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Genetic and Non-genetic Parameters for Productive and Reproductive Traits of Egyptian Buffaloes

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ABSTRACT

The objectives of the current study were to: i) Evaluate the effect of environmental factors on productive and reproductive traits of Egyptian buffaloes, ii) Estimate heritability, and correlation among these traits. Data of 1563 dairy records collected from 341 Egyptian buffaloes that were serviced naturally by 71 sires and raised at Mahallet Mousa station in Kafr El-Sheikh governorate, these collected data were analyzed statistically. Records covered the period from 2001 to 2020. The fourth parity recorded the highest calf birth weight (37.41 kg), and maximum lactation length (197.51 day), and yield (1.69 ton). Buffalo cows that calved in winter produce more milk and have a greater number of days in milk than other seasons. Calf birth weight showed significant effect on total milk yield with higher birth weight recorded for higher yield. A high heritability estimate (0.64) was reported for lactation length, while moderate heritability estimates were recorded for dam calving weight, calf birth weight and total milk yield (0.26, 0.20 and 0.15, respectively). While low heritability estimates (0.08) were recorded for CI. It seems that, season, parity, body weight at birth, and dam calving weight could be used as predictors for the improvement of productive and reproductive traits in Egyptian buffalo breeding programs. The results of our study supported the need, not only for genetic selection programs, but also enhancing the managemental practices of rearing farm for improving productive and reproductive traits of Egyptian buffaloes.

1. INTRODUCTION

Water Buffaloes (*Bubalus bubalis*) are considered one of the most important species in the agricultural economy of many developing countries like Egypt (Suhail et al., 2009). They are the main provider of milk, meat, and draught power; they supply approximately 45% of the annual milk yield in Egypt. Moreover, milk of buffaloes is more acceptable by the Egyptians consumers due to its white color, acceptable flavor, and high fat percentage (El-Salam et al., 2011).

Improvement of animal performance could be conducted either by optimizing the surrounding environmental or by enhancement of the population breeding values, or by applying both methods (Katkasame et al., 1996). Analysis of the total phenotypic variation of any productive trait into its main components of genetic and non-genetic factors is very essential in evaluation of the realized progress that can be obtained (Abou-Bakr, 2009). Productive and reproductive performances of livestock are influenced by many genetic and non-genetic factors. Investigation of these factors is essential for development of suitable breeding programs for population genetic improvement. Predicted breeding values enables us for early prediction of candidate parents with superior genetic merits which results in shortening the generation interval and improving genetic gain (Fooda et al., 2010; Johnson et al., 2018). Parity and calving season have a great effect on the buffalo's performance due to the variability of environmental temperature and feedstuffs (Marai et al., 2009; Hassan et al., 2017). Reproduction efficiency and milk yield have a great impact on farm profitability (Leblanc, 2010). Evaluation and enhancement of reproductive efficiency is a very imperative issue because low reproductive performance is considered the main factor for dairy animals culling after low milk production (Ansari-Lari et al., 2012). Few research studies have been conducted for the improvement of productive and reproductive performance of Egyptian buffaloes genetically (Othman and Abdel-Samad, 2013; Sosa et al., 2015; Ramadan et al., 2020; Shafik et al., 2022).

To improve the productivity of dairy animals, understanding the factors influencing productive and reproductive traits are necessary. Birth, weaning and calving weights are very important factors for animal's productivity (Uğurlu et al., 2016). Growth rate and body weight before maturity can influence age at first service and milk yield during the subsequent lactation (Ettema and Santos, 2004; Zanton and Heinrichs, 2005; Bach, 2011; Van De Stroet et al., 2016). Thus, the aims of the current study were to evaluate the effect of environmental factors

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on productive and reproductive traits of Egyptian buffaloes, and estimate heritability, and correlation among these traits.

2. MATERIAL AND METHODS

The present study was conducted according to the protocols of the Committee of Animal Care and Welfare, Benha University, Egypt, and was approved by the Animal Ethical Committees of the Benha University with ethical approval number (BUFVTM271022).

2.1. Animals and Management:

Data of 1563 dairy records collected from 341 Egyptian buffaloes that were serviced naturally by 71 sires raised at Mahallet Mousa Experimental station in Kafr El-Sheikh governorate, Egypt were utilized in this study. The pregnancy was diagnosed after sixty days from the last servicing by rectal palpation. Buffaloes were raised under semi-open sheds. Hand milking was adopted twice a day at 6.30 AM and 4.30 PM throughout the lactation season, and milk yield was estimated daily. Buffaloes received the routine program of feeding of Mahallet Mousa experimental station. Egyptian clover (*Trifolium Alexandrinum*) with enough rice straw and concentrate mixture was fed from December to May. Concentrate mixture with suitable amount of rice straw and clover hay was offered during the interval from June to November. Clover hay and rice straw were offered once a day while the concentrate feed mixture was given twice per day. Fresh water was allowed three times a day. Mineral mixture blocks were accessible for animals in the stalls. Calves birth weights were determined within 24 hours postnatal. Approximately at the 8thmonths of age calves were weaned and their weights were evaluated, moreover, weighing of the dam at calving was conducted.

2.2. Statistical analysis:

The productive and reproductive data were statistically analyzed using SAS software version 9.1.3 (SAS Institute Inc., Cary, NC) and MTDFREMAL program (Boldman et al., 1995) for DFREML procedures. The statistical models include season of calving (1= Summer, 2 = Winter, 3 = Autumn, and 4 = Spring), parity (1, 2, 3, and ≥ 4), calf birth weight (<35 kg, 35-40 kg, >40 kg), calf weaning weight (<90 kg, 90-100 kg, >100 kg.), and dam calving weight (Low = 300-400kg, Medium =400-500kg, High=more than500kg). The first model was used to analyze the factors affecting calf birth weight (CBW), calf weaning weight (CWW), calving interval (CI), lactation length (LL), and total milk yield (TMY) traits

$Y_{ijk} = \mu + S_i + P_j + D_k + e_{ijkl}$

Where: Y_{ijk}: The observed value; CBW, CWW, CI, LL, and TMY

μ: The overall mean.

S_i: The effect of the i^{th} season of calving

P_j: The effect of the j^{th} parity

D_k: The effect of the D^k dam calving weight

e_{ijk}: random error.

The second model was used to analyze the effect of calf birth weight (CBW), and calf weaning weight (CWW) on lactation length (LL), and total milk yield (TMY) traits

$Y_{ijk} = \mu + B_i + W_j + e_{ijk}$

Y_{ij}: The observed value; (LL, and TMY)

μ: The overall mean

B_i: The effect of i^{th} calf birth weight

W_j: The effect of the j^{th} calf weaning weight

e_{ijk}: random error.

Heritability and genetic correlation for the evaluated traits were conducted with DFREML procedures using MTDFREMAL program of Boldman et al. (1995) according to the following model

$Y = Xb + Za + e$

Where:

Y: Vector of the observed trait

X: Incidence matrix of fixed effects

b: Vector of fixed effects

Z: Incidence matrix of random animal effects

a: Vector of random animal effects

e: Vector of random residual effects.

The phenotypic correlation between traits x and y is calculated by SAS version 9.1.3 (SAS Institute Inc., Cary, NC).

3. RESULTS

Parity as an environmental factor had a significant effect on calf birth weight (CBW), calf weaning weight (CWW), calving interval (CI), lactation length (LL), and total milk yield (TMY). The fourth parity or more showed the highest CBW, CWW (37.41 & 97.95 kg), and maximum LL (197.51 day), and TMY (1.69 ton), and the shortest CI. Season of calving had a significant effect on CBW, CI and LL. CBW and CWW, showed higher weights in summer than another season (35.59 and 97.4 kg, respectively). Buffalo cows that calved in winter produce more milk and have more number of days in milk than other seasons as shown in (Table 1).

Table 1 Least squares means, standard errors of factors affecting on calf birth weight (CBW), calf weaning weight (CWW), calving interval (CI), lactation length (LL) and total milk yield (TMY) of Egyptian buffaloes.

Independent factors	CBW (kg) LSM±SE	CWW (kg) LSM±SE	CI (months) LSM±SE	LL (days) LSM±SE	TMY (tons) LSM±SE
Parity					
1st lactation	23.71^{d}±0.39	94.98^{b}±0.56	-	169.10^{b}±4.15	1.06^{C}±0.046
2nd lactation	34.36^{c}±0.39	96.83^{a}±0.58	15.89^{a}±0.22	189.35^{a}±4.28	1.39^{b}±0.048
3rd lactation	36.16^{b}±0.45	97.99^{a}±0.65	14.70^{b}±0.25	191.08^{a}±4.83	1.52^{b} ±0.055
≥ 4th lactation	37.41^{a} ±0.27	97.95^{a} ±0.39	14.00^{c} ±0.15	197.51^{a} ±2.90	1.69^{a} ±0.032
P value	0.001***	0.01**	0.01**	0.001***	0.001***
Season of Calving.					
Summer	35.59^{a}±0.35	97.40±0.51	14.48^{b}±0.23	183.78^{b}±3.87	1.38 ±0.042
Autumn	35.53^{a}±0.29	96.40±0.42	14.39^{b}±0.18	184.71^{b}±3.12	1.41±0.035
Winter	34.23^{b}±0.40	96.60±0.58	14.85^{b}±0.25	195.42^{a}±4.29	1.47±0.048
Spring	35.27^{ab} ±0.45	97.30 ±0.65	15.72^{a} ±0.29	183.12^{b} ±3.76	1.40 ±0.054
P value	0.036*	0.40^{ns}	0.006**	0.012**	0.56^{ns}
Dam calving weight.					
Low (300-400kg)	33.71^{c}± 0.46	96.08 ±0.71	14.66 ±0.44	183.91±4.92	1.29^{c}±0.059
Medium (400-500kg)	35.29^{b}± 0.29	96.37 ±0.45	14.76 ±0.19	194.80±3.15	1.52^{b} ±0.038
High (more than 500kg)	37.11^{a}± 0.31	99.10 ±0.47	14.37 ±0.19	192.50 ±3.39	1.70^{a} ±0.041
P value	0.02*	0.30^{ns}	0.35^{ns}	0.17^{ns}	0.001***

The shortest period of calving interval was recorded in autumn season. Dam calving weight had a highly significant effect on CBW, and TMY, higher values were recorded with the higher DCW as shown in (Table 2). Calf weaning weight had a highly significant effect on TMY and LL with higher values reported by increasing the weaning weight. CBW showed a significant effect on TMY with higher amount of yield recorded for the higher CBW as presented in (Table 2).

A high heritability estimate (0.64) was reported for lactation length while moderate estimates were recorded for DCW, CBW, TMY, and CWW 0.26, 0.20, 0.15, and 0.10 respectively. Low heritability estimate was recorded for CI (0.08) as presented in (Table 3). Phenotypic correlations among the studied traits were ranged from -0.04 (DCW with CI) to 0.45 (TMY with LL), while genetic correlations were ranged from -0.99 (CWW with CI) to 0.99 (DCW with CWW) as presented in (Table 4).

Table 2 Least squares mean, standard errors of the effect of calf birth weight (CBW), calf weaning weight (CWW) on lactation length (LL) and total milk yield (TMY) of Egyptian buffaloes.

Independent factors	LL (days) LSM±SE	TMY (tons) LSM±SE
Calf birth weight.		
Less than 35 kg.	185.56±3.78	1.37^{b}±0.033
35-40 kg.	185.78±3.08	1.46^{a}±0.027
More than 40 kg.	191.81±4.18	1.54^{a} ±0.037
P value	0.42^{ns}	0.003^{**}
Calf weaning weight.		
Less than 90 kg.	173.76^{c}±4.77	1.33^{b}±0.042
90-100 kg.	186.21^{b}±2.84	1.40^{b}±0.025
More than 100 kg.	203.13^{a} ±3.67	1.63^{a} ±0.032
P value	0.001^{***}	0.002^{**}

Means in each column superscripted by different alphabetic letters are significantly different. ns: not significant; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 3 Heritability estimates of different productive and reproductive traits for Egyptian buffaloes.

Traits	h^2 ± S.E
Dam calving weight (DCW)	0.26 ±0.041
Calf birth weight (CBW)	0.20 ±0.034
Calf weaning weight (CWW)	0.10 ±0.014
Total milk yield (TMY)	0.15 ±0.030
Lactation length (LL)	0.64 ±0.035
Calving interval (CI)	0.08 ±0.034

Table 4 Phenotypic (above diagonal) and genetic correlations (below diagonal) of some productive and reproductive traits of Egyptian buffaloes.

Traits	DCW	CBW	CWW	TMY	LL	CI
DCW	-	0.20	0.01	0.19	0.05	-0.04
CBW	0.21	-	0.10	0.10	0.05	0.01
CWW	0.99	0.98	-	0.02	0.01	-0.02
TMY	0.14	0.13	0.10	-	0.45	0.04
LL	-0.14	0.12	0.43	0.73	-	-0.01
CI	0.27	0.18	-0.99	0.52	0.43	-

DCW =Dam calving weight; CBW = Calf birth weight; CWW = Calf weaning weight; TMY = Total milk yield; LL = Lactation length; CI = Calving interval

4. DISCUSSION

The current study was primarily done to investigate the influence of some genetic and non-genetic factors on productive and reproductive traits of Egyptian buffalo cows. The gradual increase in TMY with the increasing of parity order was consistent with Ramadan (2018) and Eldawy et al. (2021) who reported the highest TMY at the 4th and 6th parities respectively in Egyptian buffaloes. In agreement with our results, Thiruvenkadan et al. (2014) and Eldawy et al. (2021) reported a significant effect of parity on lactation length. The increase in milk yield with advancement of parity order might be explained by the increase of the dam body weight and the growth and development of mammary gland (Eldawy et al., 2021). The increments of CBW and CWW with parity order were consistent with (Thevamanoharan et al., 2001; Marques et al., 2020). The decreasing of calving interval period with the advancement of parity order is consistent with Eldawy et al. (2021) who reported the shortest period (13.79 months) at the 6th parity of Egyptian buffaloes. The significant effect of calving season on lactation length was in agreement with Hassan et al. (2017) who recorded the longest LL in winter season in Egyptian buffaloes. Moreover, the significant effects of calving season and parity on CBW were in agreement with Kul et al. (2018) and Salem et al. (2021) in Anatolian and Egyptian buffaloes, respectively. The highest CBW in summer season of current study was in agreement with Thevamanoharan et al. (2001) who reported same trend in Thailand swamp buffaloes. The results of current study exhibit that the optimum reproductive performance was recorded in autumn-calving buffaloes. These results agree with Hassan et al. (2017) who reported that buffaloes calved during autumn had the shortest CL (414.16 days), than those calved in the other seasons. On contrast, Marques et al. (2020) reported a non-significant effect of calving season on CBW, CI and LL. The variability in reproductive performance of calving seasons might be explained by the climatic temperature, and due to the availability of high quality feed that greatly affect ovarian function and progesterone level (Ramadan, 2018).

The highly significant effect of DCW on CBW agreed with Akhtar et al. (2012) who showed that the highest birth weight of calves was observed from the dams of 500-550 kg weight while it was the lowest from dams of 330-400 kg in Nili Ravi buffalo. Moreover, these results were consistent with Bahashwan and Alfadli (2016) and Salem et al. (2021) who reported that DCW had a significant effect on CBW and a non-significant effect on CWW in dairy cattle and Egyptian buffaloes, respectively. This trend might be attributed to that the heavy cow feed more nutrients so improvement of the calf birth weight during the pregnancy stage was occurred.

The increasing of milk yield associated with the increasing of CWW and CBW of this study , were agreed with (Rahbar et al., 2020) and (Eldawy et al., 2021), respectively. Eldawy et al. (2021) reported the highest total milk yield with the calves' birth weight higher than 35 kg in Egyptian buffaloes. This may be due to CBW depends on feeding and performance of their cows.

Our results are comparable with Akhtar et al. (2012) who reported a moderate heritability estimate of CBW (0.25) and CWW (0.17) in Nili-Ravi buffaloes. The low heritability estimate of CI and TMY of current study was in agreement with Warade et al. (2005) and Morammazi et al. (2007) who reported 0.01 and 0.09 estimates for CI in Surti, and Khuzestan buffaloes, respectively, and Baharizadeh (2012) who reported 0.09 estimate for TMY in Khuzestan buffaloes. High heritability estimate of the current LL was consistent with those of El-Arian et al. (2012) and Ibrahim et al. (2012) who recorded estimates of 0.31 and 0.30 for LL in Egyptian buffaloes, respectively. Consistent with our finding, Lopez et al. (2020) recorded a high genetic correlation between CBW and CWW in Korean Hanwoo calves. The positive correlation between DCW and CBW was consistent with Bahashwan and Alfadli (2016) in Dhofari cattle. Moreover, Marques et al. (2020) and Shalaby et al. (2016) reported a similar trend where there was a positive correlation between CBW with DCW, CI and TMY, also between TMY with CI and DCW in buffaloes in Eastern Amazon region.

5. CONCLUSION

In conclusion, season, parity, body weight at birth, and dam calving weight could be used as predictors to improve productive and reproductive traits in Egyptian buffalo breeding programs. The wide variations in productive and reproductive traits indicate the significant potential of improving these performance traits in Egyptian buffalo cows. The results of our study supported the need, not only for genetic selection programs, but also enhancing the managemental practices of rearing farm for improving productive and reproductive traits of Egyptian buffaloes.

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