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AN INVESTIGATION ON YIELD AND COMPOSITION OF MILK, CALVING INTERVAL AND REPEATABILITIES IN RIVERINE BUFFALOES OF ANATOLIA

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ABSTRACT

The objective of this study was to determine the effects of some environmental factors on the lactation milk yield, milk composition (fat, protein and lactose), lactation length and calving interval of the Anatolian buffalo and to estimate of repeatability for the investigated characteristics. Data were obtained from 1749 Anatolian buffaloes maintained at 134 farm operations between 2012 and 2016 in Afyonkarahisar province of Turkey. The record numbers used for analyses of lactation milk yield, milk content and calving interval were 4379, 1123 and 2298 respectively. The overall means, with respect to the Anatolian buffaloes, the lactation milk yield and lactation length were determined as 1087.49 ± 5.91 kg and 245.43 ± 0.90 days respectively. Also, the fat, protein and lactose yield of milk were 79.54 ± 1.15, 44.87 ± 0.53 and 63.70 ± 0.79 kg respectively. The overall mean of the calving interval was 450.35 ± 2.98 days. The effects of the farm operation, calving year, season and age on these characteristics were found to be significant ($p<0.01$, $p<0.001$). The repeatability estimates of lactation milk yield, lactation length, as well as the fat, protein and lactose yields of the milk were 0.389, 0.196, 0.399, 0.429 and 0.417 respectively. They were all statistically significant ($p<0.001$). It was concluded that the factors affecting milk production and reproduction must be considered in a selection program. Also, after corrections according to factors deemed significant in terms of milk yield and composition, buffaloes could be selected based on the first lactation milk yield in early ages.

Key words: Buffaloes, milk, milk composition, repeatability.

INTRODUCTION

The water buffalo (*Bubalus Bubalis*) was domesticated in India 5 000 years ago and is comprised of two subgroups, swamp and river buffaloes. The swamp buffalo is more common in Southeast Asian countries, while the river buffalo is more common in West Asia, particularly India and Pakistan (Borgese and Mazzi, 2005; Kumar *et al*., 2007). In 2014, there were approximately 195 million heads of water buffalo in the world, and about 145 million of them were in India and Pakistan (FAO, 2017). The Anatolian buffalo, found in Turkey, belongs to the Mediterranean water buffalo, a subgroup of the river buffalo. They are black or dark gray in color and have horns with upward curling tips, which lie backwards or to the sides (Soysal, 2009).

In Turkey, buffalo breeding is mainly carried out intensively in small scale family backyards, with a few large farm operations. The water buffalo population in Turkey was approximately 1 170000 heads in 1970 but had reduced to 87 000 heads by 2010 (TUIK, 2017). As a result of the countrywide Anatolian water buffalo improvement program, which was launched by the General Directorate of Agricultural Research and Policies of the Ministry of Agriculture and Forestry in 2011,the number of water buffaloes increased to 142 000 in 2016 (TUIK, 2017). The data of about 27 000 Anatolian buffaloes registered in this project are kept in a national database using a computer software named *Manda Yıldızı*. Afyonkarahisar province is located in the western Anatolia region and has about 6 000 heads of water buffaloes (TUIK, 2017). It is prominent for buffalo milk, meat and products such as cream, yoghurt, cheese and traditional sausage.

Water buffaloes are resistant to poor environmental conditions. The milk yield, milk composition and fertility (calving interval) of buffaloes are affected by factors such as genotype, age, season, feeding and management (Kumar *et al*., 2017).

In order to increase yields in buffalo breeding, the selection of appropriate animals is very important. Genetic parameters, such as heritability and repeatability, in herds have to be estimated for early selection of study animals. Studies have been carried out in different countries with different water buffalo breeds in order to calculate repeatability of milk yield, milk composition and calving intervals (Cady *et al*.,1983; Babar *et al*.,1996; Tekerli *et al*., 2001; Thevamanoharan *et al*., 2001; Ramos *et al*., 2006; Morammazi *et al*., 2007; Marai *et al*., 2009; Baharizadeh *et al*., 2012; Malhado *et al*., 2013; El-Bramony, 2015). However, the number of studies dealing with the genetic parameters of milk yield, milk composition and fertility traits of Anatolian water buffalo is limited.

The objective of this study was to determine the effects of some environmental factors on the lactation milk yield, milk composition (fat, protein and lactose), lactation length and calving interval in the Anatolian buffalo and to estimate of repeatability for the investigated characteristics in Afyonkarahisar province, Turkey.

MATERIALS AND METHODS

Material: This study was carried out using Anatolian buffaloes from Afyonkarahisar province (38º 45' 35'' N and 30º 32' 23'' E) registered in the National Anatolian Water Buffalo Improvement Program conducted by the General Directorate of Agricultural Research and Policies of the Ministry of Agriculture and Forestry in Turkey. The data of 1749 buffaloes maintained at 134 farms in central and Çay districts of Afyonkarahisar between 2012 and 2016 were processed. The selected records were based on the following criteria: lactation length ≥120 and ≤392 days and calving interval ≥300 and ≤700 days. Farm operations with less than 10 lactations were excluded from the analyses. Only the data recorded in the period of 2014 to 2016 for milk composition with ≥10 kg lactation fat yield were included.

Method: The Anatolian water buffaloes were raised base on pasture and different degrees of concentrate feeding in farm operations. The buffalo cows in the herd were bred naturally by the bulls.

The milk yield and composition of the Anatolian water buffaloes were checked on a monthly basis. The Test Interval Method proposed by ICAR (ICAR, 2017) was used in the calculation of lactation milk, fat, protein and lactose yields recorded from daily controls (Sargent et.al., 1968). On control days, the daily milk yield was determined with a scale of 100 gram precision. The milk samples taken on the control day were brought to the laboratory under a cold chain (+4 ^{0}C), and the fat, protein and lactose levels were analyzed with a precalibrated Lactostar device (Funke Gerber). The obtained data was transferred to the electronic medium via a computer software named *Manda Yıldızı* (Tekerli, 2015).

The investigated characteristics were analyzed using General Linear Model procedures of Minitab statistical software (version 17, Minitab Inc, State College, PA, USA). The statistical model included fixed effects: farm operation (1,2,3,4…and 134), year (2012, 2013, 2014, 2015 and 2016), season (winter, spring, summer and autumn), and age (≤4, 5, 6, 7, 8, 9, 10, 11 and 12≤). The Tukey test was used in calculating the differences between subgroups. The data in the subgroups were too few to make two or three-way interactions, there these were excluded from the analysis. The following model was used in estimation of repeatabilities for investigated traits.

$Y_{ijklmn} = \mu + Settlement_i + Cow_{ij} + Year_k + Season_l + Age_m + e_{ijklmn}$

Where, each record of Anatolian Buffaloes was classified according to fixed effects of settlement (Central and Çay districts), year, season and age. In addition buffalo cows were nested within settlement as random effect. Repeatabilities were calculated from intraclass correlation coefficients by using variance components and assuming no proximity among the animals.

RESULTS

The descriptive statistics of lactation milk yield, lactation length, milk composition and calving intervals are given in Table 1; the least square means are presented in Table 2, and the estimates of repeatability are shown in Table 3.

The general means of lactation milk yield, lactation length, as well as fat, protein and lactose yields were determined as 1087.49 ± 5.91 kg, 245.43 ± 0.90 days, 79.54 ± 1.15, 44.87 ± 0.53 and 63.70 ± 0.79 kg respectively. The overall mean of the calving interval was 450.35 ± 2.98 days. The effects of the farm operation, calving year, season and age were found to be significant ($p<0.01$, $p<0.001$) for these characteristics.

The estimates of repeatability for lactation milk yield, lactation length, the fat, protein, lactose yield and calving intervals were 0.389, 0.196, 0.399, 0.429, 0.417 and 0.149 respectively. They were all statistically significant ($p<0.001$).

Table 1. Descriptive Statistics for lactation milk yield, lactation length, milk composition and calving interval in Anatolian Buffalo.

Traits	Number of Animals	Number of Records	Mean	Standard Deviation	Minimum	Maximum
Lactation milk yield (kg)	1749	4379	1128.90	350.10	171.80	2996.10
Lactation length (days)	1749	4379	250.20	44.16	120.00	392.00
Fat yield (kg)	848	1123	82.05	28.75	11.70	228.60
Protein yield (kg)	848	1123	46.17	14.21	5.04	110.77
Lactose yield (kg)	848	1123	66.22	20.66	7.56	174.71
Calving interval (days)	1164	2298	430.67	91.41	300.00	700.00

Table 2. Least squares means for lactation milk yield, lactation length, milk composition and calving interval in Anatolian Buffalo.

Factors		Lactation milk yield (kg)		Lactation length (days)		Fat yield (kg)		Protein yield (kg)		Lactose yield (kg)		Calving interval (days)	
		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	$\bar{X} \pm S_{\bar{x}}$	n	$\bar{X} \pm S_{\bar{x}}$
μ		**4379**	**1087.49±5.91**	**4379**	**245.43±0.90**	**1123**	**79.54±1.15**	**1123**	**44.87±0.53**	**1123**	**63.70±0.79**	**2298**	**450.35±2.98**
			***		***		***		***		***		***
Calving year													
	2012	673	1005.20±10.40^{c}	673	247.96±1.59^{a}	-	-	-	-	-	-	-	-
	2013	820	1084.35±9.51^{b}	820	237.33±1.45^{b}	-	-	-	-	-	-	427	424.24±4.90^{b}
	2014	905	1128.48±9.11^{a}	905	248.24±1.39^{a}	583	78.97±1.20^{b}	583	44.42±0.55^{b}	583	66.37±0.82^{a}	590	460.91±4.25^{a}
	2015	1008	1126.18±8.48^{a}	1008	246.57±1.29^{a}	385	85.69±1.43^{a}	385	48.41±0.66^{a}	385	65.99±0.97^{a}	648	461.30±4.03^{a}
	2016	973	1093.23±8.93^{b}	973	247.01±1.36^{a}	155	73.95±2.12^{b}	155	41.76±0.97^{c}	155	58.74±1.44^{b}	633	454.94±4.23^{a}
			***		***		***		***		***		***
Calving season													
	Winter	428	1203.70±12.30^{a}	428	263.38±1.87^{a}	145	84.14±1.98^{a}	145	48.32±0.91^{a}	145	68.53±1.35^{a}	202	493.90±6.52^{a}
	Spring	2093	1117.10±6.22^{b}	2093	252.98±0.95^{b}	614	81.90±1.07^{a}	614	46.89±0.49^{a}	614	66.41±0.73^{a}	1051	429.86±3.21^{c}
	Summer	1538	1037.23±6.90^{c}	1538	238.25±1.05^{c}	312	75.35±1.35^{b}	312	42.50±0.62^{b}	312	59.98±0.92^{b}	878	422.46±3.32^{c}
	Autumn	320	991.94±13.80^{d}	320	227.09±2.10^{d}	52	76.75±3.18^{ab}	52	41.75±1.46^{b}	52	59.88±2.16^{b}	167	455.17±7.03^{b}
			***		***		***		***		***		**
Calving age													
	≤ 4	1211	968.80±7.88^{d}	1211	242.56±1.20^{bc}	260	72.62±1.68^{b}	260	41.18±0.77^{b}	260	58.48±1.15^{b}	272	459.14±5.73^{ab}
	5	541	1050.90±11.00^{c}	541	245.37±1.67^{abc}	153	79.58±1.94^{a}	153	44.22±0.89^{ab}	153	63.04±1.32^{ab}	314	463.15±5.38^{a}
	6	508	1082.60±11.10^{bc}	508	249.78±1.69^{a}	114	80.00±2.22^{ab}	114	45.40±1.02^{a}	114	64.02±1.51^{a}	321	456.33±5.27^{ab}
	7	416	1097.50±12.20^{abc}	416	243.91±1.85^{abc}	104	78.74±2.31^{ab}	104	44.14±1.06^{ab}	104	62.33±1.57^{ab}	260	438.69±5.77^{b}
	8	398	1089.60±12.50^{bc}	398	239.95±1.90^{c}	109	76.80±2.25^{ab}	109	44.57±1.03^{ab}	109	63.02±1.53^{ab}	240	450.35±6.03^{ab}
	9	326	1145.60±13.70^{a}	326	248.96±2.09^{ab}	78	80.37±2.61^{ab}	78	45.32±1.20^{a}	78	64.72±1.78^{a}	234	438.39±6.13^{b}
	10	241	1119.90±15.70^{ab}	241	245.01±2.39^{abc}	80	82.49±2.58^{a}	80	46.49±1.19^{a}	80	66.58±1.76^{a}	165	445.56±7.10^{ab}
	11	177	1126.00±18.30^{ab}	177	247.90±2.79^{abc}	52	82.01±3.12^{ab}	52	46.51±1.43^{a}	52	65.94±2.12^{a}	120	444.24±8.33^{ab}
	12≤	561	1106.40±11.20^{ab}	561	245.39±1.71^{abc}	173	83.21±1.94^{a}	173	46.00±0.89^{a}	173	65.17±1.32^{a}	372	457.29±5.24^{ab}

**:p<0.01, ***:p<0.001, [a, b, c, d]:Different superscript letters differ significantly in each subgroup at the same column (p<0.05).

Table 3. Estimates of repeatability for investigated traits in Anatolian Buffalo.

Parameters	Number of animal	n	Repeatability	Std.Error
Lactation milk yield	1272	3902	0.389***	0,017
Lactation length	1272	3902	0.196***	0,018
Fat yield	251	526	0.399***	0,050
Protein yield	251	526	0.429***	0,049
Lactose yield	251	526	0.417***	0,050
Calving interval	691	1825	0.149***	0,028

***:p<0.001

DISCUSSION

The most important source of income from buffalo breeding is milk. The general mean of lactation milk yield for Anatolian buffaloes was determined as 1087.49 kg in this study. This value is less than the lactation milk yield reported by other studies (Cady *et al*., 1983; Babar *et al*., 1996; Vasconcellos and Tonhati, 1998; Rosati and Van Vleck, 2002; Malhado *et al*., 2013) for Nili-Ravi (1702-2064 kg), Brazil Murrah (1493.3-1631.5 kg) and Italian buffaloes (2286.8 kg). This result can be attributed to the differences in breed, feeding and management conditions. In addition, the lactation milk yield obtained in this study is higher than the values reported by some other studies (Tekerli *et al.,* 2001; Tekerli *et al.,* 2016; Uğurlu *et al.,* 2016) for Anatolian buffalo (894.3, 925.4 and 1000.7 kg respectively) in Afyonkarahisar and Giresun provinces of Turkey. This may be due to advances in feeding and management conditions and the effect of selection in the National Anatolian Water Buffalo Improvement Program.

Differences in milk yield were also statistically significant (p<0.001) among the farm operations involved in this study. In project-oriented farm operations where feeding and management conditions were good, milk yield was found to be much higher than the overall mean of 1087.49 kg. Similarly, studies carried out on the Nili-Ravi breed reported that the farm operation and herd have significant effects on milk yield (Cady *et al*., 1983; Bashir *et al*., 2015). In this study, the effect of the year on lactation milk yield was found to be significant (p<0.001). Likewise, there are studies that indicate that the year has a significant impact on lactation milk yield (Cady *et al*., 1983; Vasconcellos and Tonhati, 1998; Tekerli *et al*., 2001; Hussain *et al*., 2006; Araujo *et al*., 2012). The effect of calving season on lactation milk yield was found to be significant in this study (p<0.001). Similarly, it was reported that the calving season has a significant effect on milk yield (Cady *et al*., 1983; Chaudhry, 1992; Patel and Tripathi, 1998; Vasconcellos and Tonhati, 1998; Hussain *et al*., 2006; Afzal *et al*., 2007; Bashir *et al*., 2015; Uğurlu *et al*., 2016). Some studies report that the season does not have a significant effect on milk yield (Tekerli *et al*., 2001; Marai *et al*., 2009; Tekerli *et al*., 2016). In this study, the highest milk yield was produced by cows that calved in winter (1203.70 kg), while the lowest yield (991.94 kg) was produced by cows that calved in autumn season. Also, studies conducted on Nili-Ravi, Surti and Italian buffaloes show that the highest milk yield was produced by animals that calved in winter (Patel and Tripathi, 1998; Catillo *et al*., 2002; Hussain *et al*., 2006; Bashir *et al*., 2015). In pasture based buffalo breeding, the highest milk yield is observed in water buffaloes that calved in winter, which coincides with the time when pastures are at their best (spring); water buffaloes fed with fresh and plenty of rough feed may have a higher milk yield. Furthermore, milk yield may fall due to stress during seasons when the ambient temperature is high. In this study, milk yield was found to be lower in water buffaloes that calved in summer and fall compared with those that calved in winter and early spring. Milk yield increased as the age of the buffaloes increased, and the highest milk yield was detected in 9-year-old water buffaloes (1145.60 kg).

In this study, the general mean of the lactation length was determined as 245.43 days, and the effects of the farm operation, year, season and age were found to be significant (p<0.001). Similarly to the results of this study, it was reported (Vasconcellos and Tonhati, 1998; Hussain *et al*., 2006; Marai *et al*., 2009) that the year, season and age have significant effects on the lactation length. The mean of the lactation length determined in this study is shorter than those reported in other studies (Babar *et al*.,1996; Rosati and Van Vleck, 2002; Malhado *et al*., 2013) involving Nili-Ravi (327.9 days), Murrah (269.4 days), and Italian water buffaloes (270 days) but longer than those reported by some other studies (Tekerli *et al*., 2016; Uğurlu *et al*., 2016) for Anatolian buffaloes (229.4 days and 231.9 days).

The levels of fat and protein in buffalo milk is rather high compared to those of cow milk. The aims of water buffalo breeding are to increase milk quality and yield. The general means of lactation fat, protein and lactose yield of the Anatolian buffaloes were determined as 79.54, 44.87 and 63.70 kg respectively. The approximate percentage values of these characteristics were calculated and were found to be proportional to the overall lactation milk yield; their values were 7.32, 4.13 and 5.86 % respectively. These values are higher than the

values reported by other studies (Shah *et al*., 1983; Araujo *et al*., 2012; El-Bramony, 2015; Tekerli *et al*., 2016; Şahin *et al*., 2016) for Nili-Ravi (6.6 % fat), Murrah (7.1% fat), Egyptian (6.79% fat, 3.81% protein) and Anatolian buffaloes (5.98-6.90% fat, 3.97% protein, 5.17-5.69 % lactose) but less than the values reported by another study (Rosati and Van Vleck, 2002) for Italian water buffalo (8.61% fat, 4.58 % protein). This may be due to the differences in breed, care, feeding and calculation methods. In this study, the effects of the farm operation, year, season, and age on milk composition were found to be significant ($p<0.001$). Similarly, Shah *et al*. (1983) reported that the effects of the year and season on the fat content of the milk of the Nili-Ravi breed were significant. However, Tekerli *et al*. (2016) and Araujo *et al*. (2012) reported that the effects of the year and season on milk composition were not statistically significant. The fat and protein contents of the milk of water buffalo that calved in winter and spring seasons were found to be higher. In addition, the lowest fat, protein and lactose yields were found in the milk of water buffaloes that were up to 4 years old.

The calving interval is the period between the birth of a calf and the birth of the next calf, and if this time is extended it may cause a decrease in the amount of milk and number of calves produced by the water buffaloes throughout their lives (Kumar *et al*., 2017). The overall mean of the calving interval of Anatolian buffaloes was 450.35 days according to this study. The calving interval is less than the values reported in other studies (Ahmad *et al*., 1981; Gabr, 2015) involving the Nili-Ravi breed (506.6-570.6 days) and Egyptian water buffaloes (458.0-541.1 days) but more than the values reported in some other studies (Vasconcellos and Tonhati, 1998; Tekerli *et al*., 2001; Malhado *et al*., 2013) involving Murrah (385-411 days) and Anatolian buffaloes (441.97 days). The farm operation, year, season and age have significant impacts on calving interval ($p<0.001$). Similarly, it was reported that the year, season and herd have significant effects on the calving interval (Cady *et al*., 1983; Vasconcellos and Tonhati, 1998; Tekerli *et al*., 2001; Marai *et al*., 2009). In this study, the calving interval of water buffalo that calved in spring (429.86 days) and summer (422.46 days) seasons was low, while the calving interval of those that calved in winter (493.90) was higher. The water buffaloes in the farm operations of Afyonkarahisar province are kept tied indoor during winter. Therefore, water buffaloes that calve in winter cannot go to pasture and their insemination is postponed to spring. This causes an extension of the calving interval.

In order to obtain an effective breeding plan for water buffalo, the estimates of heritability, repeatability and correlations are determined. The estimates of repeatability for this study are moderate to high for lactation milk yield (0.389), fat yield (0.399), protein yield (0.429) and lactose yield (0.417) but low for lactation length (0.196) and calving interval (0.149). Regarding lactation milk yield (0.180-0.437), lactation period (0.052-0.322), fat content of milk (0.130-0.497) and calving interval (0.050-0.200), the repeatability is in the range reported by previous studies (Cady *et al*.,1983; Babar *et al*.,1996; Tekerli *et al*., 2001; Thevamanoharan *et al*., 2001; Ramos *et al*., 2006; Morammazi *et al*., 2007; Marai *et al*., 2009; Baharizadeh *et al*., 2012; Malhado *et al*., 2013; El-Bramony, 2015) for Nili-Ravi, Murrah, Egyptian and Anatolian buffaloes but less than that reported by some other studies (Baharizadeh *et al*., 2012; El-Bramony, 2015) regarding protein yield of milk (0.507-0.670). The moderate and high repeatability estimates of milk yield and composition in this study suggest that selection based on the first lactation milk yield could lead to fast genetic progress. Improvement of lactation length and calving interval can be realized by amendment of poor environmental factors.

Conclusions: The milk yield and composition of Anatolian buffaloes were found to be significantly affected by the farm operation, year, season and age. The milk yield was found to be less than those of Nili-Ravi, Murrah and Italian water buffaloes. Milk fat and protein contents were found to be higher than the values reported for Nili-Ravi, Murrah and Anatolian water buffaloes and lower than those of Italian water buffaloes. It was concluded that after corrections according to factors deemed significant in terms of milk yield and composition, buffaloes could be selected based on the lactation milk yield in early ages.

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