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Effects of calving year, season, and age on some lactation traits of Anatolian buffaloes reared at farmer conditions in Turkey

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Abstract: The aim of this study was to investigate the effects of some environmental factors like calving year, season, buffalo cow age and village on some milk yield traits of Anatolian buffaloes, such as daily milk yield for lactation length (MYLL), total lactation milk yield (TLMY), lactation length (LL), and daily milk yield for calving interval (MYCI). 1838 milk yield records obtained from 851 Anatolian buffaloes reared under different environmental conditions from 2015 through 2019 within the scope of the Bartın Anatolian Buffalo Breeding Project were assessed. The least square means and standard errors for MYLL, TLMY, LL, and MYCI were 4.07 ± 0.02 kg, 1078.6 ± 7.54 kg, 263.83 ± 1.16 days, and 2.75 ± 0.03 kg, respectively. As a result of the study, the effects of village, calving year and age (P<0.001) and calving season (P<0.05) on MYLL; village, calving year and age (P<0.001) on TLMY; village, calving year and age (P<0.001) and calving season (P<0.05) on MYCI; calving age, village (P<0.001) and calving year (P<0.05) on LL were found statistically significant. Moreover, high positive phenotypic correlations between TLMY and MYLL (r = 0.78, P<0.001) and LL and TLMY (r = 0.67, P<0.001) were estimated. The results revealed that milk production traits might be improved by considering calving season and age in breeding studies and stud-selection programs in Anatolian buffaloes. Besides, it will remarkably contribute to the number of limited studies that have focused on this breed.

Keywords: Anatolian buffalo, calving age, calving season, calving year, milk yield.

Türkiye'de yetiştirici koşullarında barındırılan Anadolu mandalarında buzağılama yılı, mevsimi ve yaşının bazı laktasyon özelliklerine etkileri

Özet: Bu çalışmanın amacı, Anadolu mandalarında çevresel faktörlerden buzağılama yılı, mevsimi, yaşı ve köyün bazı süt verimi özelliklerinden Laktasyon Süresinde Günlük Süt Verimi (LSSV), Toplam Laktasyon Süt Verimi (TLSV), Laktasyon Süresi (LS) ve Buzağılama Aralığında Günlük Süt Verimi (BASV) üzerine olan etkilerinin araştırılmasıdır. Çalışmada Bartın ili Anadolu mandası ıslah projesinde 2015-2019 yılları arasında yetiştirilen 851 baş Anadolu Mandasına ait 1838 adet süt verim kaydı kullanılmıştır. LSSV, TLSV, LS ve BASV özelliklerine ilişkin en küçük kareler ortalama ve standart hatalar sırası ile 4,07 ± 0,02 kg, 1078,6 ± 7,54 kg, 263,83 ± 1,16 gün ve 2,75 ± 0,03 kg'dır. Araştırma sonucunda LSSV üzerine köyün, buzağılama yılı ve yaşının (P<0,001), mevsiminin (P<0,05); TLSV üzerine köyün, buzağılama yılı ve yaşının (P<0,001); BASV üzerine köyün, buzağılama yılı, yaşı (P<0,001) ve mevsiminin (P<0,05); LS üzerine buzağılama yaşı, köy (P<0,001) ve buzağılama yılının (P<0,05) etkisi önemli bulunmuştur. Aynı zamanda TLSV ile LSSV (r = 0,78, P<0,001) ve LS ile TLSV (r = 0,67, P<0,001) arasında yüksek pozitif fenotipik korelasyonlar hesaplanmıştır. Sonuçlar, buzağılama mevsimi ve buzağılama yaşının yapılacak olan ıslah çalışmalarında ve damızlık seçim programlarında dikkate alındığında Anadolu mandalarının süt verimi özelliklerinin iyileştirilebileceğini ortaya çıkarmıştır. Ayrıca bu çalışma, bu ırka yönelik sınırlı sayıdaki çalışma sayısının artırılmasına önemli katkılar sağlayacaktır.

Anahtar sözcükler: Anadolu mandası, buzağılama mevsimi, buzağılama yaşı, buzağılama yılı, süt verimi.

Introduction

The buffalo (*Bubalus bubalis*) population was 173 million throughout the world in 2015 and reached 206.6 million by 2018, an increase of 19.4% (4). Buffaloes were originally reared in Asia but are now commonly reared farm animals worldwide for their milk (8). The total buffalo milk yield worldwide in 2018 was 127.3 million tons, which constitutes around 15.6% of total milk production; therefore, these animals are second to only dairy cows in milk production (4). The Anatolian

buffaloes reared in Turkey is originated from the Mediterranean buffaloes, a sub-group of river in buffaloes (11). The population in Turkey in 2010 was 84726 and reached 184192 in 2019 with the aid of the Anatolian Buffalo Breeding Project conducted by the Ministry of Agriculture and Forestry (5). The buffaloes in Turkey are mostly reared in the North, Middle, West, East, and Southeast Anatolia regions. They hold an important place in husbandry due to their resistance to environmental stresses and diseases, great ability to utilize feed, converting even low-quality rough feed into meat and milk, and lower cost of husbandry than cattle (6).

The most important buffalo yield is their milk, which is distinguished from the milk of other animals by its high dry matter and particularly fat content. Buffalo milk is used in the production of yogurt, cream, cheese, and ice cream. The composition of the Anatolian buffalo milk has been reported to be made up of 18.19% dry matter, 7.92% fat, 5.14% lactose, and 4.09% protein (27). In Turkey, 79000 tons of buffalo milk was produced in 2019 (5). The total milk yield from buffaloes depends on both genetic and non-genetic factors such as season, management, and feed amount and quality (1, 22). The milk yield traits are also affected by several environmental factors, such as calving age and season (19). TLMY and LL are important parameters in milk production of these animals (10).

It is aimed this study that is to investigate the opportunities for increasing the milk yield, raising the incomes of farmers, implementing selection studies and stud selection programs through examining the effects of calving year, season, age, and village on some milk yield traits like MYLL, TLMY, LL, and MYCI of Anatolian buffaloes.

Materials and Methods

The research material of the study constitutes of the pedigree records of 851 Anatolian buffalos that were included in the Project conducted in Bartın, its districts, and 48 villages (41° 38′ 29″ N and 32° 19′ 58″ E) with the support of the General Directorate of Agricultural Research and Policies. In that study, 1838 milk yield records obtained on the control day from Anatolian buffaloes that calved during 2015–2019 were used. The data on milk yields were obtained from the 'Manda Yıldızı' data recorder system in which the technical staff working within the body of the Project entered the data (32).

Milk was produced from buffaloes at individual farms that were included in the project. The buffaloes on these farms are milked twice a day, in the morning and evening. The buffalo breeding in the region is conducted extensively and in a manner of management and feeding that is similar among the farms. Within the farms, the buffalo cows are naturally inseminated by the bulls. Buffaloes are manually hand-milked on most of the farms, although a small number of farms use milking machines. The milk controls from the buffaloes were collected monthly using scales with a sensitivity of 10 g/50 kg. The milk yields were recorded in kilograms from the morning and evening milkings. Anatolian buffaloes data, which were recorded at least 5 test days for each lactation, were included in the analyzes (12, 34).

The study comprised milk yield traits including MYLL for TLMY/LL, MYCI for TLMY/CI (16, 33), TLMY, and LL. In the study, the records between 147≤LL≤404 days for LL and 300≤CI≤700 days (20) for CI were evaluated. In this study, Alkoyak and Öz's (2) findings obtained in a study carried out in the same study area were also used. The calving years were grouped into those between 2015 and 2019. The calving seasons were divided into four groups according to the geo-climatic conditions in Turkey as follows: (1) winter (December, January, and February), (2) spring (March, April, and May), (3) summer (June, July, and August), and (4) fall (September, October, and November). The calving ages were divided into the following five groups: (1) 3–4 years, (2) 5–6 years, (3) 7–8 years, (4) 9–10 years, and (5) ≥11 years. The study was conducted in 48 villages (The villages are listed numerically from 1 to 48). The environmental factors that were investigated for their effects were the calving year, season, age and village on MYLL, TLMY, LL, and MYCI and were determined using the least-square method. The phenotypic correlation was calculated using the Pearson correlation coefficient. For the statistical analyses, the general linear model (GLM) using Minitab ver. 18 was used. The differences between the mean values were analyzed using Tukey's multiple comparison test (3). Since the inadequate data at subgroups, two or three-way interactions were not included in analyzes.

The equation and statistical model below were used to examine the effects of the environmental factors on MYLL, TLMY, LL, and MYCI.

$$Y_{ijklm} = \mu + Y_i + S_j + A_k + V_l + e_{ijklm},$$

where, Y_{ijklm} is the quantities of traits obtained from the individual buffaloes (i. year, j. season, k. age, l. village, m. observation value for an investigated trait); μ is the overall (expected) mean value; Y_i is the effect of i^{th} calving year (i = 2015, 2016, 2017, 2018, 2019); S_j is the effect of j^{th} calving season (j = 1,2,3,4); A_k is the effect of k^{th} calving age (k = 1,2,3,4,5); V_l is the effect of l^{th} village (l = 1-48) and e_{ijklm} is the random error, presumed to be normally and independently distributed with a mean value of zero and constant variance (NID, 0, σ^2).

Results

The overall mean values and standard errors for MYLL, TLMY, LL, and MYCI are given in Table 1. The

effects of environmental factors including calving year, season and age on MYLL, TLMY, LL, and MYCI were investigated and the standard mean values, errors, and affective factors are provided in Table 2.

As a result of the study, the effects of village, calving year and age (P<0.001) and calving season (P<0.05) on MYLL; village, calving year and age (P<0.001) on TLMY; village, calving year and age (P<0.001) and calving season (P<0.05) on MYCI; calving age and village (P<0.001) and calving year (P<0.05) on LL were found statistically significant. However, the effect of the calving season on TLMY and LL was determined to be non-significant. Since the number of villages studied (48 villages) is too high, it is not given in the Table 2. Variance analysis results for all environmental factors are given in Table 3. Moreover, high positive phenotypic correlations between TLMY and MYLL (r = 0.78, P<0.001) and LL and TLMY (r = 0.67, P<0.001) were calculated.

Table 1. Descriptive statistics for milk yield traits in Anatolian buffaloes.

Paramaters	**MYLL (kg)**	**TLMY (kg)**	**LL (d)**	**MYCI (kg)**
Number of Animals	851	851	851	606
Number of Records	1838	1838	1838	1188
Mean ($\bar{x}$)	4.07	1078.6	263.83	2.75
Standard Error of Mean (SEM)	0.02	7.54	1.16	0.03
Minimum	1.23	294.9	147	0.73
Maximum	8.45	2114.3	404	6.08

MYLL: Daily milk yield for lactation length; TLMY: Total lactation milk yield; LL: Lactation length;
MYCI: Daily milk yield for the calving interval

Table 2. The least square means (±SE) of some milk yield traits for calving year, season, and age in Anatolian buffaloes.

Environmental factors	**MYLL (kg)**		**TLMY (kg)**		**LL (d)**		**MYCI (kg)**	
	n	**(Mean± SEM)**	**n**	**(Mean± SEM)**	**n**	**(Mean± SEM)**	**n**	**(Mean± SEM)**
Calving year								
2015	231	3.16 ± 0.05^{d}	231	856.5 ± 19.1^{d}	231	269.40 ± 3.62^{ab}	94	2.09 ± 0.09^{c}
2016	302	3.64 ± 0.04^{c}	302	964.7 ± 16.2^{c}	302	263.46 ± 3.06^{b}	190	2.34 ± 0.07^{c}
2017	423	4.28 ± 0.04^{b}	423	1148.8 ± 14.2^{b}	423	268.83 ± 2.70^{ab}	261	2.77 ± 0.06^{b}
2018	429	4.59 ± 0.03^{a}	429	1252.5 ± 13.8^{a}	429	273.47 ± 2.60^{a}	324	3.00 ± 0.05^{a}
2019	453	4.64 ± 0.04^{a}	453	1238.7 ± 14.0^{a}	453	266.51 ± 2.65^{ab}	319	3.00 ± 0.06^{a}
p		**		**		*		**
Calving season								
Winter	252	4.07 ± 0.04^{ab}	252	1089.1±17,4	252	266.67±3.30	163	2.50 ± 0.07^{b}
Spring	445	3.99 ± 0.04^{b}	445	1089.0±14.2	445	271.81±2.69	264	2.64 ± 0.06^{ab}
Summer	654	4.10 ± 0.03^{a}	654	1097.5±12.7	654	267.47±2.41	425	2.68 ± 0.05^{ab}
Autumn	487	4.09 ± 0.03^{ab}	487	1093.4±13.5	487	267.38±2.55	336	2.74 ± 0.05^{a}
p		*		NS		NS		*
Calving age (year)								
3–4	416	3.59 ± 0.03^{d}	416	935.2 ± 13.8^{d}	416	259.97 ± 2.62^{b}	67	2.28 ± 0.10^{b}
5–6	591	3.98 ± 0.03^{c}	591	1055.1 ± 12.3^{c}	591	264.09 ± 2.32^{b}	376	2.53 ± 0.05^{b}
7–8	400	4.14 ± 0.04^{b}	400	1113.5 ± 14.5^{b}	400	268.83 ± 2.74^{ab}	351	2.71 ± 0.05^{a}
9–10	277	4.28 ± 0.04^{a}	277	1183.8 ± 17.0^{a}	277	276.33 ± 3.23^{a}	251	2.89 ± 0.06^{a}
≥11	154	4.32 ± 0.06^{a}	154	1173.6 ± 22.3^{ab}	154	272.45 ± 4.22^{ab}	143	2.79 ± 0.08^{a}
p		**		**		**		**

MYLL: Daily milk yield for lactation length; TLMY: Total lactation milk yield; LL: Lactation length; MYCI: Daily milk yield for the calving interval;
NS: non-significant (P>0.05); *P<0.05; **P<0.001; $^{a, b, c, d}$ The different superscripts within a column in a subgroup symbolize the difference significantly (P<0.05).

Tablo 3. Analysis of variance of factors affecting MYLL, TLMY, LL and MYCI.

Environmental factors	MYLL			TLMY		LL		MYCI		
	D.F	M.S	F-Value	M.S	F	M.S	F	D.F	M.S	F
Village	47	4.6604	13.02**	749046	13.24**	18244	8.99**	47	3.4958	6.22**
Calving year	4	98.6520	275.52**	7446927	131.63**	4866	2.40*	4	22.3327	39.76**
Calving season	3	0.9983	2.79*	7313	0.13^{NS}	2029	1.00^{NS}	3	1.9451	3.46*
Calving age	4	25.1611	70.27**	2884177	50.98**	11383	5.61**	4	6.6675	11.87**
Error	1779	0.3581		56574		2029		1129	0.5616	

M.S: Mean square; D.F: Degrees of freedom; NS: non-significant (P>0.05); *P<0.05; **P<0.001.

Discussion and Conclusion

The MYLL value found in this study (4.07 ± 0.02 kg) is compatible with the value (4.07 ± 1.3 kg) determined in the study on Murrah buffaloes conducted by Jorge et al. (17). The results found in this study are lower than those reported by other studies (16, 23, 33) for buffaloes (5.61 - 6.37 kg). The MYLL amount elevated with increasing calving age. This is attributable to improvement management and experience on farms each year.

The TLMY value found in the present study (1078.6 ± 7.54 kg) is higher than those found in the studies conducted (29, 30) for Anatolian buffaloes in Turkey (657.7-894.3 kg). On the other hand, it is similar to those reported by some other studies (2, 20, 31) on the same breeds (1000.7-1087.49 kg); however, the TLMY value is lower than those found by other researchers (1, 10, 16, 18, 24, 25) for Mediterranean buffaloes in Italy (2286 kg), Murrah buffaloes in Brazil (1594 kg), Nili Ravi buffaloes in Pakistan (1831.6 L), Murrah buffaloes in India (1984-2164.13 kg). These milk yield differences are attributable to differences in breed, feeding and managerial applications and seasonal or periodic changes in environmental factors (9). In the present study, the TLMY increased with the elongation of LL (263.83 ± 1.16 d) (Table 2). There was a strong and significant correlation between the two traits. Similarly, various researchers have reported a strong and significant correlation between LL and TLMY in buffaloes (1).

LL was longer than those reported by some other studies (20, 29, 31) for Anatolian buffaloes (146.6 -245.43 days). This can be a result of the farmers' desire to obtain milk from the buffaloes for as long as possible, thus ignoring the economy of life-long milk production (15). The LL value found in this study is similar to those reported by other researchers (1, 2, 24) for Italian buffaloes (270 d), Anatolian buffaloes (260.2 d), and Nili Ravi buffaloes in Pakistan (273.3 d); however, it is shorter than that reported (10) for Nili Ravi buffaloes (302 d). The differences in the LL values may arise from different management, care, and feeding practices on farms. The number of studies on the MYCI value of Anatolian buffaloes is limited. The MYCI value found in this study (2.67 ± 0.028 kg) is lower than those reported by other studies (16, 33) for Murrah buffaloes in India (4.26 kg), and in Pakistan (3.61 kg). The low MYCI value in the present study may be the result of differences in buffalo breeds and their higher productivity.

In the present study, the effect of calving season on MYLL was significant (P<0.05). Similar to our results, those of Khosroshahi et al. (19) have indicated that calving season has an important effect on MYLL, and Şahin and Ulutaş (29) have reported that buffaloes produce the highest MYLL in autumn and the lowest in summer. Unlike the results of this study, some researchers (14, 21) have found that the effect of calving season on MYLL was non-significant. The highest MYLL was observed in summer and the lowest in spring. The differences between the results are mostly attributable to different management methods on farms, environmental factors, and breed differences (13). In this study, the effects of calving year and age on MYLL were significant (P<0.001). MYLL gradually increased and reached the highest values when the cows were ≤11 years old (Table 2). In accordance with the results of the present study, Eskandar and Karimpour (13) and Şahin and Ulutaş (29) have found that calving age had significant effects on MYLL for both Iran Khuzestan and Anatolian buffaloes, respectively.

In accordance with our study, Kul et al. (21) and Ghaffar et al. (14) have reported that the effect of calving season on milk production was non-significant for Anatolian and Nili-Ravi buffaloes, respectively. In contrast, some studies (7, 10, 22) have reported that the calving season had a considerable effect on TLMY. In the present study, the lowest TLMY was in spring and winter. Unlike this study, Şahin and Ulutaş (29) have found that milk yield from Anatolian buffaloes in summer was lower than in other seasons. The farms in the study area were mostly individual family-owned farms. The milk they produce contributes to the family income when sold as raw milk, buffalo yogurt, and cream. Thus, it is suggested that more attention is paid to feeding their buffaloes during all seasons. The lowest milk yield was observed in 2015,

while the highest was observed in 2018 (Table 2). The differences in milk yield throughout the years stemmed from the level of farm management and environmental factors. In agreement with our study, the effects of calving year and age were significant in several studies (2, 20, 29). The highest TLMY value was observed in buffaloes calving at 9–10 years old, while the 3- to 4-year-old group produced the lowest TLMY. Bashir et al. (7) have emphasized that age could be a more important factor for inclusion in the models of TLMY. In this study, one of the environmental factors of village's effect on TLMY ($P<0.001$) was found significant (Table 3). There are some studies reporting that the study region has a significant effect on TLSV (2, 28).

In the present study, the effect of calving year on LL was found significant ($P<0.05$) (Table 2). The results found in this study were similar to the Charlini and Sinniah (9), Koçak et al. (20) and Alkoyak and Öz (2). The effect of calving season on LL was found non-significant (Table 2). These findings have supported by various studies (1, 10, 14, 18, 21). In contrast, Hussain et al. (15) and Şahin and Ulutaş (29) have reported that calving season had a significant effect on LL for Nili Ravi and Anatolian buffaloes, respectively. The longest LL was from buffaloes calving in spring, while the shortest was from those calving in winter. The village effect on LL ($P<0.001$) was found significant (Table 3). There are some studies reporting that the study region has a significant effect on LL (2, 28, 29).

There are limited numbers of studies on the environmental factors that affect MYCI in Anatolian buffaloes. In their study on Murrah buffaloes in India, Jakhar et al. (16) have found that calving year and season have significant effect on MYCI, similar to present study. Unlike to the results of the present study, Singh et al. (26) and Thiruvenkadan (33) have reported that the calving season did not have a significant effect on MYCI for Nili-Ravi buffaloes in India and Murrah buffaloes, respectively.

Consequently; in Anatolian buffaloes, both MYLL and MYCI were significantly affected by all environmental factors, while TLMY and LL was significantly affected by calving year and age. However, the effect of calving season on TLMY and LL were non-significant. In general, the milk yield traits elevated with increasing age (TLMY especially peaked in the 9–10 years) and those traits from buffaloes calving in summer were better than those calving in other seasons. It is concluded that the improvements in care, feeding, and herd management, considering calving age and season during studies to increase yields can contribute to higher milk production. Besides, taking calving age and season into consideration will help to determine the best studs for breeding programs.

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Ethical Statement

This study does not present any ethical concerns.

Conflict of Interest

The authors declared that there is no conflict of interest.

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