selection for milk yield are lactation duration, calving age and milking frequency. Standardized records according to these factors will raise accuracy in selection as they reflect the genetic structure of animals. In addition, standardized

*E-mail: mtekin@selcuk.edu.tr

records are used in the estimation of heritability, repeatability and breeding value.

When the breeding values of bulls are estimated, lactation durations of some daughters and mothers may be shorter than 305 days. Not taking these records into consideration may cause errors in the evaluation of bulls. Therefore, incomplete lactation milk yields must be standardized to a 305-day basis (1). For 2 -year - old cows calving in winter, adjustment factors to 305-day for 30, 152 and 274-day milk yields were estimated respectively as 7.30, 1.60 and 1.00 for Brown Swiss by Eker et al. (2); 7.51, 1.66 and 1.05 for Holstein by Kesici et al. (3); and 8.08, 1.69 and 1.08 for Jersey by Şekerden (4).

Milk yield increases with age until maturity and then slowly declines. Therefore, if it is asked to compare the genetic merit of different aged cows, milk yield must be standardized according to their calving ages. Adjustment factors for milk yield to mature age for calving age 25, 80 and 100 months were reported as 1.49, 1.00 and 1.10, respectively, for Brown Swiss cows (2). Likewise, adjustment factors for milk yield to mature age for calving age 25, 75 and 100 months were noted as 1.57, 1.00 and 1.07, respectively, for the Holstein breed (3). Aydın (5) recorded the adjustment factors for milk yield to mature age for calving age 25, 75, 84 and 100 th months as 1.31, 1.01, 1.00 and 1.06, respectively, for Brown Swiss cows.

Before female culling, real breeding values of the animals in the herd must be determined and then culling must be done according to this. While the real breeding value of any animal is being determined, repeatability should be known (6,7). Repeatability of milk yield was reported between 0.14 and 0.71 for different breeds and herds (5,6,8-10).

While bulls or cows are being selected for breeding, in addition to their high yielding capability, their ability to transfer high yield to their progeny is considered by breeders. Heritability is the value of the parent's capability to transfer their yielding capacity to their progeny. During selection, the heritability of the trait must be known. Heritability helps one to determine the suitable selection method for the improvement of yield. Heritability of milk yield for all lactations was reported between 0.20 and 0.65 (5,6,9-12). Heritability of first lactation milk yield was reported between 0.166 and 0.40 (8,13,14).

In this study, it was aimed to calculate the adjustment factors for standardizing lactations to mature age and 305-day and to estimate the heritability and repeatability of standardized milk yield for the Simmental cows reared on Kazova State Farm.

Materials and Methods

Lactation records between 1992 and 2002 of Simmental cows reared on Kazova State Farm, which is owned by the Ministry of Agriculture, were used. Using the formulas below, lactation milk yield and lactation duration were calculated by taking the results of monthly milk yield tests on the farm with the Holland method (3).

$$X = \left(\sum_{i=1}^{n} \frac{K_i}{n}\right) x\, L$$

$L = n \times 30.4 - (15.2 - A)$

L = Lactation duration (day)

n = Test day number

A = Time from calving to first test (day)

X = Lactation milk yield (kg)

K_i = Milk yield of i^{th} test day (kg)

In lactations tested monthly more than 10 times, milk yields were calculated from the first 10 test milk yields. Lactations tested monthly less than 7 times were not used in the calculation. Adjustment factors to a 305-day basis for lactations less than 305 days were calculated using 1549 lactation records. Lactations completed before 305 days due to drying off spontaneously were regarded as 305-day milk yield.

To determine adjustment factors to 305-day for different ages, 7 groups were formed, based on lactations started at 2, 3, 4, 5, 6-8, 9, and 10 years of age and older. Daily milk yield was recorded once every month for each cow. Records were collected for 10 months. For each group the average values representing the first, second, third … up to the tenth month were calculated. Then the average of each group was accumulated subsequently as given below. Afterwards, all the average values calculated for each month were added to obtain the sum of averages (total).

$$\frac{\text{Total}}{1^{st}\ \text{Test}}, \frac{\text{Total}}{1^{st} + 2^{nd}\ \text{Test}} \ldots., \frac{\text{Total}}{1^{st} + 2^{nd} \ldots + 10^{th}\ \text{Test}}$$

Finally, the sum of averages for all test days' milk yield was divided by each accumulated average to estimate the rate for each test day. These ratios were adjustment factors to 305-day milk yield respectively for 30, 61, 91, 122, 152, 182, 213, 243, 274 and 305-day milk yields. For the other days that were not taken into consideration (40^{th}, 50^{th}, 60^{th} ... 290^{th} and 300^{th}), adjustment factors were calculated by linear interpolation. Similarly, for lactations longer than 305 days, adjustment factors to 305-day were calculated with 10-day intervals using 989 lactation records. As the numbers of animals in age groups were small, age groups were not taken into consideration.

Adjustment factors to mature age were calculated by polynomial regression and 1549 lactation records were used in the calculation. For the calculation of adjustment factors to mature age, 120 age groups beginning from the 24^{th} month and finishing at the 143^{rd} month were formed. Adjustment factors to mature age were estimated using regression analysis in Minitab (6).

Milking frequency is another important environmental factor affecting milk yield. If milking frequency increases, milk yield increases. In this study, adjustment factors for milking frequency are not needed, because the cows in this farm were milked twice a day.

In the calculation of repeatability for milk yield, 1379 lactation records of cows that had at least 2 lactations were used. Standardized milk yields were used and repeatability was estimated by intra-class correlation (7).

After records were standardized to mature age and a 305-day basis, they were standardized for year and season, the effects of which were significant, and then heritability was estimated. Heritability of milk yield for all lactations was estimated from 1169 standardized lactation records of cows sired by 36 bulls that had at least 10 daughters. Heritability of first lactation milk yield was estimated by paternal half-sib method (7) from 367 first lactations of cows sired by 23 bulls that had at least 5 daughters.

Results

For lactations less than 305 days, adjustment factors to 305-day milk yield, for 7 age groups and for each 10 days from the 30^{th} day to the 305^{th} day are presented in Table 1. For lactations more than 305 days, adjustment factors to 305-day milk yield are presented in Table 2. Mean adjustment factor for the 30^{th} day was 8.12 and for the 305^{th} day was 1.00 as expected.

In the calculation for adjustment factors to mature age, the regression equation was determined as Milk Yield = $3135 + 37.3\ x - 0.176\ x^2$. For monthly age groups (X), expected milk yield and adjustment factors to mature age are presented in Table 3. The highest milk yield (5111 kg) was in cows calving at 104-108 months of age and this yield was regarded as mature age yield. This yield was divided by milk yield of the other monthly ages and adjustment factors to mature age for each age group were calculated. Adjustment factors to mature age were 1.30 for a cow that calved in the 24^{th} month and 1.05 for another cow that calved in the 143^{rd} month. This finding suggested that the milk yield of the youngest cattle will be multiplied by 1.30, and milk yield of the oldest cattle (calving in the 143^{rd} month) will be multiplied by 1.05 to estimate the milk yield at mature age.

In the calculation of repeatability, the variance analysis results are presented in Table 4. The average lactation record number (k) was estimated as 3.79. From Table 4, total variance (σ^2_{total}) and variance between cows (σ^2_a) were found as 2,068,845.6 and 912,207.6 respectively. Then repeatability (r) was calculated as 0.44 by dividing σ^2_a / σ^2_{total}. The standard error of repeatability (S_r) was estimated as 0.028.

The variance analysis results for heritability of first lactation milk yield are presented in Table 5. The average daughter number for each bull (k) was 15.77. Total phenotypic variance (σ^2_{total}) was 1,777,906.07 and variance between bulls (σ^2_a) was 133,557.07. Then the correlation coefficient within bulls (t) was calculated by dividing σ^2_a /σ^2_{total} and was found as 0.075. Heritability was found as 0.30 from the equation $h^2 = 4\ t$. The standard error of the correlation coefficient within bulls (S_t) was estimated as 0.0385. This value was multiplied by 4 and the standard error of heritability for first lactation milk yield (S_h^2) was found as 0.154.

The variance analysis for the estimation of heritability for all lactation milk yields is presented in Table 6. The average daughter number for each bull (k) was 32.2. Total phenotypic variance (σ^2_{total}) and variance between bulls (σ^2_a) were 1,204,732.4 and 71,432.4, respectively, and the correlation coefficient within bulls (t) was

Table 1. Adjustment factors to 305-day milk yield for lactations less than 305 days.

Lactation duration (day)	Calving age of cow (year)							
	2	3	4	5	6-8	9	10+	Means*
30	8.64	8.48	8.16	7.92	7.92	7.91	7.85	8.12
40	7.26	7.13	6.87	6.67	6.67	6.65	6.60	6.84
50	5.89	5.79	5.57	5.43	5.42	5.39	5.35	5.55
60	4.52	4.44	4.28	4.18	4.17	4.13	4.11	4.26
70	3.96	3.89	3.75	3.67	3.66	3.62	3.60	3.74
80	3.49	3.44	3.31	3.24	3.24	3.19	3.16	3.29
90	3.02	2.98	2.86	2.81	2.81	2.77	2.76	2.86
100	2.77	2.72	2.63	2.58	2.58	2.55	2.53	2.62
110	2.54	2.48	2.41	2.38	2.37	2.35	2.33	2.41
120	2.31	2.24	2.20	2.18	2.16	2.15	2.13	2.20
130	2.15	2.09	2.05	2.04	2.02	2.01	1.99	2.05
140	2.01	1.95	1.92	1.91	1.90	1.89	1.87	1.92
150	1.87	1.82	1.79	1.78	1.77	1.76	1.75	1.79
160	1.76	1.72	1.70	1.69	1.68	1.67	1.66	1.70
170	1.67	1.63	1.61	1.60	1.59	1.59	1.58	1.61
180	1.58	1.54	1.52	1.52	1.51	1.51	1.50	1.52
190	1.50	1.47	1.46	1.45	1.45	1.45	1.43	1.46
200	1.44	1.41	1.39	1.39	1.39	1.39	1.38	1.40
210	1.37	1.35	1.33	1.33	1.33	1.33	1.32	1.34
220	1.32	1.30	1.28	1.28	1.28	1.28	1.27	1.29
230	1.27	1.25	1.24	1.24	1.24	1.24	1.23	1.24
240	1.22	1.21	1.19	1.19	1.19	1.19	1.19	1.20
250	1.18	1.17	1.16	1.16	1.16	1.15	1.15	1.16
260	1.14	1.13	1.12	1.12	1.12	1.12	1.12	1.13
270	1.10	1.10	1.09	1.09	1.09	1.09	1.09	1.09
280	1.07	1.07	1.06	1.06	1.06	1.06	1.06	1.06
290	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
300	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
305	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* Adjustment factors calculated by not taking the age groups into consideration

Table 2. Adjustment factors to 305-day milk yield for lactations more than 305 days.

Lactation Duration (day)	Adjustment Factors	Lactation Duration (day)	Adjustment Factors	Lactation Duration (day)	Adjustment Factors
310	0.99	410	0.79	510	0.65
320	0.97	420	0.77	520	0.63
330	0.94	430	0.76	530	0.62
340	0.92	440	0.74	540	0.61
350	0.90	450	0.73	550	0.60
360	0.88	460	0.72	560	0.59
370	0.86	470	0.70	570	0.58
380	0.84	480	0.69	580	0.57
390	0.83	490	0.68	590	0.56
400	0.81	500	0.66	600	0.54

Table 3. Adjustment factors to mature age milk yield.

Calving Age (month)	Expected Milk Yield (kg)	Adjustment factors	Calving Age (month)	Expected Milk Yield (kg)	Adjustment factors	Calving Age (month)	Expected Milk Yield (kg)	Adjustment factors
24	3929	1.30	64	4801	1.06	104	5111	1.00
25	3958	1.29	65	4816	1.06	105	5111	1.00
26	3986	1.28	66	4830	1.06	106	5111	1.00
27	4014	1.27	67	4844	1.06	107	5111	1.00
28	4041	1.26	68	4858	1.05	108	5111	1.00
29	4069	1.26	69	4871	1.05	109	5110	1.00
30	4096	1.25	70	4884	1.05	110	5108	1.00
31	4122	1.24	71	4896	1.04	111	5107	1.00
32	4148	1.23	72	4908	1.04	112	5105	1.00
33	4174	1.22	73	4920	1.04	113	5103	1.00
34	4200	1.22	74	4931	1.04	114	5100	1.00
35	4225	1.21	75	4943	1.03	115	5097	1.00
36	4250	1.20	76	4953	1.03	116	5094	1.00
37	4274	1.20	77	4964	1.03	117	5090	1.00
38	4298	1.19	78	4974	1.03	118	5086	1.00
39	4322	1.18	79	4983	1.03	119	5081	1.01
40	4345	1.18	80	4993	1.02	120	5077	1.01
41	4368	1.17	81	5002	1.02	121	5071	1.01
42	4391	1.16	82	5010	1.02	122	5066	1.01
43	4413	1.16	83	5018	1.02	123	5060	1.01
44	4435	1.15	84	5026	1.02	124	5054	1.01
45	4457	1.15	85	5034	1.02	125	5048	1.01
46	4478	1.14	86	5041	1.01	126	5041	1.01
47	4499	1.14	87	5048	1.01	127	5033	1.02
48	4520	1.13	88	5054	1.01	128	5026	1.02
49	4540	1.13	89	5061	1.01	129	5018	1.02
50	4560	1.12	90	5066	1.01	130	5010	1.02
51	4580	1.12	91	5072	1.01	131	5001	1.02
52	4599	1.11	92	5077	1.01	132	4992	1.02
53	4618	1.11	93	5082	1.01	133	4983	1.03
54	4636	1.10	94	5086	1.00	134	4973	1.03
55	4654	1.10	95	5090	1.00	135	4963	1.03
56	4672	1.09	96	5094	1.00	136	4953	1.03
57	4689	1.09	97	5097	1.00	137	4942	1.03
58	4706	1.09	98	5100	1.00	138	4931	1.04
59	4723	1.08	99	5103	1.00	139	4919	1.04
60	4739	1.08	100	5105	1.00	140	4907	1.04
61	4755	1.07	101	5107	1.00	141	4895	1.04
62	4771	1.07	102	5108	1.00	142	4883	1.05
63	4786	1.07	103	5110	1.00	143	4870	1.05

Table 4. Variance analysis for repeatability.

Source	Degree of Freedom (DF)	Means of Squares (MS)	Variance Components (VC)
Between cows	363	4,610,256	$\sigma^2_i + k\,\sigma^2_a$
Within cows	1015	1,156,638	σ^2_i
Total	1378		

Table 5. Variance analysis of first lactation milk yield.

Source	Degree of Freedom (DF)	Means of Squares (MS)	Variance Components (VC)
Between bulls	22	3,750,544	$\sigma^2_i + k\,\sigma^2_a$
Within bulls	344	1,644,349	σ^2_i
Total	366		

Table 6. Variance analysis for heritability of milk yield for all lactations.

Source	Degree of Freedom (DF)	Means of Squares (MS)	Variance Components (VC)
Between bulls	35	3,434,853	$\sigma^2_i + k\,\sigma^2_a$
Within bulls	1133	1,133,300	σ^2_i
Total	1168		

0.0593. Heritability for all lactation milk yields was 0.24. The standard error of heritability for all lactation milk yields was 0.08.

Discussion

Although there were some differences between adjustment factors estimated in this study and those in other studies (2-4), the results were similar. The adjustment factor estimated in this study for the 30th day was 1.34 higher than for Brown Swiss (2) and 0.56 higher than for Jersey (4). As lactation duration increases, these differences decline.

As expected, adjustment factors to mature age milk yield diminished from the youngest age to mature age, and then slowly increased. Adjustment factors to mature age were the highest in the 24th month and the smallest at mature age (104-108 months). The adjustment factor estimated in this study for the 25th month was 0.06 and 0.27 less than that for Brown Swiss (5) and Holstein (3), respectively. These differences decreased from younger ages to mature age. In this study, from young ages to mature age, adjustment factors to mature age were similar to adjustment factors estimated for Brown Swiss by Aydın (5). Mature age was earlier for Brown Swiss than for Simmental. This might be the reason, after mature age, for adjustment factors to mature age for Brown Swiss (5) being 0.01 and 0.06 higher than those for Simmentals. According to these results, adjustment factors to mature equivalent and 305-day basis must be estimated independently for breed, herd and area.

Repeatability of milk yield was estimated as 0.44 ± 0.028 and at a high level. Repeatability estimated in this study was near the highest limit in the literature (5,6,8-10). In agreement with the literature (6,12) repeatability was higher than heritability. Repeatability, which was estimated for the first time at this farm, can give a route for breeding, as it was taken from large data set. In other words, culling in the herd may be done according to the first lactation records. After first lactation milk yield was standardized according to environmental effects, it may be an accurate measurement in selection for milk yield in dairy cattle.

In this study, heritability of all lactation milk yields and heritability of first lactation milk yield were estimated at medium level and within the limits in the literature (5,6,8-14). Arıtürk and Yalçın (7) reported that for heritability to be reliable the standard error of heritability should be less than half of it. The results in this study are in accordance with this rule. Therefore, in these results, a large data set was used and lactations were standardized to environmental factors. For reliable calculations by paternal half-sib correlation, all necessary conditions (selection of bulls by chance, breeding in the same environmental conditions, coefficient of relationship) were performed apart from the relationship in the herd (15).

Heritability estimated for all lactations in this study was smaller than the heritability estimated as 0.52 at this farm by Şekerden and Erdem (11). This may be the result of the wide range of lactation records used (1169) and lactations being standardized for year and season, the effects of which were significant, in the present study.

Adjustment factors were estimated in this study for the first time for Simmental cattle reared in Turkey. As a wide range of lactation records (1549) were used, estimated adjustment factors may be used reliably in the selection and culling of Simmental cattle reared on this farm. Furthermore, as there are no adjustment factors for Simmental cows reared in Turkey, the adjustment factors estimated might be used for Simmental cows reared on other farms in this country. As repeatability was high, cows may be evaluated according to first milk yield records in culling. Heritability of milk yield for all lactations and first lactations were at medium level. Therefore, both individual and relative yield at this farm ought to be taken into consideration when selecting cows for milk yield.

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