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The effect of nongenetic factors on calf birth weight and growth performance in Anatolian buffaloes

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Abstract: The aim of the current study is to determine the growth performances of Anatolian buffaloes such as birth weight (BW_0), body weight at 6 months (BW_6), body weight at 12 months (BW_{12}), average daily weight gain from birth to 6 months (ADG_{0-6}), average daily weight gain from birth to 12 months (ADG_{0-12}) and average daily weight gain from 6 to 12 months (ADG_{6-12}), and to identify various nongenetic factors affecting these traits. In the study, the data of 2821 head buffalo calves born from buffaloes bred from the Anatolian Buffalo Breeding Project in Bartın province between 2015–2021 were used. In the present study, the effects of nongenetic factors such as district, calving year and season, calving age, and sex on BW_0 and growth performance characteristics were investigated. The mean and standard errors of the BW_0, BW_6, BW_{12}, ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values of buffalo calves were calculated as 28.33 ± 0.090 kg, 119.13 ± 0.459 kg, 173.53 ± 0.743 kg, 504.64 ± 2.31 g, 398.24 ± 1.88 g, and 304.27 ± 2.45 g respectively. In the study, except for the effect of calving age on ADG_{0-6} and ADG_{6-12} ($p > 0.05$), the effect of all other nongenetic factors on growth performance was found to be statistically significant ($p \leq 0.05$). There is not enough research on environmental factors affecting growth performance at different ages in Anatolian buffaloes. The data on growth performances and significant nongenetic factors obtained in this study will be useful in the selection program and improvement in buffalo husbandry and enlighten future studies.

Key words: Anatolian buffalo, birth weight, daily weight gain, growth performance, nongenetic factors

1. Introduction

The existence of buffaloes in Turkey dates back to 3000 BC. Anatolian Buffalo breed is classified as Mediterranean buffalo among river-type buffaloes. This breed is spread all over Turkey, the majority of the buffalo population in Turkey is located in the Central Black Sea Region [1,2]. The current number of these animals is 192,489 and they are generally raised for meat and milk [3][1]. Anatolian buffaloes are very resistant to sudden changes in feeding as well as diseases [4]. Buffalo milk is used in the production of cream, cheese, and ice cream. Buffalo meat is a promising market as it is preferred by consumers due to its excellent nutritional properties and taste and thus gaining popularity in many parts of the world [5,6,7]. However, only 0.38% and 0.007% of the milk and red meat produced from bovine animals in Turkey in 2019 are produced from buffaloes respectively, and these rates are quite low[1]. To increase milk and meat production, it is very important to know the factors affecting the growth performance as well as increasing the number of buffaloes.

Calf birth weight, which is an indicator of growth, is affected by genetic and nongenetic factors such as dam's age and calf sex in the prenatal period [8,9]. Birth weight (BW_0) is associated with adaptation and survival [10], and is also used as an indicator feature in selection programs to reduce the risk of dystocia [11]. The growth characteristics of buffaloes are affected by many environmental factors as well as their genetic structure. Environmental factors can suppress the real growth potential of the animal and therefore make normal selection procedures ineffective [12]. In this respect, the success of the breeding program largely depends on understanding and knowing the relationship between genetic and environmental effects [13].

There is very little information in the literature about the growth performance of Anatolian buffaloes, especially about average daily weight gains (ADG) and the effect of nongenetic factors on growth performance. This study aimed to formulate stud selection and breeding programs and to contribute to future genetic studies by determining the effect of nongenetic factors affecting some growth

[1] TURKSTAT (2022). Turkish Statistical Institute Statistics. [online]. Website http://www.turkstat.gov.tr/Start.do [Accessed 01 Jan, 2022].

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performances of Anatolian buffaloes in farms where the breeding project is applied.

2. Material and method

2.1. Study area, animals, and data collection

The material of the study consisted of birth records of 2821 calves obtained from Anatolian buffaloes (41°38′4″N and 32°20′15″E) that gave birth in Bartın province between 2015 and 2021. The data on the growth performances of Anatolian buffaloes were obtained from the "Manda Yıldızı" program [14] in which the data were recorded within the scope of the National Project of Buffalo Breeding, supported by the General Directorate of Agricultural Research and Policies. Buffalo farming is carried out under extensive conditions in the area where the study was conducted. On days when the season is suitable, buffaloes are taken to the pasture in the morning and return in the evening. When the buffaloes are out on the pasture, additional feeding is not generally performed, but farmers do additional feeding according to the current feed (hay, silage dry alfalfa hay, etc.) in winter. In the farms within the scope of the breeding project where the study was carried out, the care and feeding methods for the buffaloes are generally similar to each other. The average number of female buffaloes per farm is 10 heads and the birth rate of buffaloes is approximately 44%. Within the farms, the buffalo cows are naturally inseminated by the bulls. Bulls are replaced every 2–3 years as for the project. Ear tags are applied to all buffalo calves born in the farms and their BW_0 are weighed within 24 h with a digital scale (up to 10 g sensitive with a capacity of 50 kg). Meanwhile, the birth information (date of birth, sex, and dam's ear tag number) of the buffalo calves is taken and recorded. Buffalo calves suckle from their dams twice a day, morning and evening. After about 5–6 months of age, they go out to the pasture with their dams. Body weights of buffalo calves at the ages of 6 (BW_6) and 12 months (BW_{12}) are weighed and recorded with a scale (600 kg capacity, sensitive up to 100 g). Average daily weight gains from birth to 6 months (ADG_{0-6}), from birth to 12 months (ADG_{0-12}), and 6 to 12 months (ADG_{6-12}) were calculated using these weights (BW_0, BW_6 ve BW_{12}) [15,16]. The study was carried out in 4 districts of Bartın province; (1) Amasra, (2) Kurucaşile, (3) Center, and (4) Ulus. According to the climatic conditions, calving seasons were divided into four groups; (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 age was divided into six groups: (1) age ≤ 4 years, (2) 4 < age ≤ 6, (3) 6 < age ≤ 8, (4) 8 < age ≤ 10, (5) 10 < age ≤ 12, (6) 12 < age.

2.2. Statistical analysis

In this study, the effects of the district, calving year and season, age, and sex on the growth performance of the nongenetic factors were determined by using the "Least Squares Method". Checks for statistical significance of mean values were made by analysis of variance, and differences between significant means were made by Tukey's multiple comparison test. Due to insufficient data in subgroups, two or three-way interactions between the factors were not included in the analysis. The GLM (General Linear Model) method in the "Minitab-Version 18" program package was used for the statistical analysis of all data [17]. The effects of nongenetic factors examined in the present study on some growth characteristics (BW_0, BW_6, BW_{12}, ADG_{0-6}, ADG_{0-12}, and ADG_{6-12}) were investigated using the model below.

Y_{ijklmn}: $\mu + D_i + Y_j + S_k + A_l + G_m + e_{ijklmn}$

Where;

Y_{ijklmn}: Level of productivity feature of any buffalo (i. district, j. year, k. season l. age, m. the observation value of the feature emphasized on sex)

μ: General (expected) mean,

D_i: Effect of i^{th} district (i = 1,2,3,4)

Y_j: Effect of j^{th} calving year (j = 2015, 2016, 2017, 2018, 2019, 2020),

S_k: Effect of k^{th} calving season (k = 1,2.3,4),

A_l: Effect of l^{th} calving age (l = 1,2,3,4,5,6)

G_m: Effect of m^{th} sex (m = male, female)

e_{ijklmn}: Random error which is assumed to be normally independently distributed with zero mean and constant variance (NID, 0, σ_2).

3. Results

The effect of the nongenetic factors on these growth performances and the least squares averages are shown in Table 1 and Table 2. In this study, BW_0, BW_6, BW_{12} overall mean and standard error were determined as 28.33 ± 0.090, 119.13 ± 0.459, and 173.53 ± 0.743 kg, respectively (Table 1). The overall mean and standard error of ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} were 504.64 ± 2.31, 398.24 ± 1.88, and 304.27 ± 2.45 g, respectively (Table 2). The effects of nongenetic factors such as district, calving year, season, calving age and sex on these features were determined. Except for the effect of calving age on ADG_{0-6} and ADG_{6-12} ($p > 0.05$), the effect of all other nongenetic factors on growth performance was found to be significant ($p < 0.05$, $p < 0.01$, $p < 0.001$).

4. Discussion

The BW_0 value found in the present study (28.33 ± 0.090 kg) (Table 1) is higher than the values in the research by Uğurlu et al. [18] (26.95 ± 0.25 kg) on Anatolian buffaloes. On the other hand, it is compatible with the study performed by Kul et al. [19] (29.3 ± 0.43 kg) on Anatolian buffaloes in Turkey. However, this value found in our research is lower than the BW_0 found by many other researchers [20–27].

Table 1. Least squares means (± SE) of various growth periods in Anatolian buffaloes according to the district, calving year, season, age, and sex.

Nongenetic factors	BW_0 (kg)		BW_6 (kg)		BW_{12} (kg)	
	n	Mean ± SEM	n	Mean ± SEM	n	Mean ± SEM
Overall means	2821	28.33 ± 0.090	2536	119.13 ± 0.459	2091	173.53 ± 0.743
District		***		***		***
Amasra	144	27.50 ± 0.210^{c}	126	114.72 ± 1.080^{c}	97	165.78 ± 1.650^{c}
Kurucaşile	132	29.16 ± 0.222^{a}	124	125.75 ± 1.100^{a}	113	184.42 ± 1.540^{a}
Centrum	2193	28.52 ± 0.061^{b}	2000	117.94 ± 0.308^{b}	1646	172.73 ± 0.532^{b}
Ulus	352	28.13 ± 0.140^{c}	286	118.13 ± 0.740^{b}	235	171.20 ± 1.120^{b}
Calving year		***		***		***
2015	287	26.00 ± 0.172^{e}	270	111.43 ± 0.854^{e}	243	160.36 ± 1.210^{d}
2016	405	27.00 ± 0.147^{d}	390	117.17 ± 0.725^{d}	373	167.72 ± 0.994^{c}
2017	518	28.27 ± 0.135^{c}	502	119.88 ± 0.664^{bc}	452	176.97 ± 0.937^{ab}
2018	555	28.62 ± 0.130^{c}	518	118.80 ± 0.644^{cd}	469	175.55 ± 0.894^{b}
2019	534	29.42 ± 0.129^{b}	526	121.88 ± 0.631^{b}	502	179.30 ± 0.873^{a}
2020	522	30.66 ± 0.131^{a}	330	125.65 ± 0.766^{a}	52	181.30 ± 2.290^{ab}
Calving season		*		***		**
Winter	457	28.25 ± 0.137^{ab}	377	117.92 ± 0.706^{b}	339	173.43 ± 1.010^{ab}
Spring	637	28.13 ± 0.129^{b}	592	118.18 ± 0.650^{b}	507	171.40 ± 0.980^{b}
Summer	969	28.43 ± 0.109^{ab}	904	121.27 ± 0.550^{a}	733	175.05 ± 0.895^{a}
Fall	758	28.50 ± 0.118^{a}	663	119.17 ± 0.610^{b}	512	174.25 ± 0.980^{a}
Calving age (year)		***		***		***
3–4	499	26.92 ± 0.134^{d}	456	116.74 ± 0.675^{b}	388	170.08 ± 1.010^{b}
5–6	661	27.90 ± 0.120^{c}	592	118.45 ± 0.613^{ab}	507	172.86 ± 0.920^{ab}
7–8	647	28.40 ± 0.121^{b}	589	119.50 ± 0.609^{a}	506	174.16 ± 0.922^{a}
9–10	521	28.81 ± 0.129^{ab}	469	120.14 ± 0.657^{a}	380	174.36 ± 1.000^{a}
11–12	320	28.88 ± 0.158^{ab}	275	119.06 ± 0.809^{ab}	209	172.86 ± 1.240^{ab}
13≤	173	29.06 ± 0.211^{a}	155	120.92 ± 1.070^{a}	101	176.86 ± 1.720^{a}
Sex of calves		***		***		***
Male	1429	28.66 ± 0.102^{a}	1283	120.77 ± 0.514^{a}	1039	176.96 ± 0.817^{a}
Female	1392	27.99 ± 0.102^{b}	1253	117.50 ± 0.519^{b}	1052	170.10 ± 0.817^{b}

BW_0: Birth weight; BW_6: Body weight at 6 months; BW_{12}: Body weight at 12 months
*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$
a, b, c, d, e: Differences between averages with different letters in the same column are significant ($p < 0.05$).

In Egyptian buffaloes, the values were reported as 42.0 ± 0.5 kg by Marai et al. [21] and 33.263 ± 0.828 kg by Kamal El-den et al. [22]; in Nili Ravi buffaloes, the values were reported as 31.2 ± 0.84 kg by Charlini and Sinniah [20] and as 36.1 ± 3.23 kg by Kuthu and Hussain [23]; in Anatolian buffaloes, they were reported as 30.4 kg by Çelikeloğlu et al. [24]; in Swamp buffaloes, they were reported as 30.11 ± 4.49 kg by Thevamanoharan et al. [25]; in Murrah buffaloes, they were 32.4 ± 0.30 kg by Thiruvenkadan et al. [26], and in Iraqi buffaloes, the values were reported as 37.711 ± 0.231 kg by Al-Khauzai [27]. These variations in BW_0 may result from differences in management and a lack of genetic improvement. Although BW_0 is the first appropriate criterion for growth, maternal influences are strong and should not be ignored [22]. The low BW_0 value in the present study may be due to the breeds of buffaloes in other studies, their higher productivity, and the genotype differences in the regions where the studies are carried out.

Table 2. Least squares means (± SE) of various growth periods in Anatolian buffaloes according to the district, calving year, season, age, and sex.

Non-Genetic factors	ADG_{0-6} (g)		ADG_{0-12} (g)		ADG_{6-12} (g)	
	n	Mean ± SEM	n	Mean ± SEM	n	Mean ± SEM
Overall means	2536	504.64 ± 2.31	2091	398.24 ± 1.88	2091	304.27 ± 2.45
District		***		***		***
Amasra	126	485.15 ± 5.40^{b}	97	380.11 ± 4.15^{c}	97	291.78 ± 5.42^{c}
Kurucaşile	124	536.54 ± 5.53^{a}	113	425.47 ± 3.89^{a}	113	326.29 ± 5.07^{a}
Centrum	2000	496.81 ± 1.55^{b}	1646	395.23 ± 1.34^{b}	1646	306.99 ± 1.75^{b}
Ulus	286	500.05 ± 3.72^{b}	235	392.13 ± 2.84^{bc}	235	292.04 ± 3.70^{c}
Calving year		***		***		***
2015	270	474.39 ± 4.29^{d}	243	368.00 ± 3.05^{d}	243	270.07 ± 3.98^{b}
2016	390	500.87 ± 3.64^{c}	373	385.77 ± 2.51^{c}	373	281.32 ± 3.27^{b}
2017	502	508.78 ± 3.34^{bc}	452	407.55 ± 2.36^{ab}	452	316.92 ± 3.09^{a}
2018	518	501.09 ± 3.23^{c}	469	402.68 ± 2.26^{b}	469	314.24 ± 2.95^{a}
2019	526	513.76 ± 3.17^{b}	502	411.02 ± 2.20^{a}	502	319.75 ± 2.87^{a}
2020	330	528.93 ± 3.84^{a}	52	414.40 ± 5.77^{ab}	52	323.34 ± 7.54^{a}
Calving season		***		**		***
Winter	377	498.28 ± 3.55^{b}	339	398.18 ± 2.56^{ab}	339	310.11 ± 3.34^{a}
Spring	592	500.78 ± 3.26^{b}	507	393.11 ± 2.47^{b}	507	295.76 ± 3.23^{b}
Summer	904	515.72 ± 2.70^{a}	733	402.00 ± 2.26^{a}	733	299.44 ± 2.95^{b}
Fall	663	503.77 ± 3.06^{b}	512	399.66 ± 2.47^{a}	512	311.78 ± 3.23^{a}
Calving age (year)		NS		*		NS
3–4	456	499.07 ± 3.39	388	392.50 ± 2.55^{b}	388	300.22 ± 3.32
5–6	592	502.90 ± 3.08	507	397.35 ± 2.32^{ab}	507	304.70 ± 3.03
7–8	589	506.53 ± 3.06	506	399.87 ± 2.33^{ab}	506	304.11 ± 3.04
9–10	469	507.76 ± 3.30	380	399.33 ± 2.53^{ab}	380	302.84 ± 3.30
11–12	275	501.29 ± 4.06	209	395.19 ± 3.13^{ab}	209	303.69 ± 4.09
13≤	155	510.27 ± 5.36	101	405.17 ± 4.33^{a}	101	310.08 ± 5.66
Sex of calves		***		***		***
Male	1283	511.85 ± 2.58^{a}	1039	406.62 ± 2.06^{a}	1039	312.97 ± 2.69^{a}
Female	1253	497.43 ± 2.61^{b}	1052	389.85 ± 2.06^{b}	1052	295.58 ± 2.69^{b}

ADG_{0-6}: Daily weight gain from birth to 6 months; ADG_{0-12}: Daily weight gain from birth to 12 months; ADG_{6-12}: Daily weight gain from 6 to 12 months.

*: $p < 0.05$ **: $p < 0.01$ ***: $p < 0.001$ NS: not significant ($p > 0.05$)

a, b, c, d: Differences between averages with different letters in the same column are significant ($p < 0.05$).

The BW_6 value found in this study (119.13 ± 0.459 kg) is compatible with the study by Çelikeloğlu et al. [24] (118.46 kg) on Anatolian buffaloes. The current study finding is lower than the values reported by Marai et al. [21] (134.8 ± 0.4 kg) on Egyptian buffaloes, Al-Khauzai [27] (126.095 ± 0.393 kg) on Iraqi buffaloes, and Shahjahan et al. [15] (144.14 ± 4.10 kg) in F1 crossbred (Indigenous × Mediterranean) buffaloes. On the other hand, it is higher than the values of Thiruvenkadan et al. [26] (87.9 ± 0.95 kg) and Shahjahan et al. [15] (113.42 ± 4.47 kg) in indigenous buffaloes in Bangladesh. The BW_{12} value (173.53 ± 0.743 kg) found is higher than the values found in Murrah buffalo researches by Thiruvenkadan et al. [26] (134.2 ± 1.41). However, it is lower than the values reported by Çelikeloğlu et al. [24] in Anatolian buffaloes (179.37 kg), Kamal El-den et al. [22] (208,470 ± 5,042

kg) and Shahjahan et al. [15] in indigenous buffaloes in Bangladesh (194.88 ± 9.55 kg), and in F1 crossbred (Indigenous × Mediterranean) buffaloes (219.70 ± 6.36 kg). These differences in BW_6 and BW_{12} values may have resulted from the differences in genotypes of buffaloes in the study areas and the differences in care, feeding, and management practices in the farms.

In this study, BW_0, BW_6, and BW_{12} were significantly ($p < 0.001$) affected by the district. Similar to this study, Ergüneş et al. [16] reported that the province has a significant effect on BW_0, BW_6, and BW_{12} in Anatolian buffaloes. On the other hand, contrary to this study, Çelikeloğlu et al. [24] notified that the province did not have a significant effect on BW_0, BW_6, and BW_{12} in Anatolian buffaloes. In this study, the highest BW_0, BW_6, and BW_{12} values were obtained in Kurucaşile district, and the lowest BW_0, BW_6, and BW_{12} values were obtained in the Amasra district. These different body weight values in the region may have resulted from the breeding bulls and the different management practices of the breeders. In the present study, the effect of calving year on BW_0, BW_6, and BW_{12} was found to be significant ($p < 0.001$) (Table 1). Similar to the current study, many researchers [16, 22–25] reported that the calving year had a significant effect on BW_0. Moreover, the effect of calving year on BW_6 was significant in Murrah buffaloes [26]. In addition, significant effects of calving year on BW_6 and BW_{12} were reported in F1 cross (Indigenous × Mediterranean) buffaloes from Bangladesh [15]. On the other hand, unlike this study, it was found that the calving year did not have a significant effect on BW_0 in Egyptian buffaloes [21], on BW_6 and BW_{12} in Anatolian buffaloes [24], and in indigenous buffaloes in Bangladesh [15], and on BW_{12} in Murrah buffaloes [26]. In this study, there was a generally smooth increase in BW values as the years progressed, and this can be attributed to the experience gained by the breeders in care and feeding over the years.

In this study, calving season was found to be significant on BW_0, BW_6, and BW_{12} ($p \leq 0.05$). Similar to this study, it was reported by many researchers [19, 21] that the calving season had a significant effect on BW_0, on BW_6 in Anatolian buffaloes [24], and on BW_6 and BW_{12} again in Anatolian buffaloes [28]. On the other hand, unlike this study, some researchers [22–24] stated that calving season did not have a significant effect on BW_0, on BW_6 in Murrah buffaloes [21,26], and on BW_6 and BW_{12} in Bangladesh buffaloes [15]. In this study, the lowest BW_0 value was obtained in those born in spring (28.13 ± 0.129 kg), and the highest BW_0 value was in those born in autumn (28.50 ± 0.118 kg). This result shows that buffaloes make good use of pasture in the spring and summer seasons during the last stages of their pregnancy and contribute to the increase in BW of their offspring. In addition, in this study, while BW_6 and BW_{12} values were close to each other in buffalo calves born in autumn, winter, and spring, the highest BW_6 and BW_{12} values were obtained in buffalo calves born in summer.

In this study, the effect of calving age on BW_0, BW_6, and BW_{12} was found to be significant ($p < 0.001$) (Table 1). Consistent with this study, in studies conducted by some researchers [18,19] on Anatolian buffaloes, the calving age was significant on BW_0; in some studies on Iraqi buffaloes [27], it was significant on BW_0 and BW_6, and in some other studies on Anatolian buffaloes [29], it had a significant effect on BW_{12}. However, contrary to the current research, it was reported that the effect of calving age on BW_0 and BW_6 in Anatolian buffaloes [29] and the effect of calving age on BW_6 and BW_{12} in Anatolian buffaloes [28] were not significant. In this study, the lowest BW_0, BW_6, and BW_{12} values were reached in those born from buffaloes ≤ 4 years of age at 26.92 ± 0.134, 116.74 ± 0.675, and 170.08 ± 1.010 kg, respectively; and the highest BW_0, BW_6, and BW_{12} values were 29.06 ± 0.211, 120.92 ± 1.070, and 176.86 ± 1.720 kg, respectively, in those born from buffaloes aged 13≤ in the present study, it was observed that the BW_0, BW_6, and BW_{12} values of buffalo calves increased regularly as the calving age increased. This result shows that reproductive performance increases with increasing age in buffaloes and contributes to the increase in BW_0, BW_6, and BW_{12}. In this study, the effect of sex on BW_0, BW_6, and BW_{12} was found to be significant ($p < 0.001$) (Table 1). Similar to this study,Kul et al. [29] reported that sex had a significant effect on BW_0, BW_6, and BW_{12} in Anatolian buffaloes, on BW_6 in Iraqi buffaloes [27], and on BW_{12} in Egyptian buffaloes [22]. On the other hand, unlike this study, it was reported that sex did not have a significant effect on BW_6 and BW_{12} in Anatolian buffaloes [24] and Bangladesh buffaloes [15], and on BW_0 in Egyptian buffaloes [22]. It was also calculated in the present study that males have significantly higher BW_0, BW_6, and BW_{12} than females.

The ADG_{0-6} value (504.64 ± 2.31 g) in this study was lower than in the studies by Marai et al. [21] (0.667.24 ± 0.01 kg) on Egyptian buffaloes, and in the studies by Shahjahan et al. [15] (599.66 ± 22.21 g) on F1 crossbred (Indigenous × Mediterranean) buffaloes in Bangladesh. However, it was found to be higher than the value in the study on indigenous buffaloes in Bangladesh by Shahjahan et al. [15] (468.94 ± 21.70). It is thought that these different values may result from the different genotypes in the researched regions and the different management, care, and feeding regimes in the farms. The ADG_{0-12} (398.24 ± 1.88 g) value in the present study was found to be lower than in the studies on Egyptian buffaloes by Kamal Elden et al. [22] (0.479 ± 0.013 g), and than in the studies by Shahjahan et al. [15] on indigenous (456.85 ± 25.69 g) and F1 crossbred (Indigenous × Mediterranean) buffaloes (506.09 ± 16.82 g) in Bangladesh (456.85 ± 25.69 g), and

this result can be attributed to the breeds and higher productivity of buffaloes in other studies. In the current study, ADG_{6-12} values were found to be 304.27 ± 2.45 g, and there is not a study in the literature on this feature in Anatolian buffaloes and other buffalo breeds.

In the study, the effect of the district on ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} was found to be significant ($p < 0.001$) (Table 2). In this study, the highest ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values were found in the Kurucaşile district as 536.54 ± 5.53, 425.47 ± 3.89, and 326.29 ± 5.07 g, respectively; and the lowest ADG_{0-6}, ADG_{0-12}, ve ADG_{6-12} values were found in Amasra district as 485.15 ± 5.40, 380.11 ± 4.15, and 291.78 ± 5.42 g, respectively. The difference in ADG values between districts may be the result of the farms and the different management practices of the breeders. In the present study, the effect of calving year on ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} was found to be significant ($p < 0.001$) (Table 2). In this study, the lowest ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values were obtained as 474.39 ± 4.29, 368.00 ± 3.05, and 270.07 ± 3.98 g, respectively, in 2015; and the highest ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values were obtained in 2020 as 528.93 ± 3.84, 414.40 ± 5.77, and 323.34 ± 7.54 g, respectively. In general, it is seen that the ADG increases as the years' progress. This result may be due to the training given to the breeders each year and the improvement in management on the farm. Similar to the results of the present study, calving year had a significant effect on ADG_{0-6} and ADG_{0-12} in F1 crossbred (Indigenous × Mediterranean) buffaloes [15], and on ADG_{0-12} in Egyptian buffaloes [22]. However, unlike in the present study, it was reported in the studies that the effect of calving year on ADG_{0-6} and ADG_{0-12} in Bangladesh indigenous buffaloes [15] and on ADG_{0-6} in Egyptian buffaloes [21] were not significant.

In this study, the effect of calving season on ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} was found to be significant ($p \leq 0.01$). The highest ADG_{0-6} and ADG_{0-12} values were obtained in summer as 515.72 ± 2.70 and 402.00 ± 2.26 g, respectively, and the highest ADG_{6-12} value was obtained in autumn as 311.78 ± 3.23 g. Similar to the current study, the effect of calving season on ADG_{0-6} was found to be significant in studies on Bangladesh indigenous buffalo [15] and Egyptian buffalo [21]. However, contrary to this study, it was reported that the effect of the calving season on ADG_{0-6} and ADG_{0-12} was not significant in studies conducted in F1 crossbred (Indigenous × Mediterranean) buffaloes [15]. In addition, it was reported that the effect of the calving season on ADG_{0-12} was not significant in the study on Egyptian buffaloes [22]. These differences may have resulted from changes in management and climatic conditions at different times of the year or over a period of time. The effect of calving age on ADG_{0-6} and ADG_{6-12} was not significant ($p > 0.05$), while the effect on ADG_{0-12} was significant ($p < 0.001$). The lowest ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values were obtained as 499.07 ± 3.39, 392.50 ± 2.55, and 300.22 ± 3.32 g respectively in buffaloes calving ≤ 4 years of age; and the highest ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values were obtained as 510.27 ± 5.36, 405.17 ± 4.33, and 310.08 ± 5.66 g respectively in buffaloes calving 13 ≤ years of age. In general, it is seen that ADG increases with increasing calving age. This result can be attributed to the fact that the reproductive performance increases and contributes to the increase in ADG with the advancing age of the buffalo, and to the increased experience of the breeders in farm management. In the present study, the effect of sex on ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} was found to be significant ($p < 0.001$). In this study, the ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values in males were 511.85 ± 2.58, 406.62 ± 2.06, and 312.97 ± 2.69 g, respectively; and ADG_{0-6}, ADG_{0-12}, and ADG_{6-12} values in females were 497.43 ± 2.61, 389.85 ± 2.06, and 295.58 ± 2.69 g, respectively. Similar to the current research, the effect of sex on ADG_{0-12} was found to be significant in a study on Egyptian buffaloes [22]. On the other hand, contrary to this study, it was reported that the effect of sex on ADG_{0-6} and ADG_{0-12} was not significant in the study on Bangladesh indigenous and F1 crossbred (Indigenous × Mediterranean) buffaloes [15]. In this study, it was seen that male buffalo calves have higher ADG than female buffalo calves. This increase is probably due to the increasing differences in the endocrine system between males and females [30].

In this study, nongenetic factors significantly affected the weight and growth performance of buffalo calves at all ages. Body weights and growth performance characteristics at different ages obtained in the present study, which are economically important, should be taken into account to better predicted parameters such as heritability in future genetic studies. In addition, it was concluded that the growth performance of buffaloes can increase if the environmental factors that are important are taken into account in the selection.

Conflict of interest

The authors declare that they have no conflict of interest.

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