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Genetic Evaluation for Productive and Reproductive Traits in Egyptian Buffaloes

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Abstract

A total of 4450 normal lactation records of Egyptian buffaloes kept at Mehalet Mousa Farm, belonging to Animal Production Research Institute (APRI), Agriculture, Research Center, Ministry of Agriculture, Cairo, Egypt, during the period from 1990 to 2022 were used in this study to estimate phenotypic and genetic parameters for productive and reproductive traits. Variables studied were milk yield (MY), days in milk (DM), and days dry (DD), as productive traits and days open (DO), as reproductive trait. Data were analysis by using multi- traits animal model (Boldman et al., 1995). Means of MY, DM, DD, and DO were 1714 kg, 213 d, 217 d and 116 d, respectively. Least squares analysis of variances showed that sires of the cows and cows within sires had a significant effect on MY, DM and DD, while had no significant effects on DO. Year and month of parturition, parity and level of production (three levels of production) had a significant effect on most variables studied. Estimates of partial linear and quadratic regression coefficients of MY and DM on DO were significant ($P<0.01$), being 6.60±0.27 kg/d, and 0.02±.0.0007kg/d2 for MY and 1.011±0.005d/d, and -0.003±0.0001 d/d2 for DM, respectively. Estimates of linear and quadratic regression coefficients of MY and DM on DD were significant ($P < 0.01$), being -6.50±0.31 kg/d and 0.04±0.0006kg/d2, for MY and -0.988±0.005 d/d and 0.002±0.0001 d/d2 for DM, respectively. Estimates of direct heritability for MY, DM, DD, and DO were 0.24±0.019, 0.13±0.015, 0.07±0.012, and 0.08±0.014, respectively. Estimates of phenotypic and genetic correlations and breeding values for all variables studied are also calculated.

1. Introduction

Buffaloes are considered as the main dairy cattle in Egypt, being the principal breed, since they surpass local cows in their milk yield and growth rate (Mahdy et al., 1999; Easa et al., 2022).

The integration of several traits such as age at first calving, days open, days dry, and length of herd-life besides milk yield and the knowledge of their relationships are important for effective control of the dairy production system for maximum economic return. Poor fertility performance increases production cost through higher culling rates, longer calving interval, less milk, fewer calves per cow per year and finally decreased profit (Bagnato and Oltenacu, 1994; Helmy and Somida, 2021).

Economic traits such as productive and reproductive traits in dairy cattle are influenced by genetic and non-genetic effects. Calculating the environmental factors affecting productive and reproductive performance provide basic information for developing breeding and management programs for genetic improvement. It helps in selecting cows, sires, and dams with superior genetic merits (Khattab et al., 2023). Estimates of heritability from 0.12 to 0.42 for milk production (Tonhati et al., 2000; El- Arian et al., 2003; Amina Ahmed et al., 2017; Abu El-Naser ,2020 ;Khattab et al., 2023; Sharma et al., 2024) , from 0.04 to 0.31 for days in milk (Tonhati et al., 2000; El- Arian et al., Khattab et al., 2003; Ibrahim et al., 2012; Amina Ahmed et al., 2017, Abu El- Naser 2020 ; Khattab et al., 2023; Sharma et al., 2024) from 0.08 to 0.13 for Days dry -(Aziz et al., 2001; Shalaby et al., 2016; Easa et al., 2022), and from 0.01 to 0.10 for days open (Ashmawy and El- Bramony ,2017; Abu El-Naser ,2020 ; Helmy and Somida ,2021).

No genetic improvement is expected because most buffaloes are in small scale ownership and not selected on their productive or inherent Merits. The ultimate goal in animal breeding is to rank breeding animas according to their genetic merit for the desired characters and to use them efficiency in breeding.

Therefore, the main objectives of the present study are estimating the phenotypic and genetic parameters for milk yield (MY), days in milk (DM), days dry (DD), and days open (DO), as well as (2) construct a set of multiplicative factors for adjusting lactation records for various lengths of days open.

2. Materials and methods

Source of data

A total of 4450 normal lactation records of Egyptian buffaloes kept at Mehalet Mousa Farm, belonging to Animal Production Research Institute (APRI), Agricultural Research Center, Ministry of Agriculture, Cairo, Egypt, during the period from 1990 to 2022 were used in this study. Variables studied are milk yield (MY), days in milk (DM) and days dry (DD), as productive traits and days open (DO), as a reproductive trait. Days dry is the period during which animal remains out of milk production. Days open it is the period between calving and the subsequently successful conception. Animal were divided according to level of production to three levels 1000 kg, 1000 10 1500 kg, and 1500 kg per lactation).

Feeding system

Animals were fed Berseem (*Trifolum alexandrinum*), in addition to rice straw and amounts of integrated concentrate feed mixtures in Winter season. In summer season, animals were fed on concentrates ration and little amount of Berseem hay. Amount of ration given to the animals were determined according to animal body weight and level of milk production. The ration was offered twice daily. Clean water was freely available all the time. Buffalo cows were hand-milked- twice a day at 7 a.m. and 4 p.m. throughout the lactation period. Buffalo cows were naturally mated in a group mating system. Rectal palpation was applied to check pregnancy on Day 60 post mating. As a rule, buffalo heifers were first mated at 18 months of age or 350 kg of body weight.

Analysis

Preliminarily analysis of data was made by Statistical Analysis System (SAS) version 8.2. For MY and DM, the linear mixed model includes, the fixed effect of month and year of parturition, dam's parity and level of milk production and random effects of sire of cows and cows within sires.

For MY and DM the following mixed model (1) was used

Yijklmno = U + Si + dij+ mk + Yl + Pm + Ln - + b1xo +b2o2 + b3x p + b4p2+ eijklmnomp……….. (1)

Where

U= the overall mean of the traits; Si =random effect of the ith sire, dij = random effect of the ith dam nested within the ithsire; mk = fixed effect of the kth month of calving, (k = 1,2,……and 12), Yl= fixed effect of the year of calving and l= (1990,1991,…….and 2022) , P m=fixed effect of the mth parity and m (1,2,……>12), Ln = fixed effect of the nth level of production n = (1,2,and 3) , b1o = partial linear regression coefficient of MY and DM on days dry , b2p = partial quadratic regression coefficient of MY and DM on days dry, b3p = partial linear regression coefficient of MY and DM on days open- , b4p = partial quadratic regression coefficient of MY and DM on days open, and eijklmnopq = random residual effect.

For DD and DO the following mixed model 2 was used

Yijklmno = U + Si + dij+ mk + Yl + Pm + Ln +eijklmno…………. (2)

In addition, MY and DM all are analyzed by using multiple traits Derivate – Free Restricted Maximum Likelihood (MTDFREML) according to Boldman et al. (1995). The multi trait animal model (MTAM) includes, the fixed effects of month and year of parturition, dams' parity, level of production and days dry and days open as a covariate and random effects of animals, permanent environmental and errors. For DD and DO the model includes the fixed effects of month and year of calving and parity and random effects of animals, permanent environmental and errors. Estimates of heritability and phenotypic and genetic correlation and breeding values were estimated according to Boldman et al., (1995).

3. Results and discussion

Unadjusted means of milk yield (MY), days in milk (DM), days dry (DD), and days open (DO) for Egyptian buffaloes are presented in Table 1.

Table 1. Means, stander deviation (SD), and coefficient of Variation (CV%) for different variables studied on Egyptian buffaloes.

Variable	Mean	SD	CV%
Milk yield (MY), kg	1714	572	33.39
Days in milk (DM), d	213	50	23.48
Days dry (DD), d	217	112	51.74
Days open DO), d	116	102	88.10

Number of recedes 4450

Coefficient of variability of MY, DM, DD and DO were 33.39, 23.38, 51.74 and 88.10 %, respectively (Table 1).

Sires of the cows and cows within sires had a significant effect on MY, DM and DD, while had no significant effects on DO (Tables 2 and 3), which including that the possibility of genetic improvement of MY, DM and DD through sire and dam selection. Ibrahim et al., (2012), Amina Ahmed et al., (2017), and Khattab et al., (2023) with other sets of that herd, reported that sire of the heifers had a significant effect on milk yield and lactation period. On the other hand, Vyas et al., (2021) with Surti buffaloes in India, using (SM), found that sire of the buffalo had no significant effect on DD and DO.

Least squares of variance for factors affecting productive and reproductive variables are presented in Tables 2 and 3. Month and year of parturition had a major fixed effect on MY, DM, DD, and DO, except the effect of month of parturition on MY and year of parturition on DM. Similarly (Aziz et al., 2001; Khattab et al., 2010; El- Arian et al., 2012; Bashir et al. ,2015; Sezer et al., 2022; Khattab et al., 2023) with different strains of buffaloes arrived at the same results.

Parity or lactation order had a significant effect on MY, DM, DD and DO (P < 0.01, Tables 2 and 3). Similar results were stated by many authors worked on different strains of buffaloes (Aziz et al., 2001; Khattab et al., 2010; El- Arian et al., 2012; Bashir et al., 2015; Amina Ahmed et al. 2017; Basant Shafik et al., 2017; Ramadan, 2018; El-dawy et al., 2021; Ayad et al., 2022 ; Sezer et al., 2022 ; Khattab et al., 2023).

Table 2-Least squares analysis for factors affecting milk yield (MY) and days in milk (DM) for Egyptian buffaloes.

S.O.V	d.f	F-value	F-value
		MY Pr>f	DM pr>f
Between bulls	226	2.06 <0.0001	1.82 <0.0001
Between cows : bulls	791	1.30 <0.0001	0.85 0. 9965
Between parities	11	3.18 0.0002	6.57 <0.0001
Between month of calving	11	0.74 0.6987	1.94 0.0308
Between year of calving	31	3.45 <0.0001	1.28 0.1387
Between level of production	2	2.012 <0.0001	5.80 <0.0031
Regressions			
Days open, linear	1	186.04 <0.0001	2.55 <0.0001
Days open, quadratic	1	0.29 0.508	0.63 0.425
Days dry, linear	1	136 <0.0001	21097 <0.0001
Days dry, quadratic	1	1.41 0.0551	3.69 0.0551
Errors, MS.	3373	57014	59.65

Least squares analysis of variances (Tables 2 and 3) show that level of production had highly significant effect on MY, DM, DD and DO. Similar results were reported by many authors. In this respect, Basant Shafik et al. (2017) worked on Egyptian buffaloes, classified animals to three levels of production less than 2000 kg, 2000 to 3000 kg and more than 3000 kg, found that level of production had highly significant effect on DO and CI. Average DO was 98.48, 109.49, and 111.82 d for the three levels, respectively. The corresponding values were 13.71., 14.02 mo., and 14.06 mo., CI, respectively. Animals that produced less than 2000 kg of milk per season showed minimum day's open and calving interval. Therefore, DO and CI was higher in low producing cows than higher producing animals. In addition, Ramadan (2018) and Eldawy et al. (2021) arrived at the same conclusion.

Table 3. Least squares analysis for factors affecting days dry (DD) and days open (DO) on Egyptian buffaloes.

S.O.V	d.f	DD		DO	
		F-value	pr>F	F-value	pr>F
Between bulls	226	3.76	<0.0001	0.501	0.553
Between cows : bulls	791	1.70	<0.0001	0.40	0.670
Between parities	11	27.07	<0.0001	29.79	<0.0001
Between month of calving	11	6.87	< 0.0001	5.90	<0.0001
Between year of calving	31	12.01	<0.0001	14.12	<0.0001
Between level of production	2	112.01	<0.0001	0.014	0.941
Errors ,MS.	3377	8749		7727	

Estimates of partial linear and quadratic regression coefficients of MY and DM on Days open (DO) and dry period (DP) are presented on Table 4. Estimates of partial linear and quadratic regression coefficients of MY and DM on DO were significant (P <0.1, Table 4), being 6.60±0.27 kg/d and 0.02±0.0007kg/d2 for MY and 1.011 d/d and -0.003 d/d2, for MY, respectively.

The increase of MY and DM with the increase of days open was obvious. The prediction equations of milk yield or lactation length (Y) on days open (x), where: y = a + b1x + b2x2 Table 4) was constructed. The maximum milk yield was attained when female buffalo had the (optimum) DO at 165, 215, 186, and 78 d for all data, level1, level 2 and level 3 of production, respectively. Ashmawy and Khattab (1991) with Friesian cows concluded that the maximum production in the current lactation including calf crop was attained when cows were bred as early as possible after parturition. An intensive program of heat detection and efficient practices of insemination would significantly shorten DO. Similar results were obtained by many authors worked on different breeds of buffaloes. In this respect, Zienab et al. (2020) with another set of that herd divided the herd to three levels of production level 1 less than 2221 kg, level 2 from 2221 to 2669 kg and level three more than 2669 kg, found that days open had significant effect on Total TMY. The maximum milk yield was 1746.71 kg when DO was more than 160 days. Also, the same authors found that the average days open were 113.92, 121.16 and 103.59 d for the three levels of production, respectively.

Estimates of linear and quadratic regression coefficients of MY and DM on DD were significant (P< 0.01, Table 4), being-6.50±0.309 kg/d and 0.04±0.0006kg/d2, respectively for MY and -0.988±0.005 d/d and 0.002 ±00001d/d2 for DM, respectively.

Table 4. Estimates of partial linear and quadratic

regression coefficients of days open and days dry on milk yield (MY), and days in milk (DM) on Egyptian buffaloes

Variation	Days in milk_ (DM), _d	Milk yield (MY),_ kg
Intercept (a)	312.53±0.505 (p<0.000)	2406.38±28.83 (P< 0.0001)
Days open, linear	1.011±0.005 (p<0.0001)	6.60±0.270 (P<0.0001)
Days open, quadratic	- 0.003±0.00001 (p0.0001)	0.02±0.0007 0.006
Days dry, linear	- 0.988 ±0.005 (<0.0001)	-6.50±0.309 (P<0.0001)
Days dry, quadratic	0.002±0.00001 (<0.0001)	0.04±0.0006 (P< 0.0001)

The prediction equations of milk yield or lactation length (Y) on days dry (x) , where : y = a + b1x + b2x2 (Table 4) was constructed- . The maximum milk yield was attained when female buffalo had the (optimum) DO at 165 d. The maximum milk production when female buffalo had the (optimum) DD at 81 d (Table 4).

Estimates of heritability, phenotypic and genetic correlations among different variables are presented in Table 5. Heritability estimates for MY, DM, DD and DO were 0.24, 0.13, 0.07 and 0.08, respectively (Table 5). The h2 value for MY was moderate and in the same time it is similar to those reported, being 0.24 (Mahady et al., (1999) 0.25, (Abu El- Naser, 2020) and 0.22 (Khattab et al., 2023) working on other sets of Egyptian buffaloes, higher than0.17, 0.17, and 0.14-0.16, those as stated by (Khattab and Mourad 1992). Mourad and Khattab (2009) and Shalaby et al., (2016), respectively, worked on Egyptian buffaloes, and lower than0.33-0.41, as reported by Sharma et al., (2024) in Murrah buffaloes. In addition, Easa et al., (2022) with Egyptian buffaloes, using sire model, found that h2 estimate for MY was 0.52.

Table 5. Estimated of heritability (on diagonal), genetic correlation (below diagonal) and phenotypic correlation (above diagonal) among different variables studies

Traits	MY	DM	DD	DO
MY	0.24±0.019	0.34	-0.19	-0.20
DM	-0.03+0.01	0.13±0.017	-0.70	-0.28
DD	-0.10±0.02	-0.35±0.01	0.07±0.012	0.91
DO	-0.03±0.15	-0.20±0.01	0.86±0.03	0.08±0.014

Heritability estimates for DM was 0.13±0.017 (Table 5). The present estimates for DM from multi trait animal model was similar to values of 0.13, 0.17, 0.19, 0.13, 0.08-0.19, and 0.17, as reported by Khattab and Mourad (1992); El- Arian et al., (2003); Aziz et al., (2001); Mourad and Khattab (2009); Shalaby et al., (2016) and Khattan et al., (2023) on Egyptian buffaloes. Heritability estimates for DM was 0.05-0.13 for Murrah buffaloes (Sharma et al., 2024), while, Easa et al., (2022) with Egyptian buffaloes, using sire model found that direct h2 estimates for DM was 0.47.

Direct heritability estimates for DD and DO were 0.07±0.012 and 0.08±0.014, respectively (Table 5). Our results are within the range (0.0001 to 0.23) reported by many authors working on different strain of buffaloes (Mourad et al., 1989; Aziz et al., 2001; Shalaby et al., 2016; Ashmawy and El- Bramony, 2017; Abu El- Naser, 2020; Helmy and Somadia, 2021and Sharma et al. 2024). Lower h2 estimates for DM, DD, and DO conclude that, these variables are influenced by non-genetic factors, improvement of feeding, management, detection of animal in heat, and their insemination at proper time by good quality semen would help in improving calving interval, which comprises days in milk and dry period.

Genetic and phenotypic correlations among all variables studied are presented in Table 5. Genetic and phenotypic correlations between MY and DM were positive, highly significant being 0.34 and 0.68, respectively (Table 5), while (genetic and genetic) correlations between MY and DM, DD and DO were negative and genetic and phenotypic correlations between DD and DO were positive being 0.86 and 0.91, respectively (Table 5).

Moderate and high coefficients of variations reflected the wide variation among the individual's performance. Also, the higher estimates for DD and DO were due to higher variation between animals and this attributed to that artificial insemination is not available in most times, it does not have the exact date on which the conception occurred and it was obtained on predetermined values. Also, the variation in DO may be attributed to difference in extremes of climatic conditions during different years and season within the year, management practices, presence of teaser bull and skill to detect heat by labour (Bashir et al., 2015). With another set of that herd (Helmy and Somida, 2021) found that the CV % for DO was 57.67 % and indicating a large variation among individual buffaloes which can be a good opportunity for this trait.

Sire selection may be used as useful tool for the genetic improvement of milk yield, lactation length and dry period, while DO and can be improved by better management and controlled of silent heat.

The significant effect of month and year of parturition may be due to the change in herd size, age of animals, managerial practices which vary from year to year, different in weather conditions and phenotypic trends. A significant effect of parity on productive and reproductive traits is logically due to the increase in body weight and age of animals and increase the feed intake. The present results show that lactation length increased with increases level of production, while DP and DO decrease as increase level of production.

The present results indicated that the lowest days open were obtained at the maximum milk yield in level 3 of production. Therefore, female buffaloes producing more and high milk are less days open and selection cows with high milk production will decrease days open and there is the aim of the breeder.

The moderate h2 estimates for milk yield suggested that, the genetic progress in milk production can be achieved through selection breeding program. Lower h2 estimates for DM, DD and DO conclude that these variables are influenced by non-genetic factors, Improvement of feeding, management, detection of animal in heat and their insemination at proper time by good quality semen would help in improving calving interval, which comprises days in milk and dry period. Negative genetic correlations between MY and DM, DD and DO suggest that selection for high yielding milk, would cause a correlated decrease in their days in milk, days dry and days open. Therefore, a decrease of dry period and days open are a desirable goal of dairymen and will help in minimizing the cost of raising breeding cows and maximizing the number of lactations per cow.

4. Conclusion

The present results indicated that the level 3 of production more than 1500 kg had lower days open (105 d) and less dry period (108 d) rather than level 1 (115 and 219 d), respectively and level 2 (115 d and 112), respectively. Therefore, it is important to selection higher lactating female buffaloes. On other words, increasing the length of days dry are dependent on the cost of milking cows with extended lactations. Dairy breeders tend to milk their cows in late lactation as long as the difference of income over feed cost per day exceeds the cost of milking. Year and month of parturition, parity and level of production (three levels) had a significant effect on most variables studied. Estimates of partial linear and quadratic regression coefficients of MY and DM on DO were significant (P <0.01), being 6.60 kg/d and 0.02kg/d2 for MY and 1.011 d/d and -0.00001 d/d2 for DM, respectively. Estimates of linear and quadratic regression coefficients of MY and DM on DD were significant (P<0.01), being -6.502 kg/d and 0.0015kg/d2, respectively for MY and for DM were-0.988 d/d and 0.002 d/d2, respectively. Estimates of direct heritability for MY, DM, DD and DO were 0.24±0.019, 0.13±0.015, 0.07±0.012 and 0.08±0.014, respectively. Estimates of phenotypic and genetic correlations and breeding values for all variables studied are also calculated.

Conflict of interest:

The authors declare that they have no compact of interests.

Author contributions

Amina Ahmed, S.; El- Barbary, A.S.A.; Set El-Habiab, S.Awad, El- Awady, H.G.; Khattab, A.S.;and Shymma El- Komy, M., collected the data. All authors wrote and drafted the corresponding sections of the manuscript and revised the complete manuscript.

Ethics Approval and consent to participate

The protocol for the conducted animal experiments was approved by the institutional animal care and use the committee of Tanta University.

Consent for publication

Not applicable

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