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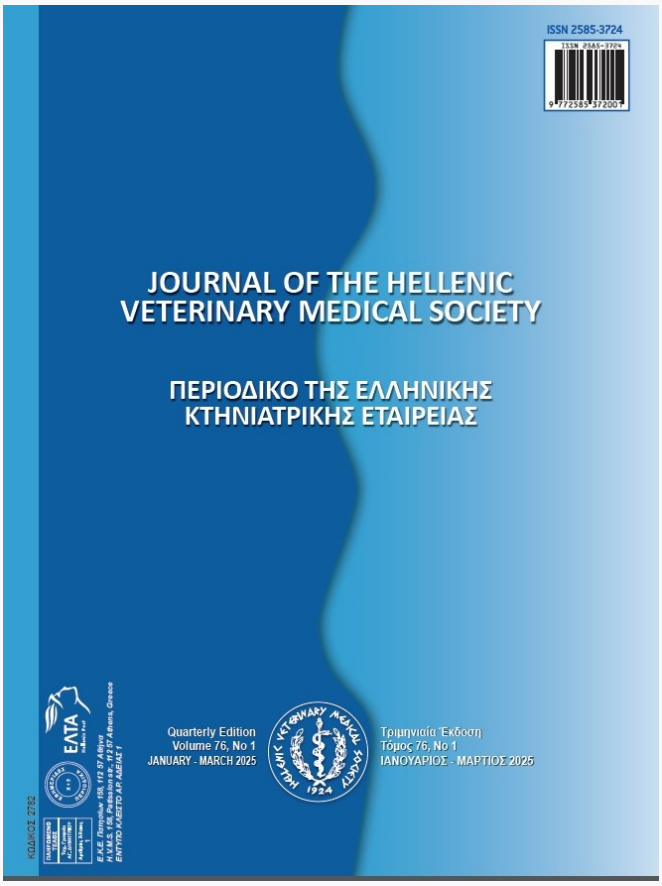

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Research article
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Estimation of Factors for Standardizing Lactations to Mature Equivalent of Simmental Cattle

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ABSTRACT: This study determined correction factors that will use mature age equivalent in the Turkish Simmental cattle population. Across the country, 59247 lactation milk yield records of 28971 head of cows between 1990 and 2023 were used. Correction coefficients for milk yield according to maturity age were calculated by considering 22 different age groups and 4 seasonal groups. Cows calving in spring, summer, autumn, and winter reached their adult milk yield of 305 days at 64-66 months, 52-54 months, 58-60, and 37-39 months, respectively. Accordingly, the current results show that cows calving in autumn and winter reach mature age for 305-day milk yield earlier than those calving in spring and summer seasons.

Keywords: Simmental; Milk yield; Adjustment factor

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INTRODUCTION

Milk yield in cattle is affected by many genetic and non-genetic factors (Atıl & Khattap, 1999; Sonmez et al., 2024). To make an effective selection, the milk yield records of cows should be corrected for systematic environmental factors (Khan & Sook, 1996). Because making corrections in terms of non-genetic effects allows for a more accurate estimation of breeding values, in the correction of milk yields, environmental effects such as lactation period, calving age, herd, calving year, and season are generally taken into consideration. However, in practice, 305-day milk yields of dairy cattle are corrected for calving season and calving age to calculate mature equivalent (ME) milk yield. Correction factors also allow a more accurate genetic evaluation and comparison of the milk production ability of cows calving at different ages and seasons (Cho et al., 2004). Khattab and Ashmawy (1990) reported that age correction factors differed according to seasons and regions in their study on Frisian cattle.

Calving age is one of the non-genetic factors affecting milk yield. In the studies conducted on Holstein cattle (Kaya et al., 2003; Bayrıl & Yılmaz, 2010; Hossein-Zadeh, 2010; Şahin & Ulutaş, 2011; Bakır & Kaygısız, 2013; Parlak & Kendir, 2015; Sarar & Tapkı, 2017; Karaağaç & Genç, 2019; Bakri & Djemali, 2022); Simmental cattle (Petrović et al. 2015; Bolacali & Öztürk, 2018; Akıllı et al. 2022); Jersey cattle (Gürses et al. 2014) and Frieswal cows (Holstein*Sahiwal) cattle (Kumar et al. 2017) found that milk yield increased as calving age progressed until maximum yield was obtained and then decreased. Holstein cattle (Hossein-Zadeh, 2010; Şahin & Ulutaş, 2011; Bakır & Kaygısız, 2013; Parlak & Kendir, 2015; Sarar & Tapkı, 2017; Karaağaç & Genç, 2019); Simmental cattle (Milun Petrović et al. 2015; Bolacali & Öztürk, 2018; Akıllı et al. 2022); Jersey cattle (Gürses et al. 2014) and Frieswal cows (Holstein*Sahiwal) cattle (Kumar et al. 2017) found that milk yield increased as calving age progressed until maximum yield was obtained and then decreased.

Correction factors are categorized as (i) additive correction factors and (ii) multiplicative correction factors. However, in practice, multiplicative correction factors are mostly used for the correction of yield records in dairy cattle (Norman et al., 1974).

In Turkiye, studies were conducted to investigate the correction factors for milk yield according to mature age in Holstein (Kesici et al. 1986; Açıkgöz et al. 2004; Çilek 2008), Simmental (Kaygısız et al. 1998; Çilek & Tekin, 2006b), Brown Swiss (Eker et al. 1982; Çilek & Tekin, 2006a), and Jersey (Şekerden, 1991) populations. The correction factors calculated for the populations should be recalculated and updated at certain intervals. Because the accuracy of genetic evaluations depends on the correctness of the correction process (Keown & Everett, 1985),.

In this study, mature equivalent correction factors were calculated for the population in Turkiye by using milk yield records of Simmental cattle registered in the pedigree registry, which contains a very large database.

MATERIALS AND METHODS

Material

The material of the study consisted of 59247 lactation milk yield records of 28.971 Simmental breed cows reared in 538 farms operating in 55 provinces of Türkiye between 1990 and 2023.

Method

Three different methods were used to calculate the adult age correction coefficients: (i) the simple averages method, (ii) the polynomial regression method, and (iii) the gross comparison method. The details of the methods are given by Şekerden (1990) and Vanlı et al. (2024).

(i) Simple averages method (Method-1*)*

In this method, all available yield records were included in certain class intervals (age groups). An average value was found for each of these class intervals. "Age correction factors" (a_i) were obtained by dividing the 305-day milk yield average for each season-age group by the average of the most productive season-age group.

$$a_i = Y_m / Y_i$$

Where; Y_m= 305-day milk yield average of the highest productive season-age group, Y_i= 305-day milk yield average of the i. season-age group.

(ii) Polynomial regression method (Method-2)

The calculation of age correction coefficients by the polynomial regression method is the same as with the simple averages method. However, in this method, the average milk yields obtained for each group are the expected yield averages calculated according

to the regression technique. The polynomial method was used in the calculation of correction coefficients according to mature age. In this method, the relationship between calving age and milk yield variables is expressed by the formula $Y = a + bX + cX^2$. In this equation, Y = 305 days milk yield and X = calving age. With this method, expected milk yields and correction coefficients were calculated for 20-160 age groups.

According to the regression equation, the expected average 305-day milk yield was calculated for each season-age subgroup. The average of the most productive season-age group was divided by the average expected yield of each season-age group separately, and "age correction factors" (a_i) were obtained.

$$a_i = Y_m / Y_i$$

Where; Y_m = 305-day milk yield average of the highest yielding season-age group. Y_i = 305-day milk yield average of the i. season-age group.

(iii) Gross comparison method (Method-3*)*

As in the simple averages method, age correction factors (a_i') were calculated by dividing the average of the highest-yielding season-age group by the average expected yield of each season-age group separately.

$$a_i = Y_m / Y_i$$

Where; Y_m = 305-day milk yield average of the highest yielding season-age group. Y_i = 305-day milk yield average of the i. season-age group.

The a_i values were stabilized by using the following formula and 5-month weighted moving average and thus a_i' value was obtained for each season-age group.

$$a_i' = \frac{\sum_{j=i-2}^{i+2} k_i n_i a_i}{\sum_{j=i-2}^{i+2} k_i n_i}$$

Here, k_j = 1-2-3-3-2-1 represents the weights given to a_i' values (k_i = 1 for i-2, k_i = 2 for i-1, k_i = 3 for i, k_i = 2 for i+1, k_i = 1 for i+2), n_i = i. The number of yields in the season-age group, a_i' = the values obtained according to the given k_j weights.

The a_i" values were calculated by dividing the a_i' values within each season-age group by the a_i' value corresponding to the highest yield age in that season-age group. SAS's (1985) package program was used in calculations.

RESULTS AND DISCUSSION

305-day milk yields according to calving season are given in Figure 1, 305-day milk yield, expected 305-day milk yield calculated according to 3 different methods (simple averages method, polynomial regression method, gross comparison method) are given in Tables 1-4.

According to the simple averages method, the milk yield (7642 kg) obtained at the age of 52-54 months in cows calving in the spring season was divided by the milk yields of the other monthly age groups, and adult age correction factors were calculated (Table 2). Accordingly, the milk yield of the youngest cattle (≤24 months) should be multiplied by 1.110, and the milk yield of the oldest cattle (≥ 109 month) should be multiplied by 1.245 to estimate the daily milk yield of the ME-305 days.

According to the polynomial regression method, the highest expected milk yield of cows calving in the spring season was calculated in the age group of 49-54 months. Accordingly, the milk yield of the youngest cows (≤24 per month) would have to be multiplied by 1.084, and the milk yield of the oldest cows (≥ 109 per month) would have to be multiplied by 1.276 to estimate the milk yield per day of the ME-305 days.

The highest milk yield was 52-54 months (7642±129.9) for cows calving in spring, 55-57 months (7589±132.6) for those calving in summer, 46-48 months (7654±90.8) for those calving in autumn, and 49-51 months (8000±107.3) for those calving in winter.

According to the gross comparison method, the highest expected milk yield was calculated as 7407 kg in the age group of 55-60 months in cows calving in the spring season. Accordingly, the milk yield of the youngest cows (≤24 months) should be multiplied by 1.087, and the milk yield of the oldest cows (≥109 month) should be multiplied by 1.124 to estimate the daily milk yield of ME-305 days.

The milk yield (7589 kg) obtained at the age of 55-57 months for cows calving in summer was divided by the milk yields of other monthly age groups to calculate the adult age correction factors (Table 3). Accordingly, the milk yield of the youngest cattle (≤24

Table 1. Factors of adult age correction in Simmental cows calving in spring

Calving age (months)	N	305 days milk yield (kg)	Expected milk yield (kg)	Correcting factor Method-1	Method-2	Method-3
≤ 24	1903	6.888±115.5	6832	1.110	1.084	1.087
25-27	2372	6.881±113.9	6951	1.111	1.066	1.089
28-30	1129	6.811±117.6	7031	1.122	1.054	1.084
31-33	476	6.779±131.8	7103	1.127	1.043	1.064
34-36	939	7.429±122.0	7168	1.029	1.033	1.029
37-39	1237	7.441±118.1	7225	1.027	1.025	1.013
40-42	870	7.420±121.6	7274	1.030	1.018	1.008
43-45	564	7.263±129.9	7315	1.052	1.013	1.008
46-48	619	7.550±127.3	7349	1.012	1.008	1.001
49-51	683	7.502±126.9	7375	1.019	1.004	**1.000**
52-54	535	**7.642±129.9**	7394	**1.000**	1.002	**1.000**
55-57	385	7.235±139.0	7404	1.056	**1.000**	1.019
58-60	332	7.021±143.9	**7407**	1.088	**1.000**	1.038
61-63	362	7.048±141.1	7403	1.084	1.001	1.048
64-66	320	7.329±143.8	7391	1.043	1.002	1.048
67-69	218	7.088±158.0	7371	1.078	1.005	1.051
70-72	178	6.738±168.2	7343	1.134	1.009	1.054
73-75	196	7.332±164.2	7308	1.042	1.014	1.047
76-78	170	7.303±169.9	7264	1.047	1.020	1.039
79-84	224	7.100±157.9	7195	1.076	1.029	1.041
85-96	200	7.296±162.8	6962	1.047	1.064	1.056
97-108	97	6.568±205.7	6607	1.164	1.121	1.085
≥ 109	62	6.137±243.6	5803	1.245	1.276	1.124
Total	14071		$Y = 5936.20 + 50.13X - 0.42X^2$			

*** P<0.0001

Table 2. Factors of adult age correction in Simmental cows calving in the summer season

Calving age (months)	N	305 days milk yield (kg)	Expected milk yield (kg)	Correcting factor Method-1	Method-2	Method-3
≤ 24	1789	6899±117.3	6726	1.100	1.100	1.099
25-27	2036	6816±115.8	6848	1.113	1.081	1.115
28-30	1135	6599±119.7	6932	1.150	1.068	1.109
31-33	506	6719±132.5	7009	1.130	1.056	1.070
34-36	1085	7355±120.8	7079	1.032	1.046	1.033
37-39	1255	7204±118.8	7142	1.053	1.036	1.046
40-42	1015	7107±121.2	7198	1.068	1.028	1.042
43-45	597	7200±128.0	7247	1.054	1.021	1.027
46-48	706	7465±125.9	7290	1.017	1.015	1.014
49-51	798	7295±124.5	7326	1.040	1.010	1.017
52-54	666	7378±127.1	7355	1.029	1.006	1.006
55-57	482	**7589±132.6**	7377	**1.000**	1.003	**1.000**
58-60	412	7443±137.0	7392	1.020	1.001	1.014
61-63	395	7349±137.1	7400	1.033	**1.000**	1.018
64-66	361	7358±140.4	**7402**	1.031	**1.000**	1.015
67-69	305	7430±144.4	7396	1.021	1.001	1.011
70-72	244	7402±153.3	7384	1.025	1.002	1.018
73-75	175	7427±165.2	7365	1.022	1.005	1.022
76-78	142	7142±178.3	7339	1.063	1.009	1.042
79-84	290	7480±145.3	7294	1.015	1.015	1.046
85-96	309	6815±144.4	7128	1.114	1.038	1.103
97-108	116	6963±187.5	6858	1.090	1.079	1.111
≥ 109	76	6428±220.2	6218	1.181	1.190	1.167
Total	14895		$Y = 5837.22 + 48.77X - 0.38X^2$			

*** P<0.0001

Table 3. Factors of adult age correction in Simmental cows calving in the autumn season

Calving age (months)	N	305 days milk yield (kg)	Expected milk yield (kg)	Correcting factor Method-1	Method-2	Method-3
≤ 24	1668	6941± 79.4	6784	1.103	1.114	1.099
25-27	2135	6910± 75.6	6912	1.108	1.093	1.114
28-30	982	6646± 84.1	7000	1.152	1.080	1.118
31-33	426	6717±101.5	7082	1.140	1.067	1.081
34-36	1021	7233± 84.4	7157	1.058	1.056	1.039
37-39	1380	7365± 80.4	7226	1.039	1.046	1.035
40-42	872	7272± 85.9	7288	1.053	1.037	1.034
43-45	596	7215± 95.0	7344	1.061	1.029	1.023
46-48	729	**7654± 90.8**	7393	**1.000**	1.022	1.006
49-51	823	7423± 88.5	7436	1.031	1.016	1.019
52-54	547	7323± 96.9	7472	1.045	1.011	1.012
55-57	400	7638±106.0	7502	1.002	1.007	**1.000**
58-60	476	7608±101.1	7525	1.006	1.004	1.002
61-63	482	7539±100.8	7542	1.015	1.002	1.016
64-66	338	7379±111.8	7553	1.037	1.001	1.028
67-69	306	7291±115.4	**7557**	1.050	**1.000**	1.023
70-72	275	7423±120.1	7554	1.031	**1.000**	1.006
73-75	276	7643±120.0	7545	1.001	1.002	1.002
76-78	186	7540±138.3	7530	1.015	1.004	1.016
79-84	224	7266±129.1	7494	1.053	1.008	1.029
85-96	297	7540±115.9	7380	1.015	1.024	1.042
97-108	140	7240±153.7	7137	1.057	1.059	1.091
≥ 109	69	6468±209.4	5981	1.183	1.264	1.170
Total	14648		$Y = 5875.82 + 49.20X - 0.36X^2$			

*** P<0.0001

Table 4. Factors of adult age correction in Simmental cows calving in the winter season

Calving age (months)	N	305 days milk yield (kg)	Expected milk yield (kg)	Correcting factor Method-1	Method-2	Method-3
≤ 24	1888	6712± 97.4	6832	1.192	1.084	1.129
25-27	2436	6911± 94.7	6951	1.158	1.066	1.127
28-30	1227	6790± 99.1	7031	1.178	1.053	1.125
31-33	451	6294±117.4	7103	1.271	1.043	1.106
34-36	1152	7283±101.1	7168	1.098	1.033	1.070
37-39	1345	7505± 99.4	7225	1.066	1.025	1.046
40-42	955	7386±103.5	7274	1.083	1.018	1.034
43-45	547	7188±113.4	7315	1.113	1.013	1.022
46-48	811	7830±106.4	7349	1.022	1.008	1.004
49-51	765	**8000±107.3**	7375	**1.000**	1.004	**1.000**
52-54	704	7461±108.8	7394	1.072	1.002	1.013
55-57	439	6960±119.0	7404	1.149	**1.000**	1.029
58-60	439	7700±119.3	**7407**	1.039	**1.000**	1.025
61-63	430	7749±120.4	7403	1.032	1.001	1.019
64-66	410	7560±121.3	7391	1.058	1.002	1.027
67-69	252	6910±138.2	7371	1.158	1.005	1.051
70-72	269	7047±135.9	7343	1.135	1.009	1.061
73-75	230	7667±142.2	7308	1.043	1.014	1.051
76-78	197	7348±149.2	7264	1.089	1.020	1.041
79-84	184	7272±152.4	7195	1.100	1.029	1.040
85-96	271	7423±134.5	6962	1.078	1.064	1.049
97-108	131	7308±169.6	6607	1.095	1.121	1.059
≥ 109	100	6724±189.1	5803	1.190	1.276	1.078
Total	15633		$Y = 5603.20 + 60.65X - 0.46X^2$			

*** P<0.0001

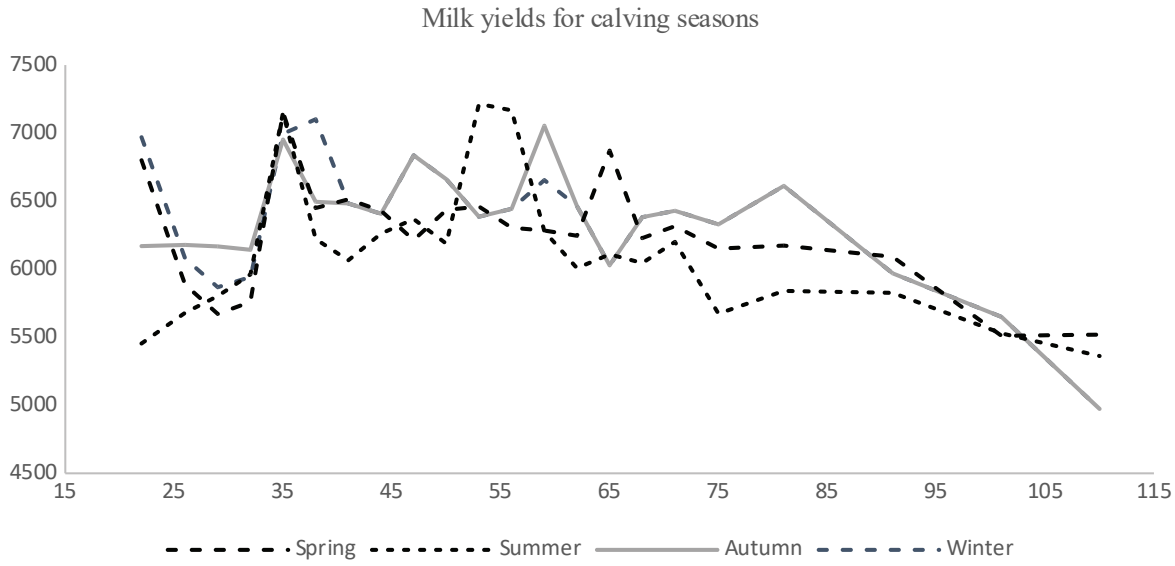

Figure 1. Milk yields for calving seasons

months) should be multiplied by 1.100, and the milk yield of the oldest cattle (≥ 109 months) should be multiplied by 1.181 to estimate the daily milk yield of the ME-305 days. The lowest (1.017) correction coefficient for cows calving in spring was calculated at the age group of 46-48 months, and the highest (1.181) correction coefficient was calculated at the age group of ≥109 months.

According to the polynomial regression method, the highest expected milk yield was calculated as 7402 kg in the age group of 61-66 months for cows calving in the summer. Accordingly, the milk yield of the youngest cows (≤24 months) should be multiplied by 1,100, and the milk yield of the oldest cows (≥ 109 months) should be multiplied by 1.190 to estimate the milk yield per day of ME-305 days.

According to the gross comparison method, the highest expected milk yield was calculated in the age group of 55-57 months for cows calving in the summer. Accordingly, the milk yield of the youngest cows (≤ 24 months) would need to be multiplied by 1.099, and the milk yield of the oldest cows (≥ 109 months) would need to be multiplied by 1.167 to estimate the milk yield per day of ME-305 days.

The milk yield (7654 kg) obtained at the age of 46-48 months in cows calving in the autumn season was divided by the milk yields of the other monthly age groups, and the adult age correction factors were calculated (Table 4). Accordingly, the milk yield of the youngest cattle (≤24 months) should be multiplied by 1.103 and the milk yield of the oldest cattle (≥ 109 months) should be multiplied by 1.183 to estimate the daily milk yield of the ME-305 days. For cows calving in the autumn season, the lowest (1.002) correction coefficient was calculated at 55-57 months of age, and the highest (1.183) correction coefficient was calculated at ≥109 months of age.

According to the polynomial regression method, the highest expected milk yield of cows calving in the autumn season was calculated as 7557 kg in the 67-69 month age group. Accordingly, the milk yield of the youngest cows (≤24 months) should be multiplied by 1.114, and the milk yield of the oldest cows (≥109 months) should be multiplied by 1.264 to estimate the daily milk yield of ME-305 days.

According to the gross comparison method, the highest expected milk yield of cows calving in the autumn season was calculated in the 55-57-month age group. Accordingly, the milk yield of the youngest cows (≤24 months) should be multiplied by 1.099, and the milk yield of the oldest cows (≥ 109 months) should be multiplied by 1.170 to estimate the milk yield per day of ME 305 days.

The milk yield (7407 kg) obtained at 58-60 months of age in cows calving in winter was divided by the milk yields of the other age groups, and the adult age correction factors were calculated (Table 4). Accordingly, the milk yield of the youngest cows (≤24

months) should be multiplied by 1.103, and the milk yield of the oldest cows (≥ 109 months) should be multiplied by 1.183 to estimate the milk yield per day of the ME-305 days. The lowest (1.022) correction coefficient was calculated in the age group of 46-48 months, and the highest (1.192) correction coefficient was calculated in the age group of 24 months for cows calving in winter.

According to the polynomial regression method, the highest expected milk yield of cows calving in the winter season was calculated as 7407 kg in the 58-60 month age group. Accordingly, the milk yield of the youngest cows (≤24 months) should be multiplied by 1.114, and the milk yield of the oldest cows (≥ 109 months) should be multiplied by 1.146 to estimate the daily milk yield of ME-305 days.

According to the gross comparison method, the highest expected milk yield was calculated in the age group of 49-51 months for cows calving in winter. Accordingly, the milk yield of the youngest cows (≤24th month) should be multiplied by 1.129, and the milk yield of the oldest cows (≥109 months) should be multiplied by 1.078 to estimate the milk yield per day of ME-305 days.

DISCUSSION

In this study, correction factors for milk yield according to mature age were calculated for the Simmental cattle breed population bred in Türkiye. In all 3 methods, correction factors were calculated considering 4 seasons.

The trend of the multiplicative correction factors decreased gradually from the youngest age to the adult age and then gradually increased, as expected. These results are in agreement with those obtained in Simmental cattle (Kaygısız et al., 1998; Çilek & Tekin, 2006b), Red Chittagong cattle (Habib et al., 2012), and Holstein Friesian cattle (Açıkgöz et al., 2004; Kumar et al., 2017).

The present results indicate that cows calving in autumn and winter reach adulthood earlier than those calving in spring and summer. Khattab and Ashmawy (1990), working on another group of Frisian cattle in Egypt, reported that the maximum milk production in winter, spring, summer, autumn, and all seasons was approximately 76.9, 78.8, 85.7, 96.8, and 80.1 months of age. In other studies on Simmental cattle, it was reported that high milk yield (5111 kg) was observed in cows calving at 104-108 months of age in Kazova Agricultural Farm (Çilek & Tekin, 2006b), and cows calving in the autumn season reached adult age (4th lactation) earlier than those calving in other seasons. lactation) earlier than those calving in other seasons (Kaygısız et al. 1998), and in Çorum province, it was reported that milk yield, which was low in the first lactation, increased in the second lactation and decreased in the following lactations (Bolacali & Öztürk, 2018).

CONCLUSION

As a result of this study, it was observed that milk yields in all seasonal groups started to decrease after reaching adult age but increased again after a certain age. This increase can be explained by the fact that high-yielding cows are kept in the herd. In this study, unlike the studies published so far, a very large data set covering the whole Türkiye was used in the calculation of correction factors. Therefore, the correction factors obtained should be expected to contain less sampling error.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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