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Genetic parameters of growth, reproductive, and productive characteristics in Anatolian buffaloes

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Abstract: It was aimed to investigate the genetic parameters in growth, fertility, and productivity of Anatolian buffaloes maintained at private farms of Yozgat. A total of 1139 buffalo cows and their calves were used in the study. The weights at birth, weaning, 6th and 12th months of age, and daily live weight gains (DLWG) of buffalo calves born from 2015 to 2019 were recorded. Calving interval (CI) and service period (SP), lactation milk yield (LMY), milk yield per day of lactation period (MYPDLP), milk yield per day of calving interval (MYPDCI), peak yield (PY), a day at peak yield (DPY) and persistency (P) were the traits examined. An animal model was used to estimate the genetic and phenotypic parameters by using Wombat software. The village, year, season, sex, age of dam, and age at calving were considered as fixed and animals were taken as random effects. The heritabilities were 0.28 ± 0.08, 0.45 ± 0.29, 0.56 ± 0.10, 0.76 ± 0.18, 0.32 ± 0.28, 0.54 ± 0.10, 0.69 ± 0.17, and 0.24 ± 0.19, respectively in above mentioned growth traits. Reproductive traits had heritabilities as low as 0.11. The heritabilities of production traits were about 0.25 overwhelmingly. The heritabilities and correlations indicated that the weight at twelve months and lactation milk yield could be used for selection in growth and production traits. Environmental factors such as feeding and management should be corrected for improving fertility.

Key words: Anatolian buffalo, animal model, genetic parameters, heritability

1. Introduction

Buffalo breeding is spread over a wide range of areas in the world. Most (95%) of the world's buffalo population is in the Asian continent. Buffalo breeding has been one of the important livestock branches in Turkey due to distinctive geographical conditions. The Anatolian buffaloes have 50 chromosomes and belong to the riverine type. In recent years, buffalo breeding has been given special importance. Some valuable products such as sausage, pastrami, yogurt, cheese, butter, and cream are produced by using buffalo meat and milk. Therefore, the Anatolian buffalo has a significant place in terms of animal genetic resources in Turkey [1,2]. Buffalo and its products reflect different regional cultures in Turkey. Today, buffalo has been named "Camız", "Kömüş", "Dombey" or "Medek" in different regions as showing the depth of cultural influence [2]. Economically, the buffalo breeders demand an increase in the yield of fertility, milk, and meat obtained from the individual animals. It is necessary to determine the environmental factors affecting these traits and to estimate the genetic parameters for this reason. By using these parameters, the animals, which have the best breeding values, could be selected and given a chance to reproduce.

Different environmental factors such as herd, year, season, and age of the dam have significant effects on growth, reproduction, and production traits. The heritabilities for growth, reproductive and productive traits in different buffalo breeds were found in the ranges of 0.09 ± 0.03 and 0.86 ± 0.08, 0.048 ± 0.008 and 0.32 ± 0.12, 0.02 ± 0.06 and 0.56 ± 0.16, respectively [3–21]. The aim of the study was to reveal the genetic parameters of growth, reproduction, and production traits of Anatolian buffaloes in Yozgat.

2. Material and methods

The material consisted of 1139 buffaloes. Productive and reproductive characteristics of cows and the growth records of calves were used in the study. The data were acquired from the subproject TAGEM-66-MANDA/2015-01. The research was carried out in 39 villages with the participation of 143 breeders in Yozgat province.

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The records of the project were entered into the program called Manda Yıldızı[1] and the raw data studied in this article were obtained from this program. The birth weight (BW_0), weaning weight (BW_W), live weights at 6th (BW_6) and 12th months (BW_{12}), and average daily live weight gains (DLWG) were investigated in calves born from 2015 to 2019. CI and SP were reproductive traits. The service period was calculated as the difference between two consecutive calving intervals and a fixed gestation period (320 days) [21,22]. The lactation milk yield (LMY), milk yield per day of lactation period (MYPDLP), milk yield per day of calving interval (MYPDCI), peak yield (PY), day at peak yield (DPY), and persistency (P = 100 – coefficient of variation of control day milk yield) were regarded as production characteristic. The equation of persistence was obtained by modifying the coefficient of variation formula reported by Tekerli [23] and Tekerli et al. [24].

Heritabilities, genetic and phenotypic correlations were estimated from the univariate and bivariate animal models using AI-REML procedure of Wombat software [25]. The village, year, season, sex, age of dam, and age at calving were considered as fixed and individual animals were taken as random effects. Environmental factors, whose effects were found to be significant in the preliminary analysis of variance, were used for the estimate of genetic parameters.

The statistical mixed model is as follows:

$$\mathbf{Y = Xb + Zu + e}$$

Where: **Y** is the vector of observations for each characteristic, **b** is the vector for fixed effects, **u** is the vector of the effects for individual animals, **e** is the vector of residuals and **X** and **Z** are incidence matrices for **b** and **u**.

3. Result and discussion

3. 1. Genetic and phenotypic parameters of growth traits

The estimated heritabilities for growth traits are presented in Table 1. The heritabilities for BW_0, $DLWG_{0\text{-}W,}$ and $DLWG_{6\text{-}12}$ were found to be lower than those of the other growth traits. The heritability estimate for BW_0 (0.28 ± 0.08) was in the range of 0.12–0.66 reported by different researchers [4,7,20,26–28]. This variability may be due to the fact that each study was conducted on different breeds and the statistical models used. The heritability estimate for BW_W (0.45 ± 0.29) was high in Anatolian Buffaloes maintained at the farm operations of Yozgat province. Similarly, intermediate and high estimates in various breeds have been notified by Malhado et al. [29]. However, lower heritabilities were reported [7,15,20] in Nili Ravi and Egyptian buffaloes. Contrary to our finding (0.56 ± 0.10) for BW_6 moderate estimates of heritabilities were declared by different researchers [12–26] in Murrah and Surti buffaloes. Whereas, higher values were announced by Shahin et al. [4] in Egypt buffaloes. The moderate and high heritabilities for $DLWG_{0\text{-}W}$ (0.32 ± 0.28) and BW_{12} (0.76 ± 0.18) were in consonant with the result of Shahin et al. [4]. However, Thiruvenkadan et al. [26] in Murrah, Akhtar et al. [7] in Nili Ravi, and Pandya et al. [12] in Surti buffaloes reported lower heritability estimates for BW_{12}. So far, no literature has been found on any genetic parameters for $DLWG_{0\text{-}6}$, $DLWG_{0\text{-}12,}$ and $DLWG_{6\text{-}12}$ traits in buffaloes. However, moderate to high heritability has been detected in these traits. These estimates of heritabilities indicated that individual selection is efficient for improving growth traits.

Genetic and phenotypic correlations in growth traits are presented in Table 2. Positive genetic and phenotypic correlations were found among live weights at birth, six and twelve mounts of age. Genetic correlations in the desired way between the last two traits and daily body weight gains revealed that selection for these traits would increase the growth rate in the next generations. It would be more beneficial for breeders involved in community-based buffalo breeding projects to consider the weights at sixth and twelve mounts of age instead of birth weight.

1 Tekerli M (2015 - 2019). Manda Yıldızı: Buffalo recording software.

Table 1. Heritability of growth traits.

Traits	n	h^2 ± SE
Birth weight (BW_0)	2181	0.28 ± 0.08
Weaning weight (BW_w)	551	0.45 ± 0.29
Six-month weight (BW_6)	1805	0.56 ± 0.10
Twelve-month weight (BW_{12})	1016	0.76 ± 0.18
Daily live weight gain from birth to weaning ($DLWG_{0\text{-}W}$)	551	0.32 ± 0.28
Daily live weight gain from birth to the sixth month ($DLWG_{0\text{-}6}$)	1805	0.54 ± 0.10
Daily live weight gain from birth to twelve month ($DLWG_{0\text{-}12}$)	1016	0.69 ± 0.17
Daily live weight gain from sixth to twelve month ($DLWG_{6\text{-}12}$)	1016	0.24 ± 0.19

n: Number of animals. h2: Heritability. SE: Standard error.

Table 2. The genetic and phenotypic correlation coefficient between growth traits.

Growth traits	BW_0	BW_W	BW_6	BW_{12}	BW_0-$DLWG_{0-W}$	BW_0-$DLWG_{0-6}$	BW_0-$DLWG_{0-12}$	BW_6-$DLWG_{6-12}$
BW_0	–	0.60 ± 0.39	0.22 ± 0.20	0.39 ± 0.30	0.18 ± 0.47	0.08 ± 0.22	0.30 ± 0.33	0.05 ± 0.48
BW_W	0.17 ± 0.04	–	0.69 ± 0.16	0.41†	0.79 ± 0.18	0.61 ± 0.22	–0.54†	0.89†
BW_6	0.12 ± 0.02	0.72 ± 0.03	–	1.00 ± 0.11	0.60 ± 0.26	0.99 ± 0.01	0.95 ± 0.11	1.00 ± 0.52
BW_{12}	0.06 ± 0.03	0.46 ± 0.11	0.61 ± 0.02	–	0.99†	0.99 ± 0.17	0.99 ± 0.01	1.00 ± 0.15
BW_0- $DLWG_{0-W}$	–0.17 ± 0.04	0.86 ± 0.01	0.69 ± 0.03	0.43 ± 0.11	–	0.54†	0.99†	–0.31 ± 0.26
BW_0-$DLWG_{0-6}$	–0.11 ± 0.02	0.70 ± 0.03	0.97 ± 0.01	0.59 ± 0.02	0.74†	–	1.00 ± 0.16	0.99 ± 0.60
BW_0-$DLWG_{0-12}$	–0.11 ± 0.03	0.39 ± 0.11	0.59 ± 0.02	0.98 ± 0.01	0.43 ± 0.11	0.62 ± 0.02	–	1.00 ± 0.14
BW_6-$DLWG_{6-12}$	–0.04 ± 0.03	–0.31 ± 0.12	–0.09 ± 0.03	0.73 ± 0.02	–0.30 ± 0.12	–0.08 ± 0.03	0.73 ± 0.02	–

*: Genetic correlations are above the diagonal, phenotypic correlations are below the diagonal. †: The standard error could not be calculated. BW_0: Birth weight. BW_w: Weaning weight. BW_6: Six-month weight. BW_{12}: Twelve-month weight. $DLWG_{0-W}$: Daily live weight gain from birth to weaning. $DLWG_{0-6}$: Daily live weight gain from birth to the sixth month. $DLWG_{0-12}$: Daily live weight gain from birth to twelve month. $DLWG_{6-12}$: Daily live weight gain from sixth to twelve month.

Similar results were found by Thiruvenkadan et al. [26] and Shahin et al. [4].

3.2. Genetic and phenotypic parameter estimates of reproduction traits

Estimated heritabilities of calving interval and calculated service period are presented in Table 3. Both heritabilities were 0.11. These findings are in the ranges of 0.06–0.14 for the calving interval and service period reported by some Egyptian researchers [17,21,30]. The inheritance of fertility is generally notified as low in different breeds [5,10,14,18,19,31–33]. However, Rana et al. [34] reported a higher heritability value (0.64). Genetic and phenotypic correlations in relation to growth traits are presented in Table 4. The genetic correlation between CI and calculated SP suggested that both traits were determined by the same genes.

3.3. Genetic and phenotypic parameter estimates of production traits

Estimated heritabilities of LMY, MYPDLP, MYPDCI, PY, DPY, and P are presented in Table 5. The heritabilities for the above-mentioned production traits were 0.25 ± 0.02, 0.58 ± 0.55, 0.25, 0.25 ± 0.05, 0.25 ± 0.02, and 0.25 ± 0.02, respectively. The heritability estimate of LMY obtained in the present study was in agreement with the result of Cady et al. [35] in Nili Ravi buffaloes. Different studies around the world have reported heritabilities ranging from 0.03 to 0.53 for different breeds of buffalo. This is a sign of wide variation. This phenomenon provides invaluable probabilities for improving milk production [3,5,6,8–11,13,14,16–20,30,32–34,36–40].

The heritability of MYPDLP was estimated as 0.58 ± 0.55. This finding is beyond the predicted values of 0.24, 0.18, and 0.29 in Murrah buffaloes [13,19,41]. However, the high standard error of this parameter did not allow to make more interpretations. The heritability of MYPDCI (0.25) was in the range of 0.25 ± 0.07 and 0.30 ± 0.21 estimated by Dhar and Deshpande [41] and Patil et al. [19]. The significant heritability of the day at peak yield (0.25 ± 0.05) was slightly behind the 0.34 ± 0.11 reported in Mehsana buffaloes [14]. This trait can be used to avoid from steeping the lactation curve. Thus persistence could be improved. The heritability of peak yield was estimated to be 0.25 ± 0.05. This finding is between 0.17 ± 0.07 and 0.56 ± 0.16 reported in Murrah buffaloes [9,34]. The heritability of persistency, which is one of the most important production traits, was 0.25 ± 0.02 and was found to be significant. This value was higher than different estimates between 0.02 and 0.19 in Murrah, Nili Ravi, and Egyptian buffaloes [3,9,42].

Genetic and phenotypic correlations along with standard errors of various production traits are presented in Table 6. In this study, the genetic correlation between LMY and MYPDLP was 0.93 ± 0.12 and the phenotypic correlation was 0.89 ± 0.01. This finding is short of the genetic and phenotypic correlations reported in Murrah buffaloes [11]. However, different researchers [10,13,14] found lower values in Murrah and Mehsane breeds. Additionally, the phenotypic and genetic correlations between MYPDLP and MYPDCI were estimated as 0.48 ± 0.08 and 0.63 in this study. These findings showed that a selection on lactation milk yield will increase the average daily milk yield and so on the daily earnings of the breeders.

Genetic and phenotypic correlations between LMY and PY were 0.60. While the same correlations between PY and

Table 3. Heritability of reproductive traits

Traits	**n**	**h^2 ± SE**
Calving interval (CI)	493	0.11†
Service period (SP)	493	0.11†

†:The standard error could not be calculated. n: Number of animals. h^2: Heritability. SE: Standard error.

Table 4. The genetic and phenotypic correlation coefficient between reproductive traits.

Reproductive traits	**Calving interval**	**Service period**
Calving interval	–	1.00 ± 0.00
Service period	1.00 ± 0.00	–

*: Genetic correlations are above the diagonal, phenotypic correlations are below the diagonal.

Table 5. Heritability of production traits.

Traits	**n**	**h^2 ± SE**
Lactation milk yield (LMY)	571	0.25 ± 0.02
Milk yield per day of lactation period (MYPDLP)	571	0.58 ± 0.55
Milk yield per day of calving interval (MYPDCI)	270	0.25†
Day at peak yield (DPY)	277	0.25 ± 0.05
Peak yield (PY)	277	0.25 ± 0.02
Persistency (P)	277	0.25 ± 0.02

†: The standard error could not be calculated. n: Number of animals. h^2: Heritability. SE: Standard error.

Table 6. The genetic and phenotypic correlation coefficient between production traits

Traits	**LMY**	**MYPDLP**	**MYPDCI**	**DPY**	**PY**	**P**
LMY	–	0.93 ± 0.12	0.35†	0.14 ± 0.13	0. 60 ± 0.05	0.01 ± 0.13
MYPDLP	0.89 ± 0.01	–	0.63†	0.16 ± 0.13	0.80†	0.24 ± 0.02
MYPDCI	0.84 ± 0.02	0.48 ± 0.08	–	0.05 ± 0.01	0.60 ± 0.18	–0.21 ± 0.26
DPY	0.14 ± 0.06	0.15 ± 0.06	0.05 ± 0.13	–	0.10 ± 0.13	0.03 ± 0.01
PY	0.60 ± 0.04	0.80 ± 0.02	0.61 ± 0.08	0.10 ± 0.06	–	–0.23 ± 0.02
P	0.01 ± 0.06	0.24 ± 0.06	–0.21 ± 0.12	0.03 ± 0.06	–0.23 ± 0.06	–

*: Genetic correlations are above the diagonal, phenotypic correlations are below the diagonal. †: The standard error could not be calculated. LMY: Lactation milk yield. MYPDLP: Milk yield per day of the lactation period. MYPDCI: Milk yield per day of the calving interval. DPY: Day at peak yield. PY: Peak yield. P: Persistency.

persistency were estimated as –0.23 in this study. Galsar et al. [14], Pareek and Narang [9] found a similar result in Mehsane and Murrah buffaloes. The negative correlations must be considered by the breeders due to the hazardous effect of a steep lactation curve, that is to say, high peek yield, in the aspect of metabolic disease. The positive and significant phenotypic and genetic correlations (0.24) between MYDLP and Persistence showed that the higher the persistence, the higher the daily milk yield.

4. Conclusion

The weight at twelve months was more heritable than the other growth traits. The selection directed to this trait may result in faster genetic improvement in the aspect of body weight. The phenotypic and genetic correlations among growth traits were generally found to be high, positive, and in the desired way. Instead of birth weight, breeders may prefer the weights at six and twelve months of age due to significant and high genetic correlations with daily weight gains at different periods.

The inheritance of reproductive traits was found to be low. Therefore, more successful results can be obtained for these traits by adjustment of environmental factors such as management and nutrient condition. Additionally, the control of the service period would be helpful to reduce the calving interval.

The moderate and significant heritabilities of milk production traits showed that there is a high genetic potential for increasing milk yield in Anatolian buffaloes. Significant and high correlations were detected among lactation milk yield, peak yield, and milk yield per day of lactation. However, the negative correlations between persistence and peak yield must be considered in a selection program. Milk yield per day of the lactation period can be used as an indirect selection criterion for improving persistency. The genetic parameters of MYPDCI indicated that the attention should be paid to this trait by breeders because it expresses the high or low economic incomes throughout all seasons. This is the first investigation in terms of the inheritance of buffaloes in the Yozgat province of Turkey. It will be useful for buffalo breeders and future research.

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This paper was summarized from the PhD thesis of the corresponding author.

Conflict of interest

No conflict of interest is declared by the authors.

Ethical statement

The Afyon Kocatepe University Animal Experiments Ethics Committee was approved this study (49533702/169).

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