Turkish Journal of Agriculture - Food Science and Technology, 12(10): 1659-1667, 2024
DOI: https://doi.org/10.24925/turjaf.v12i10.1659-1667.6819

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Some Yield and Growth Traits of Anatolian Buffaloes and the Effects of First Calving Age and Calving Interval on These Traits

Ahmet Akyol[1,a], Hüseyin Erdem[1,b,*]

[1]*Ondokuz Mayıs University, Faculty of Agriculture, Department of Animal Science, Samsun, Türkiye*
[*]*Corresponding author*

A R T I C L E I N F O

Research Article

Received : 18.04.2024
Accepted : 01.06.2024

Keywords:
Anatolian buffalo
Calf
Live weight
Milk yield
First calving age

A B S T R A C T

Numerous in-depth studies have described the fertility traits, growth performance and milk yield traits of dairy animals, which are considered indicators of welfare, but there are limited studies examining these traits within the framework of cause-effect relationships, especially in buffaloes. The aim of this study was to determine the changes in some milk, growth and fertility traits of Anatolian buffaloes over the years in some dairy farms where the Buffalo Breeding Project in Public Conditions was implemented in Samsun province and, to investigate the effects of first calving age (FCA) and calving interval (CI) on milk and growth traits. The study was conducted in 27 buffalo farms (3295 buffalo cows and 3317 buffalo calves) located in Bafra district, the region with the highest buffalo population in Samsun province, Türkiye. The data was taken from records previously kept within the scope of the relevant project. The data such as growth characteristics [birth weight (BW), 6th and 12th-mo live weight (LW) values of calves born between 2013-2020] and lactation traits of cows [lactation milk yield (LMY) and lactation duration (LD)] and FCA and CI values were analyzed by analysis of variance. The effect of years on LMY of buffalo cows was found to be significant, and significant positive changes were determined from year to year. In addition, the BW, 6th-mo, and 12th-mo LW values of calves also varied from year to year. As the FCA value of buffaloes increased, the BW, 6th-mo, and 12th-mo LW values of calves and LMY of cows increased. Similarly, CI values affected the BW values of calves ($P<0.01$), and LMY and LD values increased in parallel with the increase in CI values. Consequently, determining the lactation and growth traits of buffaloes could benefit developing herd management practices that would optimize these performance indicators.

[a] *ahmet_akyol55@hotmail.com* *https://orcid.org/0000-0003-2551-2371* | [b] *hserdem@omu.edu.tr* *https://orcid.org/0000-0001-5273-3925*

Introduction

As in dairy cattle buffalo cows (*Bubalus bubalis*) that are removed from the herd for various reasons such as old age, poor productivity and disease are replaced by young heifers and production continues with these animals. Therefore, it is important to determine and improve the growth performance of these young animals from birth until they reach adulthood, as well as the genotypic and environmental factors that may affect milk yield in lactation for sustainable buffalo breeding. However, the improvement of some environmental factors such as shelter, care, feeding, calving season, first calving age (FCA), calving interval (CI), lactation order, lactation duration (LD) and first breeding age which are effective on the fertility and milk yield traits of buffaloes raised in Türkiye, are generally neglected. Most of these environmental factors are considered important indicators in evaluating herd management practices and determining productivity (Şahin & Ulutaş, 2011). Although most of the environmental factors in question are features related to the determination of fertility, they stand out as important features effective on productivity as a result of being directly related to many productivity aspects of animals (Özçelik & Arpacık, 2000; Şahin & Ulutaş, 2011).

Milk yield and fertility are the main factors affecting the profitability of farms. Since milk yield is directly related to reproductive activities, shortening the birth interval leads to an increase in milk yield and the number of offspring throughout the animal's life (Seno et al., 2010). In addition, it is also emphasized that there are negative relationships between milk yield and reproductive traits (Eldawy et al., 2021; Sathwara et al., 2020). Besides, Pryce et al. (2002) report that there is a genetic correlation between milk yield and calving interval ranging from -0.22 to 0.67. This situation is interpreted as the reproductive performance of cows with high milk yield being low (Seno et al., 2010). As a matter of fact, in a study conducted by the same researchers, the genetic and phenotypic correlations between milk yield and FCA and first CI in

Murrah breed buffaloes were determined as -0.12 and 0.07 and -0.15 and 0.30, respectively. It was determined CI as 426.35 ± 2.91 d in Anatolian buffaloes by Alkoyak & Öz (2020). Theoretically, FCA in buffalo breeding is expressed as the period from the day the animal is born to the day it gives its first birth, and this feature, which is considered an important indicator of fertility, is calculated in days or months (Christa & Sinniah, 2015; de Araujo Neto et al., 2020). Since buffalo heifers are unproductive until they start lactation, the age at first calving is important for the dairy industry. There are many sources of costs during this period, including feed, barn, labor, and veterinary expenses. Therefore, an increase in FCA results in an increase in breeding costs. However, the increase in FCA causes the generation interval to increase and indirectly negatively affects the herd's genetic progress (Verma et al., 2021).

Similarly, CI is defined as the time between two consecutive calving or, more broadly, as the time from the calving date until the next calving (Christa & Sinniah, 2015). This period is calculated in days or months. Calving interval is also an important criterion of fertility that affects the farm's economy.

In studies conducted on Anatolian buffaloes, the values obtained for milk yield traits vary significantly depending on the breeding conditions. In the studies conducted, it was determined that different results were obtained for LMY, ranging from 470.91±9.784 kg to 1607.4 kg, and for LD, the values varied between 171.8±1.66 d and 263.83±1.16 d (Uğurlu et al., 2016; Soysal et al., 2016; Soysal et al., 2018; Soysal et al., 2019; Alkoyak & Öz, 2020; Yılmaz et al., 2017, Kul et al., 2016; Koçak et al., 2019; Ergüneş Berkin et al., 2020; Şahin et al., 2020; Öz et al., 2022). In Egyptian and Murrah buffaloes, lactation milk yield and lactation duration, as the average of many years, were determined as 1865.50±18.37 kg, 295.43±4.49 d (Ayad et al., 2022) and 1855.6 ± 16.1 kg, 297.8 ± 1.9 d (Thiruvenkadan et al., 2014), respectively. Similarly, different results were obtained in studies on growth traits and it is thought that the difference arises from growing conditions. In studies conducted on the determination of birth, 6^{th}-mo, and 12^{th}-mo weights of Anatolian buffalo calves, birth weight was found to be between 28.33±0.090kg and 34.62±0.11kg; It was determined that the 6th-mo weight varied between 90.8±3.21 kg and 119.13±0.459 kg, and the 12th-mo weight varied between 142.16±1.50 kg and 200.0±1.09 kg (Şekerden, 2013a; Uğurlu et al., 2016; Yılmaz et al., 2017; Genç et al., 2019; Han et al., 2019; Alkoyak & Öz, 2022; Erdem et al., 2022). In addition, similar results were obtained in the studies conducted by Erdem et al., (2015), Kul et al., (2018), Tekerli et al., (2015) and Soysal et al., (2015) and the average birth weight were determined to be around 29 kg.

In the study conducted by Şekerden (2013b), FCA was determined as 1210.4±35.38 d and CI was determined as 599.2±15.27 d in Anatolian buffaloes. In the same study, the same values were determined as 1126.4±44.37 d and 545.2±38.5 d in Anatolian buffalo and Italian buffalo F1 crossbreeds, respectively. Again, in Anatolian buffaloes, it was determined as 441.97 ± 7.93 d by CI Tekerli et al. (2001) and 417 ± 1.73 d by Soysal et al. (2018). In addition, in the study conducted by Ayad et al. (2022) on Egyptian buffalos, they determined the long-term average of CI as 393.75±5.713 d and FCA as 39.46±0.597 mo. In Italian buffaloes, FCA and CI were determined as 35.9 months and CI 443 d, respectively (Mattii et al., 2005). Similarly, Thiruvenkadan et al. (2014) determined the CI for Murrah buffaloes to be 532.8 ± 5.5 d. Parlato & Zicarelli (2016) reported that increasing the CI negatively affects milk yield and lactation milk yield is higher following a shorter CI. Data on the fertility traits of Anatolian buffaloes are limited due to the fact that this species is generally raised under extensive breeding conditions.

To our knowledge, limited information exists on the relationships between the growth traits of calves born and lactation milk yield traits of buffalo cows with FCA and CI, which are considered important indicators of sustainable and profitable production in buffalo farms. Determining the effect of these fertility traits on buffalo productivity based on the growth of newborns and lactation milk yield traits of cows, will also contribute to filling this gap in the literature. We hypothesized that (i) some milk and fertility traits of buffaloes, as well as the growth traits of newborn calves, changed over the years and (ii) the lactation yield traits of buffalo cows and the growth traits of calves (BW, 6^{th} mo and 12^{th} mo LW) are affected by the fertility traits of the cow (FCA and CI). The objective of this study was (i) to determine how the growth traits of buffalo calves born with LMY, LD, FCA, and CI change over the years, and (ii) to examine the effects of fertility traits of cows (FCA and CI) on the lactation yield traits of cows and growth traits (BW, 6th-mo and 12th-mo LW) of calves.

Materials and Methods

Materials

This study did not require approval by the Local Ethical Committee of Ondokuz Mayıs University because no animal subjects were used. The data in our study were the records previously kept in the Samsun Province Public Water Buffalo Breeding Project.

Within the scope of the "Buffalo Breeding Project in Public Conditions", a total of 3295 Anatolian buffaloes were used in 27 farms determined by using simple random sampling method among the 56 farms regularly recorded (lactation information of buffaloes and data on the growth performance of newborn calves) by the breeders in Bafra district and the Samsun Province Buffalo Breeders Association.

Methods

The following formula was used to calculate the sample size to be used in the Simple Random Sampling Method (Baş, 2006).

$$n = \frac{N\,t^2\,p\,q}{d^2(N-1) + t^2\,p\,q}$$

In the formula;

N= Number of individuals in the universe

n= Number of individuals to be sampled

p= Probability of occurrence of the event under consideration,

q= Probability of the event being examined not occurring, (1-p)

t= Theoretical value in the t table at a certain degree of freedom and the determined error level

d= What is intended to be done according to the frequency of occurrence of the event is symbolized as + deviation.

If p = 0.90, q = 0.10 and t = 2.58 at 10% error rate;

$$n = \frac{56 \times (2.58)^2 \times 0.90 \times 0.10}{(0.10)^2 \times (56-1) + (2.58)^2 \times 0.90 \times 0.10}$$

n= 28.6 (approximately 29) (sample size)

A total of 29 farms were identified out of a total of 56 farms registered to the Buffalo Breeding Project in Public Conditions in Bafra district. The data records kept in two farms were removed because they showed significant deviations, and the data records of a total of 27 farms were evaluated.

The records kept within the project's scope were recorded in the computer program called "Manda Yildizi" created for this purpose. The recorded data were transferred to the Excel program and evaluated with permission from the General Directorate of Agricultural Research and Policies of the Ministry of Agriculture and Forestry.

The data obtained consists of the LMY and LD values of the buffalo cows that were calving between 2013 and 2020, as well as the BW, 6th mo LW, and 12th mo LW values of the buffalo calves born. In addition, the parity and calving dates of the cows that calved between these years were also recorded. FCA and CI values were calculated from these records. The following formulas were used for these calculations.

FCA (day) = Cow's first calving date - Cow's birth date

CI (day) = Last calving date - Previous calving date

The following groupings were made to determine the effect of year, FCA and CI values on the milk yield traits of cows and the growth traits of calves. Data between 2013 and 2020 were evaluated in 8 separate years. CI values from the data obtained are divided into three groups; group 1: 365-450 d, group 2: 451-600 d and group 3: 600< d. FCA data, which is another important fertility feature, was evaluated by dividing it into four groups (group 1: <1000 d; group 2: 1001-1200 d; group 3: 1201-1400 d; group 4: 1400< d).

Analysis of variance was used to investigate the effect of the years that are thought to have an effect on the growth traits of calves (BW, 6th-mo LW and 12th-mo LW), lactation milk yield traits (LD and LMY), FCA and CI (Model 1). Similarly, ANOVA, General Linear Model was used to determine the effect of FCA and CI values of buffalo cows on lactation milk yield traits and growth traits of calves (Model 2). Differences between the averages of statistically significant environmental factors were determined according to the Duncan Multiple Comparison Test.

In this study, the impact of the environmental factors emphasized was evaluated with the following linear models.

Model 1:

$$Y_{ij} = \mu + a_i + e_{ij}$$

Here,

Y_{ij}: the observation value of the buffalo cow or calf regarding the traits emphasized (LD, LMY, FCA, CI of the cow; BW, 6th-mo LW and 12th-mh LW of the calf),

In the model;

μ: population mean,

a_i: the effect of calving year (i: 2013-2020),

e_{ij}: the random error.

Model 2:

$$Y_{ijk} = \mu + a_i + b_j + e_{ijk}$$

Here,

Y_{ijk}: the observation value of the buffalo cow or calf regarding the traits emphasized (LD, LMY of the cow; BW, 6th-mo LW and 12th-mo LW of the calves),

In the model;

μ: population mean,

a_i: the effect of first calving age (i: 1-4),

b_j: the effect of calving interval (j: 1-3),

e_{ijk}: the random error.

All of the statistical analyzes in question were carried out in the SPSS 21.0 (IBM Corp., Armonk, New York, USA) package program.

Results and Discussion

Growth, Milk Yield and Fertility Traits According to Years

The average BW, 6th-mo and 12th-mo LW values of calves between 2013 and 2020 were determined as 31.0±0.08 kg, 106.5±0.44 kg and 168.1±0.60 kg, respectively (Table 1). In a similar study, Kul et al. (2018) found the BW value (29.3±0.43 kg) of Anatolian buffalo calves close to the findings obtained in this study. However, the result determined by Uğurlu et al. (2016) in Anatolian buffaloes (26.95 kg) and the result found by Yılmaz et al. (2017) is much lower than the results of this study. On the other hand, the BW determined by Genç et al (2019) as 34.62±0.11 kg in Anatolian buffaloes is considerably higher than the results of this study. These results demonstrate that the BW of the Anatolian buffalo varies significantly depending on the conditions of the region where it is raised. This situation gives important clues to the need for breeding stock transfer between regions and therefore for outbreeding. In studies conducted on Murrah crossbred (Mohd Azmi et al., 2021) and pure Murrah breed (Thiruvenkadan et al., 2009) buffalo calves, the average BW values are higher than the results obtained in this study.

The 6th-mo and 12th-mo LW results of calves are lower than the findings of Genç et al. (2019) and Alkoyak & Öz (2022), but higher than the values reported by Yılmaz et al. (2017) and Şekerden (2013a). Additionally, unlike the results obtained in this study, Thiruvenkadan et al. (2009) determined lower mean values of 6th-mo LW (87.9±0.95 kg) and 12th-mo LW (134.2±1.41 kg) of buffaloes. This variability in the study results can be associated with differences in genotype, care, feeding, housing, climatic conditions, and genotype x environment interaction (Thiruvenkadan et al., 2009).

The effect of the year considered as environmental factors was found to be statistically significant on LW in three different growth periods (P<0.001). In the study, the BW of calves born in 2018 and 2020 was found to be higher than calves born between 2013 and 2016. In addition, the BW values of valves born in 2015 were determined to be lower than in other years (P<0.001). In addition, it was observed that the 6th-mo LW values of calves born in 2015, 2016 and 2017 were higher than those born in 2019. Similar findings were determined in 12-mo-old buffaloes, and the LW values of 12-mo buffaloes in 2015 showed a higher average than in other years except 2014. Similarly, the 12th-mo LW values of buffaloes in 2013 were found to be higher than those in 2018, 2019 and 2020. It is thought that the variability seen yearly is due to environmental factors and changes in the feeding opportunities of calves after weaning from year to year. In a previous study on the Anatolian buffalo, Alkoyak & Öz (2022) found the effect of year significant on BW, 6th-mo LW and 12th-mo LW values. In a similar study conducted by Thiruvenkadan et al. (2009) on Murrah calves, the effect of year on the BW of calves and LW in the third and 6th-mo was found to be statistically significant. In their study on Holstein Friesian cattle, Bayrıl & Yılmaz (2010) found that the effect of year on the 6th-mo LW value of calves was statistically significant. According to the findings, the variability in the effect of the year on growth traits from year to year can be explained by differences in many environmental factors such as maternal effect, climate, season, care, feeding and housing conditions. However, we underlined that the variability in growth traits from year to year in the region where the study was conducted is mostly due to farm feeding problems and the insufficiency of pasture in the Kizilirmak delta. Also, a positive and continuous change is expected because genetic improvement in growth traits is one of the main goals of the Buffalo Breeding Project in Public Conditions. Especially for the 6th-mo and 12th-mo of LW, the direct exposure of calves to many environmental conditions, especially feeding conditions, suppresses the expected direction of genetic improvement and fluctuations can be observed from year to year (Figure 1a). An important situation seen in Table 1 and Figure 1a is that the LW increases or decreases in the periods do not follow a linear direction. For example, in 2018 and 2020, when BW was highest, 12th-mo LW values decreased to the lowest level. On the contrary, in 2015, when BW was at its lowest, the 12th-mo LW value increased to the highest level. This situation is thought to be related to improving or worsening care-feeding conditions after weaning. It is a known fact that the buffalo breeding of the region largely depends on the Kizilirmak delta vegetation. Therefore, it is thought that the reason for this change is changes in vegetation due to climatic effects. Since the effects of environmental factors on growth performance are significant, the changes in 6th and 12th-mo LW values can be largely attributed to environmental reasons. The positive increase in birth weight in the last five years is an important indicator for the project objectives.

The changes in LMY and LD of buffaloes over the years are presented in Table 1 and Figure 1b. Under the conditions of the region where the study was conducted, the average LMY and LD values of the buffaloes studied between 2013 and 2020 were determined as 899.2±3.07 kg and 256.0±0.45 d, respectively.

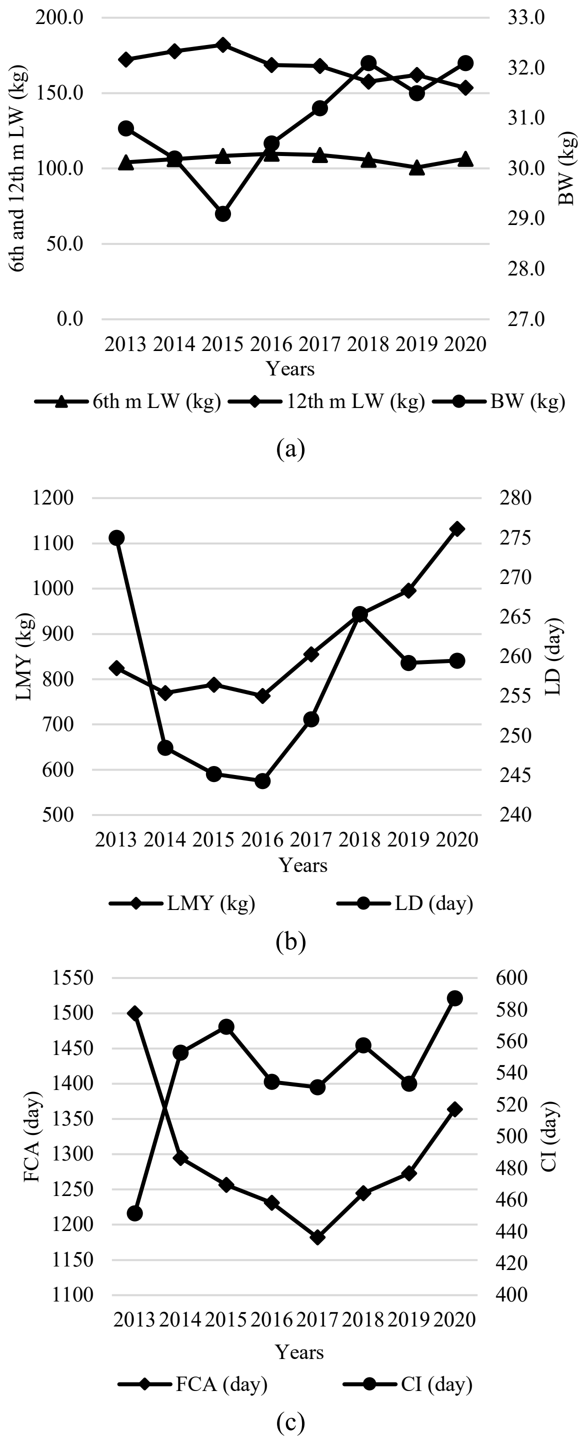


Figure 1. Changes in growth (a), milk yield (b) and fertility (c) traits according to years

In this research, the highest LMY value was detected in 2020 (1132.3±4.58 kg) (P<0.001). It is thought that the higher LMY values in 2020, when the data were taken in the study, compared to other years, is due to both genetic changes in the animals and positive developments in breeding conditions in line with the relevant project goals. To this aim, farmers are constantly being made aware of breeding techniques, and these efforts are effective. In addition, it is thought that the increase in earnings from milk sales is also effective. In the previous 2019, 2018, 2017 and 2013 years, it was determined as 995.5±5.15 kg, 942.8±4.68 kg, 855.1±5.10 and 824.5±12.06 kg, respectively, and the LMY values between these years were found to be statistically different (P<0.001). However, while the LMY values of buffaloes in these years were higher than in 2014, 2015 and 2016, no statistical difference was detected in terms of LMY in these three years.

In recent years, it has been observed that the LMY values of buffaloes have tended to increase in line with the project targets (Figure 1b). This situation is thought to be due to the genotypic change created in the buffalo population and the fact that more importance is given to milk production due to the demand for buffalo products. Similarly, the LD values of buffaloes also varied over the years (P<0.001), and the highest LD was determined in 2013. Although the LD value varies numerically in some years, it tends to decrease after 2018. The goal of improving milk yield traits, which is one of the main goals of the Buffalo Breeding Project in Public Conditions, is noticeable in the sub-project in Samsun province. However, rearing conditions and climatic changes from year to year cause fluctuations in some parameters from time to time.

The LMY average determined in studies conducted on Anatolian buffalo cows was determined to be higher (Soysal et al., 2018; Soysal et al., 2019; Uğurlu et al., 2016) than this study value, but the LD average was determined to be lower. Öz et al. (2022) found both milk yield traits to be higher than the averages determined in this study. Although the buffaloes raised under our country's conditions are generally Anatolian buffaloes, previous studies indicate that differences in rearing and feeding conditions may cause different productivity levels. For this reason, we underlined that breeders especially in Bafra district of Samsun province should be more sensitive about buffalo breeding conditions and feeding buffaloes.

This study determined the average FCA and CI values of the buffaloes studied as 1288.3±8.66 d and 550.9±3.87 d, respectively. (Table 1). The values achieved for both traits are at a high level for economic buffalo breeding. The 1578.7 ± 20.3 d reported by Thiruvenkadan et al. (2015) for FCA in Murrah buffaloes is considerably higher than the result of this study. While Thiruvenkadan et al. (2014) reported a value for CI close to this study of 532.8 ± 5.5 d, Nava-Trujillo et al. (2018) and Koçak et al. (2019) determined a lower result as 453.55 and 450.35 ± 2.98 d respectively. A review by Uçar et al. (2005) reported that the puberty and first insemination age of buffaloes was higher than that of cattle. These statements support the results of this study. According to the study's findings, the effect of year on both FCA and CI values was found to be statistically significant. (Table 1). While the highest FCA value was determined in 2013, this value varied from year to year (P<0.001). Kumar et al. (2015) determined the FCA average as 43.69±0.46 mo and emphasized that it showed significant change over the years, as in this study.

Table 1. Growth traits of buffalo calves and milk and fertility traits of buffalo cows according to years

Years	BW ***		6th mo LW ***		12th mo LW ***		LMY ***	
	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$
2013	234	30.8±0.30^{bc}	227	104.0±1.24^{ab}	219	172.3±1.67b^{c}	259	824.5±12.06^{e}
2014	258	30.2±0.25^{c}	256	106.2±0.92^{ab}	245	177.7±1.21^{ab}	276	769.8±11.17^{f}
2015	425	29.1±0.14^{d}	416	108.4±1.11^{a}	415	182.0±1.13^{a}	434	787.8±5.89^{f}
2016	421	30.5±0.17b^{c}	397	109.8±1.33^{a}	304	168.6±1.76^{cd}	434	763.2±4.82^{f}
2017	429	31.2±0.18^{abc}	419	109.0±1.27^{a}	410	167.9±1.45^{cd}	421	855.1±5.10^{d}
2018	558	32.1±0.22^{a}	504	105.8±1.09^{ab}	377	157.6±1.62^{fe}	555	942.8±4.68^{c}
2019	473	31.5±0.22^{ab}	367	100.7±1.19^{b}	367	162.0±1.86^{de}	451	995.5±5.15^{b}
2020	497	32.1±0.21^{a}	387	106.5±1.30^{ab}	201	153.5±2.13^{f}	487	1132.3±4.58^{a}
Overall	3295	31.0±0.08	2973	106.5±0.44	2538	168.1±0.60	3317	899.2±3.07

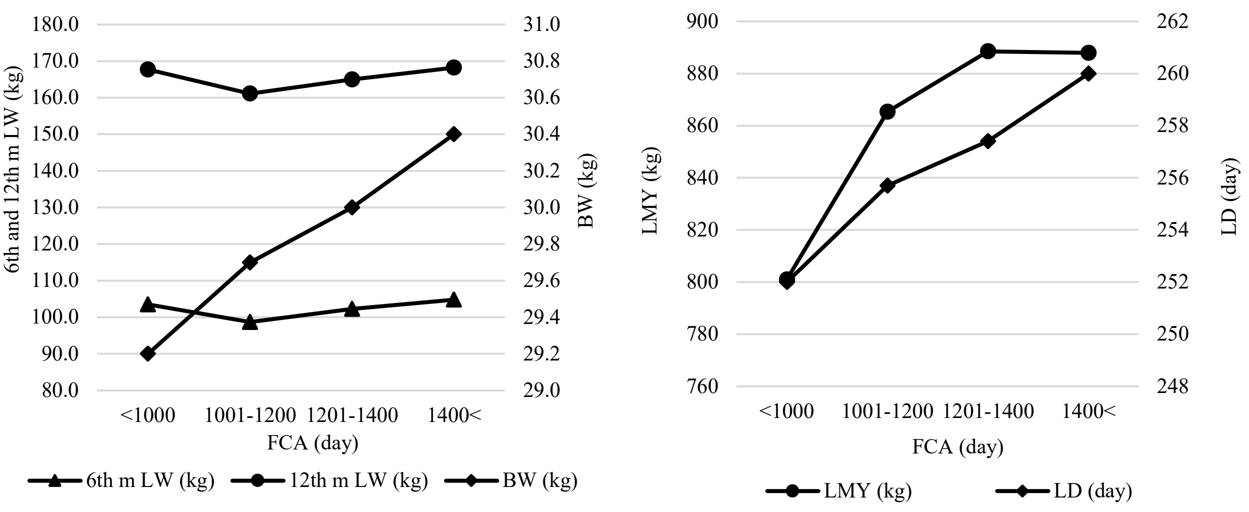
Years	LD ***		FCA ***		CI ***	
	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$
2013	268	275.0±2.10^{a}	105	1499.8±31.85^{a}	49	451.6±9.36^{b}
2014	294	248.5±1.77^{de}	76	1294.5±33.44^{bc}	178	552.9±9.19^{a}
2015	440	245.2±1.19e	133	1256.6±23.65^{bc}	250	569.3±11.91^{a}
2016	435	244.3±0.98^{e}	124	1231.0±21.63^{c}	278	534.5±11.95^{a}
2017	420	252.1±0.98^{d}	96	1181.8±18.78^{c}	301	531.1±9.23^{a}
2018	557	265.4±1.19^{b}	166	1244.7±16.02^{c}	348	557.5±10.17^{a}
2019	451	259.2±1.03^{c}	137	1272.7±19.95^{bc}	313	533.4±9.39^{a}
2020	486	259.5±0.75^{c}	109	1363.7±25.41^{b}	373	587.2±9.53^{a}
Overall	3351	256.0±0.45	946	1288.3±8.66	2090	550.9±3.87

***P<0.001; BW: Birth weight (kg); LW: Live weight (kg); LMY: Lactation milk yield (kg); LD: Lactation duration (day); FCA: First calving age (day); CI: Calving interval (day)

Table 2. Change in growth and milk yield traits according to first calving age

FCA	BW*		6th mo LW**		12th mo LW*		LMY***		LD*	
	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$
<1000	87	29.2 ± 0.41^{b}	81	103.5 ± 2.87^{ab}	72	167.7 ± 3.11^{ab}	97	801.0 ± 20.07^{b}	99	252.0 ± 3.23^{b}
1001-1200	296	29.7 ± 0.20^{ab}	265	98.7 ± 1.19^{b}	240	161.1 ± 1.71^{b}	307	865.3 ± 9.17^{a}	314	255.7 ± 1.36^{ab}
1201-1400	195	30.0 ± 0.28^{ab}	182	102.3 ± 1.60^{ab}	158	165.0 ± 2.36^{ab}	201	888.5 ± 12.55^{a}	205	257.4 ± 1.97^{ab}
1400<	281	30.4 ± 0.26^{a}	247	104.8 ± 1.30^{a}	212	168.2 ± 1.86^{a}	297	887.9 ± 11.04^{a}	298	260.0 ± 1.70^{a}
Overall	859	29.9 ± 0.13	775	102.0 ± 0.76	682	164.9 ± 1.05	902	871.0 ± 6.01	916	257.1 ± 0.92

*P<0.05; **P<0.01; ***P<0.001; FCA: First calving age (day); BW: Birth weight (kg); LW: Live weight (kg); LMY: Lactation milk yield (kg); LD: Lactation duration (day)



(a) (b)

Figure 2. Changes in growth (a) and milk yield (b) traits according to first calving age

In this study, contrary to the findings regarding FCA, it was found that the lowest CI value was in 2013. While the CI value of buffaloes in 2013 was found to be lower than other years (P<0.001), no statistically significant difference was determined between other years. In a similar study on Anatolian buffaloes, Koçak et al. (2019) concluded that CI did not change statistically after the first year. In another study, it was emphasized that CI values in Anatolian buffaloes changed from year to year (Soysal et al., 2018). In addition, since buffaloes are mostly grazed on pastures, they may be exposed to many environmental factors or unknown variables from year to year that may affect their insemination at the appropriate time during the estrus period. When all the above-mentioned expressions are evaluated as a whole, it is an expected result that the CI values of buffaloes will vary from year to year.

Growth and Milk Yield Traits According to First Calving Age

FCA in the study was divided into four groups and it was investigated how this feature affected the LW values of buffalo calves up to one year old. According to FCA groups, the BW, 6th-mo and 12th-mo LW averages of the calves were found as in Table 2. It was determined that the BW values of the calves of the buffaloes in the first FCA group were lower than the cows in the fourth group. Additionally, it was concluded that the 6th-mo LW values of the calves of the buffalos in the fourth FCA group were higher than those in the second FCA group (P<0.01). Similarly, as the FCA value increased, it was determined that the 12th-mo LW values of the calves tended to increase, although there was no linear increase. Bhatti et al. (2007) emphasize that since reproduction in buffaloes is partly seasonal, the age at first mating may vary seasonally, and therefore FCA values may be affected by the birth season of the buffaloes.

FCA is a trait that changes the cow's transition to a productive position and has economic importance. FCA generally takes a long time in buffalos, such as 3.5-4.5 years. This brings a significant economic burden to the farms. Shortening these values as much as possible may significantly affect farm profitability. However, the shortening in question should not negatively affect the cow's own development, milk yield and calf development. According to the results in Table 2, although there are changes in calf weights in all three periods for 4 different FCA, it is seen that these changes are not a linear increase or decrease for the other two periods except birth weight (Figure 2a). The prenatal growth of calves directly depends on the mother and the environmental conditions provided to it. Therefore, buffaloes with late FCA may give birth to heavier calves as their growth is significantly completed. However, this effect varies between the 6th and 12th-mo. Because during these periods, environmental effects may affect calf growth more. Therefore, although there was a partially linear increase in weight, especially in the 12th-mo, there was no difference in calf growth between FCA under 1000 d and FCA over 1400 d. For this reason, it can be said that the FCA value should be reduced in general, and for this, herd management and animal feeding conditions should be rearranged.

In the study, the mean values of LMY and LD according to FCA groups are shown in Table 2. According to the data obtained; while the LMY values of the buffaloes in the first FCA group were found to be lower than those in the second, third and fourth FCA groups (P<0.001), no statistically significant difference was determined between the second, third and fourth groups. According to these results, it can be said that reducing the FCA in buffalos up to 1000 d (approximately 2.7 mo) will not cause a decrease in milk yield. However, the need for adequate feeding and reaching sufficient live weight should also be taken into account. Similarly, the FCA value of buffaloes also affected their LD values (P<0.05). It was concluded that the LD value of the cows in the first FCA group (252.0±3.23 d) was lower compared to those in the fourth group (260.0±1.70 d). Studying on Egyptian buffaloes, El-Awady et al. (2021) reported that LSV changed for three different FCA, and similar to this study, there was an increase in milk yield due to the increase in FCA. Contrary to the findings obtained in this study, Basant et al., (2017) reported in their research on Egyptian buffaloes that FCA did not create a statistical difference in the LMY value. Seno et al., (2010) determined the genetic and phenotypic correlations between milk yield and FCA and first CI in buffalos as -0.12 and 0.07 and -0.15 and 0.30, respectively. Thiruvenkadan et al. (2015) determined a genetic correlation of 0.166±0.35 and 0.584±0.47, and a phenotypic correlation of 0.018±0.05 and -0.012±0.05, between FCA and LMY and LD in Murrah buffaloes, respectively. These results are generally low, except for the genetic correlation between FCA and LD. According to these values, the researcher reports that the first CI of buffaloes with high milk yield tends to increase. It is thought that the different results obtained between studies may be due to many environmental factors such as genotype, feeding and growing conditions.

Growth and Milk Yield Traits According to Calving Interval

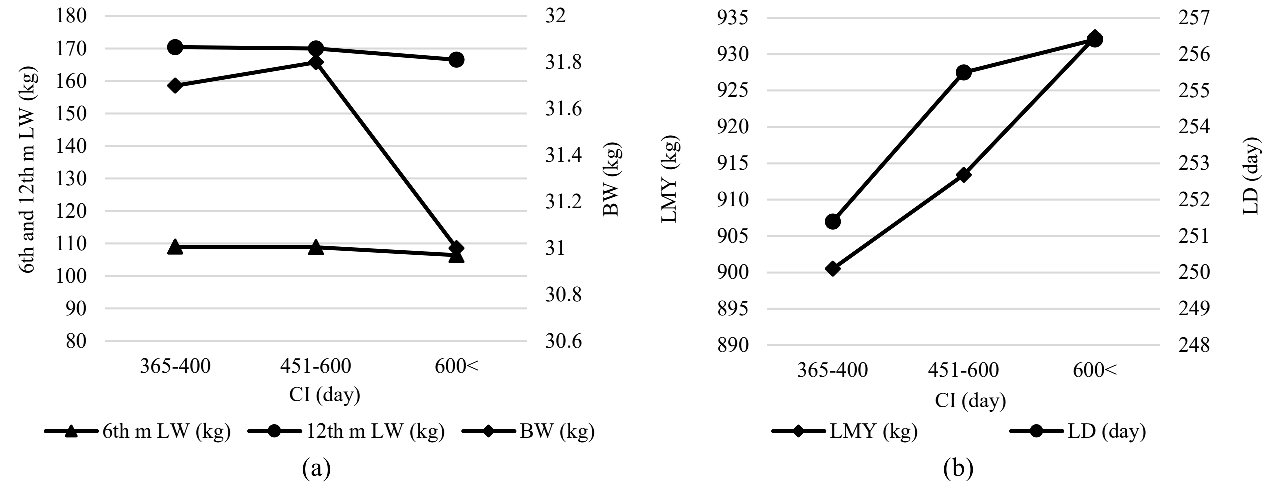
According to the CI data divided into 3 groups, the LW averages of the calves in the 3 periods and the effects of CI on these features are given in Table 3 and Figure 3a. According to the findings, while the change in the CI values of the cows created a statistically significant difference in the BW values of the calves (P<0.01), it did not have a statistically significant effect on the 6th-mo and 12th-mo LW values. The BW value of the calves of the cows in the first and second CI groups was found to be higher than the calves of the cows in the third group. That is, as the CI values of the buffaloes increased the BW values of the calves born decreased. Although the group averages are quite close to each other, a statistical difference was detected between them due to the large number of data in each group and the low variation in the data. There was no statistical difference between live weights in other periods. Therefore, in general, it can be said that long or short CI does not have a significant effect on the growth performance of the calves.

In the study, the changes in LMY and LD values of buffaloes according to CI groups were determined as in Table 3 and Figure 3b. LMY and LD values of cows in the first CI group are lower than those in the third MA group. It is thought that the prolongation of CI provides a significant advantage for the recovery of body nutrient reserves in cows and the adequate increase of mammary gland cells. However, contrary to the results of this study, the result found by Parlato & Zicarelli (2016) indicates that prolonged CI reduces milk yield. If the animals were fed adequately, it might not be desirable to prolong the CI due to the possibility of fat gain.

Table 3. Change in growth and milk yield traits according to calving interval

CI	BW**		6th mo LW		12th mo LW		LMY**		LD***	
	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$	n	$\bar{X}\pm S\bar{x}$
365-400	731	31.7±0.17^{a}	653	109.0±0.97	541	170.4±1.31	696	900.5±6.32^{b}	700	251.4±0.84^{b}
451-600	600	31.8±0.17^{a}	524	108.8±1.08	457	170.0±1.53	612	913.4±7.06^{ab}	612	255.5±1.07^{ab}
600<	610	31.0±0.18^{b}	555	106.4±1.02	456	166.5±1.50	619	932.3±7.16^{a}	625	256.4±1.00^{a}
Overall	1941	31.5±0.10	1732	108.1±0.59	1454	169.1±0.83	1927	914.8±3.95	1937	254.3±0.56

**P<0.01; ***P<0.001; CI: Calving interval (day); BW: Birth weight (kg); LW: Live weight (kg); LMY: Lactation milk yield (kg); LD: Lactation duration (day)



(a) (b)

Figure 3. Changes in growth (a) and milk yield (b) traits according to calving interval

However, under the conditions of the region where the study was conducted, since the buffaloes are fed in more extensive conditions, fatness and the resulting low productivity are not expected results. CI length causes an increase in milk yield as it does not cause any negative effects such as fat formation under current feeding conditions. As the next weaning date gets longer, the milking time also gets longer and therefore the LD also increases. At the same time, the relationship between the LMY and LD values of cows confirms the results in the table. Contrary to the results of this study, Basant et al. (2017) reported that differences in CI values of Egyptian buffaloes did not have a statistically significant effect on 305-day milk yield. Malhado et al. (2013) determined a genetic correlation of 0.40 and a phenotypic correlation of 0.08 between CI and LMY. In other words, it is reported that there is a moderate genetic relationship between milk yield and CI. Similarly, Nava-Trujillo et al. (2018) determined positive correlations between CI and total milk yield (r = 0.34) and LD (r = 0.67).

Conclusion

According to the results obtained in this study, the milk and fertility traits of buffalo cows and the growth traits of calves show significant changes from year to year, and these changes are caused by different environmental factors such as climate, rearing and nutritional conditions every year. In addition, it can be said that the genetic variation created in the buffalo population by the selection carried out within the scope of the Buffalo Breeding Project in Public Conditions carried out in the region is also effective in this change. As a matter of fact, the main goal of the project is to provide genetic improvement. The changes seen from year to year show a linear feature mostly in BW and LMY. 6th-and 12th-mo LW changes of calves, LD, FCA and CI of buffalo cows fluctuate from yearly due to environmental effects. The increase in FCA of buffalo cows again caused a linear increase in BW, LMY and LD. The CI difference had a more significant effect on LMY and LD than the traits emphasized and caused a general increase. Considering that FCA and CI values affect some yield and growth traits, further in-depth studies are needed to evaluate the environmental and genetic factors that cause variation in fertility traits and examine the effects of variability in these traits on sustainable and profitable production.

In light of these findings, although it seems that the increase in FCA and CI values has a positive effect on some yield and growth traits, it can be said that the time lost and the yield increases obtained in return should be evaluated economically.

Acknowledgments

In this research, Samsun Province Anatolian Buffalo Breeding Project in Public Conditions data was used (Project No: TAGEM/55MANDA2011-01). We would like to thank the Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies and Samsun Province Breeding Buffalo Breeders Association for their contributions.

References

Alkoyak, K., & Öz, S., (2020). The effect of some environmental factors on lactation length, milk yield and calving intervals of Anatolian Buffaloes in Bartın province of Turkey. *Livestock Studies*, 60 (2), 54-61. https://doi.org/10.46897/livestockstudies.846415

Alkoyak, K., & Öz, S., (2022). The effect of nongenetic factors on calf birth weight and growth performance in Anatolian buffaloes. *Turk J. Vet. Anim. Sci*., 46, 609-616. https://doi.org/10.55730/1300-0128.4232

Ayad, A.A., Abd-Allah, M., & Kamal, M.A., (2022). Non-genetic factors affecting phenotypic parameters of milk production and reproductive performance in lactating Egyptian buffaloes. *Archives of Agriculture Sciences Journal*, 5(1), 10-24. https://doi.org/10.21608/AASJ.2022.230030

Basant, M.N.S., El-Bayomi K.M., Abo-Salem, M.E.S., & Darwish, S.A., (2017). Environmental factors affecting some productive and reproductive traits in Egyptian buffaloes. *Benha Veterinary Medical Journal*, 32(1), 153-159.

Baş, T., 2008. Anket. Seçkin Yayıncılık, 236s. Ankara.

Bayrıl, T., & Yılmaz, O., (2010). Growth performance and survival rate traits in Holstein calves raised in Kazova Vasfi Diren Agriculture Farm. *Yüzüncü Yıl Üniversitesi Veteriner Fakültesi Dergisi,* 21(3), 169-173. (in Turkish)

Bhatti, S. A., Sarwar, M., Khan, M. S., & Hussain, S. M. I., (2007). Reducing the age at first calving through nutritional manipulations in dairy buffaloes and cows: a review. *Pakistan Veterinary Journal*, 27(1), 42-47.

Christa, C. B., & Sinniah, J., (2015). Performance of Murrah, Surti, Nili-Ravi buffaloes and their crosses in the intermediate zone of Sri Lanka. *Livestock Research for Rural Development.* 27(3), 1-7.

de Araujo Neto, F. R., Takada, L., Dos Santos, D. J. A., Aspilcueta-Borquis, R. R., Cardoso, D. F., do Nascimento, A. V., Leão K.M., de Oliveira H. N., & Tonhati, H., (2020). Identification of genomic regions related to age at first calving and first calving interval in water buffalo using single-step GBLUP. *Reproduction in Domestic Animals,* 55(11), 1565-1572. https://doi.org/10.1111/rda.13811

El-Awady, H. G., Ibrahim, A. F., & El-Naser, I. A. M. A., (2021). The effect of age at first calving on productive life and lifetime profit in lactating Egyptian buffaloes. *Buffalo Bulletin*, *40*(1), 71-85.

Eldawy, M. H., Lashen, M. E. S., Badr, H. M., & Farouk, M. H. (2021). Milk production potential and reproductive performance of Egyptian buffalo cows. *Tropical Animal Health and Production*, *53*, 1-12. https://doi.org/10.1007/s11250-021-02722-2

Erdem, H., Atasever, S., Kul, E., Onder, H., & Demirci, H., (2015). Growth characteristics of Anatolian buffalo calves reared in farm conditions: A case study in Samsun province of Turkey. *8th Asian Buffalo Congress.* April 21-25, 2015. Istanbul, Turkey.

Erdem, H., Okuyucu, I. C., & Abaci, S. H. (2022). Milking temperament of Anatolian buffaloes during early lactation. *Applied Animal Behaviour Science*, 253, 105679. https://doi.org/10.1016/j.applanim.2022.105679

Ergüneş Berkin, E., Küçükkebapçı, M., & Kaptan, C., (2020). Effects of some environmental factors on the some growth and lactation characteristics of Anatolian Water Buffalo in Balıkesir, Düzce and Kütahya. Black Sea Journal of Engineering and Science 3(4), 146-150. https://doi.org/10.34248/bsengineering.782547 (in Turkish)

Genç, S., Aksel, M., Ozkan Unal, E., Soysal, M.I., & Gurcan, K., (2019). Environmental effects on birth weight and growth of Anatolian Water Buffaloes in Istanbul. *12th World Buffalo Congress*, 18-20 September 2019, Istanbul-Turkey.

Han, Y., Vural, M.E., Karataş, A., Keskin, B., Yakişan, R., & Bakır, G., (2019). Some yield features of Anatolian Water Buffaloes grown in Diyarbakir province by Local Stock Breeders. *12th World Buffalo Congress*, 18-20 September 2019, Istanbul-Turkey.

Koçak, S., Tekerli, M., Çelikeloğlu, K., Erdoğan, M., Bozkurt, Z., & Hacan, Ö., (2019). An investigation on yield and composition of milk, calving interval and repeatabilities in riverine buffaloes of Anatolia. *The Journal of Animal & Plant Sciences*, 29(3), 650-656.

Kul, E., Filik, G., Sahin, A., Cayiroglu, H., Ugurlutepe, E., & Erdem, H., (2018). Effects of some environmental factors on birth weight of Anatolian Buffalo Calves. *Turkish Journal of Agriculture - Food Science and Technology*, 6(4), 444-446. https://doi.org/10.24925/turjaf.v6i4.444-446.1716

Kul, E., Şahin, A., Çayıroğlu, H., Filik, G., Uğurlutepe, E., & Öz, S., (2016). Effects of calving age and season on some milk yield traits in Anatolian Buffaloes. *Scientific Papers. Series D. Animal Science.* Vol. LIX, 33-37.

Kumar, V., Chakravarty, A., Patil, C., Valsalan, J., & Mahajan, A., (2015). Estimate of genetic and non-genetic parameters for age at first calving in Murrah buffalo. *Indian J Anim Sci*, *85*(1), 84-85.

Malhado, C. H. M., Malhado, A. C. M., Ramos, A. D. A., Carneiro, P. L. S., Souza, J. C. D., & Pala, A., (2013). Genetic parameters for milk yield, lactation length and calving intervals of Murrah buffaloes from Brazil. *Revista Brasileira de Zootecnia*, *42*, 565-569. https://doi.org/10.1590/S1516-35982013000800005

Mattii, S., Tommei, B., & Pasquini, M., (2005). Reproduction and production in a buffaloes farm of the Marche region: a ten-year study. *Italian Journal of Animal Science*, 4(sup2), 310-312, https://doi.org/10.4081/ijas.2005.2s.310

Mohd Azmi, A. F., Abu Hassim, H., Mohd Nor, N., Ahmad, H., Meng, G. Y., Abdullah, P., Abu Bakar, M., Vera, J., Mohd Deli, N.S., Salleh, A., & Zamri-Saad, M., (2021). Comparative growth and economic performances between indigenous swamp and Murrah crossbred buffaloes in Malaysia. *Animals*, 11(4), 957. https://doi.org/10.3390/ani11040957

Nava-Trujillo, H., Escalona-Muñoz, J., Carrillo-Fernández, F., & Parra-Olivero, A., (2018). Effect of parity on productive performance and calving interval in water buffaloes. *Journal of Buffalo Science*, 7(1), 13-16.

Öz, S., Alkoyak, K., & Küçükersan, S., (2022). Effects of calving year, season, and age on some lactation traits of Anatolian buffaloes reared at farmer conditions in Turkey. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*, 69(2), 157-162. https://doi.org/10.33988/auvfd.813234

Özçelik, M., & Arpacık, R., (2000). The effect of lactation number on milk production and reproduction in Holstein Cows. *Turk J. Vet. Anim. Sci*., 24, 39-44. (In Turkish)

Parlato, E., & Zicarelli, L., (2016). Effect of calving interval on milk yield in Italian buffalo population. *Journal of Buffalo Science*, *5*(1), 18-22.

Pryce, J. E., Coffey, M. P., Brotherstone, S. H., & Woolliams, J. A., (2002). Genetic relationships between calving interval and body condition score conditional on milk yield. *Journal of Dairy Science* 85(6), 1590-1595. https://doi.org/10.3168/jds.S0022-0302(02)74229-X

Sathwara, R.N., Gupta, J.P., Chaudhari, J.D., Parmar, G.A., Prajapati, B.M., Srivastava, A.K., Chauhan, H.D., Patel, P.A., and Prajapati, M.N., (2020). Analysis of association between various fertility indicators and production traits in Mehsana buffaloes. Tropical Animal Health and Production, 52, 2585-2592. https://doi.org/10.1007/s11250-020-02288-5

Seno, L. O., Cardoso, V. L., El Faro, L., Sesana, R. C., Aspilcueta-Borquis, R. R., De Camargo, G. M. F., & Tonhati, H., (2010). Genetic parameters for milk yield, age at first calving and interval between first and second calving in milk Murrah buffaloes. *Livestock Research for Rural Development*, *22*(2), 38.

Soysal, M.İ., Aksel, M., Gürcan, E.K., Özkan Ünal, E., & Genç, S., (2019). The prediction of lactation milk yield from partial milk record in Anatolian Water Buffalo. *12th World Buffalo Congress*, 18-20 September 2019, Istanbul-TURKEY.

Soysal, M.İ., Genç, S., Aksel, M., Özkan Ünal, E., & Gürcan, E.K., (2018). Effect of environmental factors on lactation milk yield, lactation length and calving interval of Anatolian Buffalo in Istanbul. *Journal of Animal Science and Products (JASP)* 1(1), 93-97.

Soysal, M. İ., Gürcan, E. K., & Aksel, M., (2016). The comparison of lactation curve with different models in Italian origined water buffalo herd raised in Istanbul province of Turkiye. *Journal of Tekirdag Agricultural Faculty*, 13(04), 139-144.

Soysal, M.İ., Tekerli, M., Daskiran, I., Ayar, A., Sozen, O., & Kaplan, Y., (2015). Anatolian water buffalo husbandry in Turkey. *8th Asian Buffalo Congress*, April 21-25, 2015, Istanbul, Turkey.

Şahin, A., & Ulutaş, Z., (2011). Some environmental factors affecting the milk yield and reproductive traits of Holstein cattle raised at Tahirova State Farm. *Anadolu J Agr Sci,* 26(2), 156-168. (in Turkish)

Şahin, A., Yıldırım, A., Ulutaş, Z., & Aksoy, Y., (2020). The effect of calving age, calving year and calving season on some milk yield characteristics of Anatolian Buffaloes reared in Tokat Province. *Journal of Animal Science and Products (JASP)* 3(1), 13-19. (in Turkish)

Şekerden, Ö., (2013a). Growth traits of Anatolian and Anatolian x Italian crossbred Buffalo calves under the village conditions. *Buffalo Bulletin* 32 (Special Issue 2), 632-636.

Şekerden, Ö., (2013b). Comparison of some reproductive traits of Anatolian and F1 crossbred (Anatolian×Italian) Buffalos under village conditions in Turkey. *Macedonian Journal of Animal Science*, 3(1), 3-7.

Tekerli, M., Altuntaş, A., Birdane, F., Sarımehmetoğlu, O., Doğan, İ., Bozkurt, Z., Erdoğan, M., Çelik, H.A., Koçak, S., Gürler, Z., Bülbül, T., Çelikeloğlu, K., & Kabu, M., (2015). Comparative determination of improvement opportunities for production traits, body measurements and protein polymorphisms in a herd consisting of Anatolian buffaloes from different regions. *8th Asian Buffalo Congress*, April 21-25, 2015, Istanbul, Turkey.

Tekerli, M., Kucukkebabci, M., Akalin, N. H., & Kocak, S., (2001). Effects of environmental factors on some milk production traits, persistency and calving interval of Anatolian buffaloes. *Livestock Production Science*, *68*(2-3), 275-281. https://doi.org/10.1016/S0301-6226(00)00240-2

Thiruvenkadan, A. K., Panneerselvam, S., & Murali, N., (2015). Study on ages at first mating and calving of Murrah buffaloes in hot and humid climate of Tamil Nadu, India. *Indian Journal of Animal Research*, *49*(5), 591-94. https://doi.org/10.18805/ijar.5567

Thiruvenkadan, A. K., Panneerselvam, S., Murali, N., Selvam, S., & Saravanakumar, V. R., (2014). Milk production and reproduction performance of Murrah buffaloes of Tamil Nadu, India. *Buffalo Bulletin*, *33*(3), 291-300.

Thiruvenkadan, A. K., Panneerselvam, S., & Rajendran, R., (2009). Non-genetic and genetic factors influencing growth performance in Murrah Buffalos. *South African Journal of Animal Science*, 39(1), 102-106. https://hdl.handle.net/10520/EJC94685

Uçar, M., Gündoğan, M., & Yılmaz, O., (2005). Seasonal reproductive traits and follicular dynamics in water buffaloes (A Review). *Hayvancılık Araştırma Dergisi*, 2, 24-29. (in Turkish)

Uğurlu, M., Kaya, I., & Saray, M., (2016). Effects of some environmental factors on calf birth weight and milk yield of Anatolian Water Buffalo (Bubalus bubalis). *Bulgarian Journal Of Agricultural Science,* 22(6), 995-998.

Verma, R., Vijayalakshmy, K., Virmani, M., Kumar, S., & Verma, A., (2021). Seasonal influence of age at first calving on genetic variation and subsequent reproductive performances in Murrah buffaloes. *Biological Rhythm Research,* 52(4), 622-635. https://doi.org/10.1080/09291016.2019.1627655

Yılmaz, A., Ocak, E., & Kose, S., (2017). A research on milk yield, milk composition and body weights of Anatolian buffaloes. *Indian J. Anim. Res*., 51 (3), 564-569. https://doi.org/10.18805/ijar.11474