ORIGINAL ARTICLE

Effect of some genetic and non-genetic factors on productive and reproductive traits of Egyptian buffaloes

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ABSTRACT

Objective: The objectives of our study were to estimate the effect of some non-genetic factors on production and reproduction traits of Egyptian buffaloes and to estimate the breeding values for these traits.

Materials and Methods: Data from 965 lactation records of 305 Egyptian buffalo cows mated by 73 sires that were raised at Mahallet Mousa Experimental farms of Animal Production Research Institute were collected. Dairy records covered the period from 2001 to 2015. The data were arranged and statistically analyzed using SAS version 9.1.3 to study the effect of non-genetic factors and the MTDFREMAL program was included in estimating the expected breeding values.

Results: Our results showed that buffalo cows that calved in winter season recorded the highest and significant total milk yield (TMY) and daily milk yield (DMY) traits and the best reproductive performance was indicated by the lower number of services per conception and the shortest calving interval (CI) period. Moreover, age at first calving and dry period (DP) showed a highly significant effect on the TMY and DMY. A significant effect for the level of milk production on days open (DO) period was recorded in our study. The range of sires EBV was 540 kg, 295.2 days, 113.9 days, 2.8 months, and 71.1 days for TMY, LL, DO, CI, and DP, respectively.

Conclusion: Buffalo's breeders must consider the season of calving, parity, and DP in management program because they greatly affect the farm productivity and profitability and they must select animals with higher breeding values to be the parent of the next generation.

Introduction

Improvement of dairy animal production could be achieved either by the improvement of the animals environmental conditions or by the improvement of the mean breeding values of the population, or by a combination of both methods [1]. Partitioning the total phenotypic variance of the animal economic traits into a genetic and non-genetic component is the most important factor in determining the real progress that can be achieved [2]. Productive and reproductive traits are affected by genetic and non-genetic factors. Evaluation of these factors provides the basic information for establishing sound breeding programs for genetic improvement of the animal population. It helps in selecting animals with superior genetic merits based on their high breeding values [3]. Moreover, it assists for early prediction of genetic merit and

reducing the generation interval which results in increasing the amount of genetic gain [4]. In subtropical regions, the season of calving and parity plays a great role on the buffalo performance [5–7] because of the great variation in environmental temperature and availability of feedstuffs [8].

Milk production and reproduction performance are the most important determinants of dairy animal profitability [9]. Milk yield is the most important productive trait of a dairy animal. High milk yield decreases the rearing cost of dairy cattle and consequently improves the farm profitability [10]. Reproductive efficiency has a great impact on the overall profitability of dairy animal production [11]. Among the reproductive performance, fertility traits such as a number of services per conception (NSC) and days open (DO) play an important role because these traits make the calving interval

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How to cite: Ramadan SI. Effect of some genetic and non-genetic factors on productive and reproductive traits of Egyptian buffaloes. J Adv Vet Anim Res 2018; 5(4):374–80.

(CI) either longer or shorter [12]. The more services per conception and longer service period increase the cost of animal rearing and decrease the profitability [13]. Monitoring and improvement of reproductive performance is a very important concern because after low milk production, poor fertility is the main reason for culling dairy animals [14]. There are much argument among dairy breeders and researcher about the unfavorable genetic correlations between the reproductive traits and the high milk production, so evaluation of the association between levels of milk yield with reproductive and fertility traits at the dairy herd is a very important economic concern [15]. It has been demonstrated that there is a negative association between reproductive performance and high milk production [16,17].

Water Buffaloes (*Bubalus bubalis*) are considered the main dairy and the most important species from a socio-economic point of view in developing countries like Egypt. Water buffaloes are considered the main source of milk in Egypt and contribute to about 70% of the annual milk production [2]. Buffalo's milk is preferred by the Egyptian consumer due to its white color, acceptable flavor, and good fat percent [18]. The total number of buffaloes in Egypt was estimated to be 4,164,928 heads that produce approximately 2,650,000 ton of milk [6]. Little efforts have been made to improve genetic potentiality for productive and reproductive traits of Egyptian buffaloes. The objectives of the present study were as follows: first, to estimate the effect of some non-genetic factors on buffalo production and reproduction traits; second, to estimate some genetic parameters such as breeding values for sire and buffalo cows in the investigated farm.

Materials and Methods

Ethical approval

The current study was done according to the protocols that were approved by the Committee of Animal Care and Welfare, Benha University, Egypt. No special permission for collecting and statistically analyzing dairy buffalo's records such as this study is required in Egypt.

Animals and Management

Data from 965 lactation records that were obtained from 305 Egyptian buffalo cows which were mated by 73 sires that were raised at Mahallet Mousa Experimental farms at Kafr El-Sheikh, Egypt were used in the current study. Dairy records started from 2001 to 2015. Buffaloes were mated naturally. The pregnant animal was investigated by rectal palpation after 60 days from the last mating. Buffaloes were kept under semi-open sheds. Lactating animals were milked by hand milking two times a day at 7.00 AM and 4.00 PM throughout the lactation interval and milk production was recorded daily. Buffaloes were kept under the routine feeding program in Mahallet Mousa Experimental farms. From December to May, animals were fed on Egyptian clover (*Trifolium Alexandrinum*) with a little amount of concentrate mixture and rice straw. During the interval from June to November, animals were fed on a concentrate mixture with a little amount of rice straw and clover hay. The concentrate feed mixture was given two times per day while rice straw and clover hay were offered once a day. Drinking water was allowed three times a day. Licking blocks of the mineral mixture were available for animals in the stalls.

Statistical analysis

The data were arranged and statistically analyzed using SAS version 9.1.3 (SAS Institute Inc., Cary, NC) and DFREML procedures using MTDFREMAL program of Boldman et al. [19].

The statistical models include parity (1, 2, 3 till 8), age at first service (AFS) (1 = less than 22 m, 2 = 22–24 m, and 3 = more than 24 m), DO (1 = less than 46 days, 2 = 46–108 days, and 3 = more than 108 days), NSC (1 = one service, 2 = two services, 3 = three services or more), dry period (DP) (1 = less than 167 days, 2 = 167–285 days, and 3 = more than 285), season of calving (S) (1= Autumn, 2 = Winter, 3 = Spring, and 4 = Summer), age at first calving (AFC) (1 = less than 34 m, 2 = 34–37 m, and 3 = more than 37 m), and the level of milk production (1 = less than 1,490 kg, 2 = 1,490–1,794 kg, and 3 = more than 1,794 kg).

The first model was used to analyze the factors affecting total milk yield (TMY) and daily milk yield (DMY) traits

$$Y_{ijklmnop} = \mu + S_i + P_j + AFS_k + NSC_l + AFC_m + DO_n + DP_o + e_{ijklmnop}$$

Where:

$Y_{ijklmnop}$: The observed value; TMY and DMY

μ: The overall mean.

S_i: The effect of the ith season of calving

P_j: The effect of the jth parity

AFS_k: The effect of the kth AFS

NSC_l: The effect of the lth NSC

AFC_m: The effect of the mth AFC

DO_n: The effect of the nth DO

DP_o: The effect of the oth DP

$e_{ijklmnop}$: random error.

The second model was used to analyze the effect of season and parity on reproduction traits

$$Y_{ijk} = \mu + P_i + S_j + e_{ijk}$$

Where:

Y_{ijk}: observed value; (NSC, CI, and DO)

μ: overall mean

P_i: effect of the ith parity

S_j: effect of the ith season of calving

e_{ijk}: random error.

The third model was used to analyze the effect of level of TMY and DP on reproductive traits of the subsequent season

$$Y_{ijk} = \mu + DP_i + L_j + e_{ijk}$$

Where:

Y_{ij}: The observed value; (NSC, CI, and DO)

μ: The overall mean

DP_i: The effect of ith dry period

L_j: The effect of the jth level of milk production

e_{ijk}: random error.

The expected breeding values for the studied traits were estimated with DFREML procedures using MTDFREMAL program of Boldman et al. [19] 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.

Results

Least square means for the effects of non-genetic factors such as season of calving, parity, AFS, NSC, AFC, DO, and DP on traits of milk production was presented in Table 1. The statistical analysis showed that season, parity, AFC, and DP had a significant ($p < 0.05$) effect on TMY and DMY. The highest values were recorded for animals which calved in the winter season (1,716.46 and 8.18 kg, respectively) while the least values were recorded in summer calvers (1,550.33 and 7.81 kg, respectively). Parity recorded highly

significant ($p < 0.001$) effect on the studied milk yield traits. The highest TMY and DMY were observed in the fourth parity (1,715.31 and 8.39 kg, respectively) then decreased thereafter. Moreover, AFC and DP showed a significant ($p < 0.05$) effect on the TMY and DMY, whereas the highest TMY (1,646.67 and 1,876.67 kg) and DMY (8.08 and 8.33 kg) were observed in the lowest classes of AFC and DP (less than 34 months and 167 days, respectively).

The effects of season of calving, parity, DP, and level of milk production on reproductive traits were shown in Table 2. The results of our study showed that animals that calved in winter season had the best reproductive performance, whereas this season had significantly ($p < 0.01$) lower NSC (1.46) and the shortest CI period (13.61 months) than those calved in the other seasons. The DO and CI showed the longest periods in summer calvers (108.22 days and 15.15 months, respectively). The NSC recorded in summer season showed the highest value (2.15). The pairwise comparison revealed that the NSC and CI of the second parity were significantly different ($p < 0.05$) than NSC and CI of other parities. Animals with the second time calving recorded the longest CI and the highest NSC among different parities (15.43 months and 2.06, respectively), which decreased thereafter. Similarly, the NSC, DO, and CI varied significantly among days DP, where the buffaloes have lower DP than 167 days had the best reproductive indices (NSC = 1.44, DO = 65.87 days, and CI = 13.29 months) while the highest values were observed in DP longer than 285 days (NSC = 1.85, DO = 164.39 days, and CI = 14.70 months).

The effect of level of milk production on the reproductive traits of the subsequent season (NSC, DO, and CI) showed a general trend that buffaloes producing higher milk yield recorded lower reproductive performance indicated by the higher value of NSC and a longer period of DO and CI. A significant effect ($p < 0.01$) for the level of milk production in DO period was recorded in our study. Estimation of expected breeding values from sires and cows for TMY, LL, DO, CI, and DP are shown in Table 3. The breeding values showed large differences in the studied traits. The range of sires EBV was 540 kg, 295.2 days, 113.9 days, 2.8 months, and 71.1 days for TMY, LL, DO, CI, and DP, respectively. While the corresponding values for cows were 760 kg, 956 days, 140.2 days, 4.6 months, and 119.3 days, respectively.

Discussion

The current study was primarily performed to study the effect of some environmental factors on productive and reproductive traits in the Egyptian buffaloes. The significant effect of calving season on milk yield and reproductive traits were consistent with those reported for Egyptian, Nili-Ravi,

and Murrah buffaloes [5,6,20–24]. In the current study, the winter calvers showed the highest TMY and DMY while summer calvers have the lowest ones. The high milk production of buffaloes calving in winter season might be attributed to the comfort temperature and the high-quality green forages that were available to lactating buffaloes. The negative effect of the summer season on production and reproduction traits may be due to the adverse environmental condition and to the low availability of green forages. These results were consistent with Hassan et al. [17] who reported the highest

Table 1. Least square means (±SE) of factors affecting TMY and DMY.

Independent factor	Independent factor levels	n	TMY (kg) LSM ± SE	DMY (kg) LSM ± SE
Season	Autumn	255	1,563.25[c] ± 25.78	7.91[b] ± 0.10
	Winter	198	1,716.46[a] ± 28.30	8.18[a] ± 0.11
	Spring	153	1,629.64[b] ± 32.43	7.96[ab] ± 0.13
	Summer	359	1,550.33[cb] ± 22.88	7.81[b] ± 0.09
parity	1	159	1,360.19[c] ± 32.81	7.00[c] ± 0.13
	2	169	1,595.06[b] ± 30.72	7.86[b] ± 0.12
	3	155	1,641.90[ab] ± 32.10	7.9[b] ± 0.13
	4	143	1,715.31[a] ± 34.26	8.39[ba] ± 0.14
	5	104	1,693.85[ab] ± 39.27	8.23[a] ± 0.16
	6, 7	132	1,664.46[ab] ± 35.32	8.22[ba] ± 0.14
	8	103	1,633.68[b] ± 39.93	8.20[ba] ± 0.16
AFS (month)	< 22	388	1,616.08 ± 21.73	8.00 ± 0.09
	22–24	305	1,620.90 ± 24.90	8.02 ± 0.10
	> 24	272	1,607.78 ± 27.89	7.89 ± 0.11
NSC	1	513	1,593.99 ± 18.14	7.94 ± 0.07
	2	259	1,604.22 ± 24.83	8.01 ± 0.10
	≥ 3	193	1,646.55 ± 30.81	7.95 ± 0.12
AFC (month)	< 34	266	1646.67[a] ± 29.27	8.08 ± 0.12
	34–37	355	1634.64[a] ± 22.63	7.94 ± 0.09
	> 37	344	1563.45[b] ± 22.81	7.88 ± 0.09
DO (day)	< 46	295	1448.81 ± 27.44	8.07 ± 0.11
	46–108	318	1585.29 ± 24.33	8.00 ± 0.10
	> 108	352	1810.66 ± 26.26	7.83 ± 0.10
DP (day)	< 167	315	1876.67[a] ± 26.59	8.33[a] ± 0.11
	167–285	321	1594.68[b] ± 23.37	7.86[b] ± 0.09
	> 285	329	1373.41[c] ± 28.70	7.83[b] ± 0.11

SE = standard error. Means with different superscript letters in each column are significantly different.

Table 2. Least square means (±SE) of factors affecting NSC, DO, and CI.

Independent factor	Independent factor levels	n	NSC LSM ± SE	DO (day) LSM ± SE	CI (month) LSM ± SE
Season	Autumn	152	1.63[b] ± 0.06	98.99 ± 6.48	13.78[b] ± 0.23
	Winter	207	1.46[c] ± 0.05	97.88 ± 5.56	13.61[b] ± 0.20
	Spring	316	1.49[cb] ± 0.04	99.27 ± 4.50	13.71[b] ± 0.16
	Summer	143	2.15[a] ± 0.06	108.22 ± 6.69	15.15[a] ± 0.24
Parity	1	32	2.00[a] ± 0.13	105.59 ± 14.10	14.03[b] ± 0.51
	2	155	2.06[a] ± 0.06	99.30 ± 6.41	15.43[a] ± 0.23
	3	150	1.67[b] ± 0.06	103.79 ± 6.51	13.85[b] ± 0.23
	4	130	1.52[cb] ± 0.06	113.22 ± 7.00	13.54[b] ± 0.25
	5	105	1.44[c] ± 0.07	103.50 ± 7.79	13.74[b] ± 0.28
	6, 7	145	1.41[c] ± 0.06	91.50 ± 6.63	13.35[b] ± 0.24
	8	101	1.39[c] ± 0.07	88.70 ± 7.94	13.41[b] ± 0.28
DP (day)	<167	296	1.42[c] ± 0.04	62.24[c] ± 4.09	13.24[c] ± 0.17
	167–285	273	1.63[b] ± 0.05	87.54[b] ± 4.08	14.18[b] ± 0.17
	>285	212	1.85[a] ± 0.05	167.35[a] ± 4.64	14.62[a] ± 0.20
Level of milk production	<1,490	209	1.574 ± 0.05	93.18[c] ± 4.71	13.88 ± 0.17
	1,490–1,774	265	1.620 ± 0.04	106.00[b] ± 4.15	14.01 ± 0.20
	>1,774	307	1.703 ± 0.04	117.95[a] ± 3.97	14.15 ± 0.17

SE = standard error. Means with different superscript letters in each column are significantly different.

Table 3. Expected breeding values for different milk productive and reproductive traits for sire and cow.

Trait	Sire				Cow			
	Min	Max	Average	Range	Min	Max	Average	Range
TMY	−300	240	2.2	540	−430	330	−3.1	760
LL	−72.3	222.9	1.2	295.2	−144.7	811.3	0.21	956
DO	−31.5	82.4	0.16	113.9	−42.5	97.7	−0.33	140.2
CI	−1.1	2.7	0.001	2.8	−1.4	3.5	−0.01	4.6
DP	−24.2	46.9	−0.13	71.1	−39.4	79.9	−0.1	119.3

milk yield in winter calvers for Egyptian buffaloes and both of Sarkar et al. [23] and Thiruvenkadan et al. [24] who recorded the same trend for Murrah buffaloes. Moreover, Hussain et al. [25] and Khosroshahi et al. [26] reported similar results where the highest milk yield was observed in winter season calvers for Nili-Ravi buffaloes while the lowest milk yield was recorded for summer calvers. In contrast, Chaudhry [20] reported that Nili-Ravi buffaloes calving in spring recorded the highest milk yield followed by those calved in winter. On the other hand, Chakraborty et al. [27] reported a non-significant effect of calving season on milk yield of Murrah buffaloes.

Our results showed that the best reproductive indices were recorded in winter calvers and this agreed with Motlagh et al. [28] who recorded the shortest DO and CI in winter calvers of dairy cattle. These trends agreed with Ribeiro et al. [29] and Khatri et al. [30] who recorded the lowest service interval in dairy animals calving in the winter months while those who calved in June had the longest interval. The opposite trend was observed by Aziz et al. [5] and Thiruvenkadan et al. [24,31] where the highest service and CIs, and the NSC were observed for buffaloes calved in the winter season. The variation in reproductive efficiency among calving seasons might be attributed to the weather temperature and to the quality of available feed on progesterone level and ovarian function [32]. It is obvious that climatic air temperature affects the buffalo's fertility. The stress of summer temperature adversely affects the quality of ovarian oocytes and hormones [33]. In dairy animals suffering from heat stress, it was observed that the intrauterine environment was interrupted and there was an increase in uterine temperature and a decrease in blood flow [34]. The previous changes might reduce the success rate of inseminations and increase the early embryonic loss in the summer season.

Our study concluded that average TMY and DMY increased with parity till reaching the peak at the fourth lactation, then decreased in the later parities. Many researchers have recorded that buffaloes produce a higher amount of milk from the parity number three to number five [26]. Moreover, Gabr [35] and Hassan et al. [6] reported the highest TMY and DMY of Egyptian buffaloes during the fourth parity. Moreover, in Murrah buffaloes, Sarkar et al. [23] and Thiruvenkadan et al. [24] reported the same trend. In contrast, Hussain et al. [25] reported a lower milk yield in

the fourth and fifth parities of buffaloes. Chaudhry [20] in Nili-Ravi buffaloes reported the highest milk yield during the seventh parity. The parity of our study showed highly significant effects on the value of NSC and on the period of CI, where the second time calvers recorded the highest values for both of NSC and CI which decline thereafter. Our results are comparable with other studies such as Devaraj and Janakiraman [36], who recorded longer interval till the first estrus after the first three parities comparing to the fourth to sixth parities and also Abayawansa et al. [37] who recorded a negative correlation between parity order and DO. However, Hassan et al. [6], Hussain et al. [25], and Gabr [35] reported the highest values for reproductive indices during the first parity.

AFC is an important reproductive trait as well as an economic trait in buffalo. In our study, AFC had a significant effect on total milk yield per lactation and daily milk yield with a trend that younger heifer (less than 34 months) recorded the highest TMY and DMY. These results agreed with those of Albarrán-Portillo and Pollott [38] and Eid et al. [39] who found a highly significant effect of AFC on TMY and DMY in dairy cattle. The decrease in AFC resulting in a decrease in the cost of raising the animals to reach a productive life and an increase in the annual genetic gain [22]. The DP is a very important trait to all dairy animals including buffaloes, it helps the udder tissue to be repaired. In our study, the highest TMY and DMY were obtained from buffaloes having a DP of less than 167 days. This was consistent with El-Wakeel et al. [40] who showed a significant effect of DP on TMY for Egyptian buffaloes where the highest TMY was recorded for a DP that ranged from 60 to 90 days. Moreover, Panja and Taraphder [41] reported that the optimum DP for maximum milk production was 51–70 days for Karan Fries cattle. Reddy and Basu [42] reported in HFXSW crosses that the optimum DP per lactation for life milk, life profit, life milk per day, life profit per day, and herd life was 116, 107, 87, 103, and 147 days, respectively.

Our results showed a general trend that buffaloes producing higher milk yield recorded lower reproductive performance indicated by the higher value of NSC and a longer period of DO and CI periods but the significant effect was recorded only in DO. Our results agreed with Berry et al. [43] and Canaza-Cayo et al. [44] who reported antagonistic relationships between milk production and

fertility traits where higher yielding animals were associated with more DO. However, other studies have reported no correlation between milk yield and reproductive traits [21,45]. Managemental factors have an important effect on the relationship between milk yield and fertility traits. Further studies need to be done for controlling the production environment to avoid the lower rate of genetic gain in milk production due to an antagonistic relationship with fertility. The expected breeding values of our study showed large differences in the studied traits. The range of sires EBV was from −300 to 240 kg, −72.3 to 222.9 days, −31.5 to 82.4 days, −1.1 to 2.7 months, and −24.2 to 46.9 days for TMY, LL, DO, CI, and DP, respectively. While the corresponding values for cows were −430 to 330 kg, −144.7 to 811.3 days, −42.5 to 97.7 days, −1.4 to 3.5 months, and −39.4 to 79.9 days, respectively. Similar values were obtained by Fooda et al. [3] working on five Egyptian buffaloes populations, they reported that the range of breeding values for TMY was −265.19 to 393.51 with an average 1.17 kg. Also, Khattab et al. [46] working on 1,226 records of Egyptian buffaloes, found that EBV of sires ranged between −211 and 407 kg.

Conclusion

Season of calving, parity, and DP plays great roles in dairy buffalo's profitability through their significant effect on productive and reproductive traits. Buffaloes which calved in the winter season recorded the highest amount for TMY and for DMY and the best reproductive performance. The highest milk yield was obtained on the fourth parity, and then the amount gradually decreased. Buffaloes having shorter DP than 167 days recorded the highest milk yield traits and the best reproductive performance. In order to increase dairy buffalo productivity under a subtropical environment such as Egyptian condition, it is advisable to make synchronization of estrus cycle in order to have more winter season calvers and to reduce the adverse effect of autumn and summer season's environment by applying for appropriate managemental programs. Moreover, it is recommended to avoid longer DP and to decide the best interval for keeping the animal in production. Finally, the breeder should select the animals with higher breeding values to be the parents of the next generation.

Conflict of Interests

No conflict of interest was declared by the author.

Acknowledgments

Authors' contribution

Sherif Ibrahim Ramadan analyzed the data and wrote the manuscript

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