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ASSESSMENT OF LONGEVITY AND LIFETIME PRODUCTION TRAITS IN EGYPTIAN BUFFALO

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SUMMARY

The current study aimed to assess the longevity and lifetime production traits in Egyptian buffalo and to evaluate the influence of age at first calving (AFC), first lactation milk yield (FLMY), and other environmental factors on such traits. Data on 1769 lactation records of 307 Egyptian buffalo were collected from the history databases of three herds to cover the period from 1996 to 2022. The longevity traits were herd life (HL), productive life (PL), buffalo efficiency index (BEI), and number of lactations (NL); whereas, lifetime production traits included lifetime days in milk (LDIM), lifetime milk yield (LMY), lifetime daily milk yield (LDMY), coefficient of lactation (CL), milk yield per day of herd life (MY/HL), milk yield per day of productive life (MY/PL), and longevity index (LI).

The least squares mean (LSMs) of longevity traits were 3898.4±31.1 days, 2732.8±30.8 days, 65.6±0.3%., and 6.9±0.1 lactations for HL, PL, BEI, and NL, respectively. The LSMs of lifetime production traits were 1522.2±19.2 days, 12045.6±160.8 kg, 7.5±0.1 kg/day, 60.4±0.5%, 3.0±0.03 kg/day, 4.7±0.1 kg/day, and 39.1±0.4% for LDIM, LMY, LDMY, CL, MY/HL, MY/PL, and LI, respectively.

The effect of the herd, AFC, FLMY, and period of first calving was significant ($P < 0.05$, $P < 0.01$, and $P < 0.001$) on all studied traits. The season of first calving significantly affected all studied traits except MY/PL. It can be concluded that the significant environmental factors examined in this study should be considered when planning the management policy and adjusted to achieve more accuracy in the genetic evaluation of selected animals for the studied traits in Egyptian buffalo.

Keywords: Age at first calving, Egyptian buffalo, Lifetime traits, Longevity

INTRODUCTION

Egyptian buffalo is a fundamental part of the national agricultural economy due to its substantial contribution to milk and meat production. Egyptian buffalo is about 3.4 million heads, contributing approximately 45% and 37% of the nation's milk and red meat production, respectively, and contributes around 1.7% and 10.9% of the global buffalo's milk and meat, respectively (FAOSTAT, 2019).

In general, buffalo are characterized by the high ability to withstand harsh environmental and managerial conditions, high efficiency for utilizing low quality roughage, and a remarkable resistance to various infectious diseases (Guerrero-Legarreta *et al*., 2020). These characteristics enhance the lifespan and productive life to be longer in buffalo than in cattle under common environmental conditions (De Vries and Marcondes, 2020).

Longevity and lifetime production traits are the most economic functional traits that directly affect the profitability and the economic return of dairy farms (Siriak *et al*., 2022). Such traits reflect the performance of the animal throughout its productive life in the herd, which is greatly determined by its ability to remain alive in the herd for a longer period as possible and avoid the culling pressure (Schuster *et al*., 2020).

Lactating buffalo are typically culled due to low productivity (voluntary culling) or fertility and health failures (involuntary culling); therefore, increased longevity always indicates an enhanced reproductive and health status (Bashir *et al*., 2007, and Dallago *et al*., 2021). In the dairy industry, longevity has been defined by using many different expressions such as the length of herd life, the length of productive life, and the number of lactations of the animal (Schuster *et al*., 2020).

Improvement of longevity in a given herd allows dairy animals to express their maximum potential for milk production, which is, in turn, positively associated with achieving a larger number of lactations throughout their productive life (Ali, 2021). Moreover, reducing the proportion of culled low milk producing animals at their early productive lives, along with keeping a high proportion of highly producing mature animals for long productive lives will reduce the costs of rearing a high number of replacement heifers and will raise the herd average of lifetime milk production. This in turn should maximize the profit of the dairy enterprise (Novotný *et al*., 2017).

Likewise, high longevity presents an objective indicator of animal welfare that is reflected in high productivity of milk, supreme growth, and success in adopting and practicing the developed technology of rearing animals overtime, especially under intensive production systems (Ali, 2021, and Vredenberg *et al*., 2021). Additionally, extended longevity in a herd diminishes the adverse environmental impacts of milk production, for instance, significantly less methane is emitted per kg of milk produced by multiparous animals compared to primiparous ones, which promotes environmental sustainability (De Vries and Marcondes, 2020 and Vredenberg *et al*., 2021).

Lifetime production traits incorporate longevity and production traits (Novotný *et al*., 2017). Lifetime traits of dairy buffalo are usually influenced by its reproductive and productive performances of the first lactation. This correlation provides the opportunity to improve the lifetime production traits based on the selection of buffalo with superior early performance records (Tamboli *et al*., 2021).

Age at first calving (AFC) and first lactation milk yield (FLMY) proved to be highly influential for the most lifetime traits in buffalo (Tamboli *et al*., 2022). For a profitable dairy buffalo enterprise, achieving the optimal AFC is usually associated with shorter nonproductive periods of heifers; lower rearing costs, longer productive life, higher lifetime milk yield as well as accelerating the genetic gain by decreasing the generation interval (Tamboli *et al*., 2022). Furthermore, as FLMY was effectively utilized as a determinant for the future milk productivity of the primiparous dairy animals in subsequent lactations, it could be used similarly for all lifetime production traits (Dev *et al*., 2016, and Almasri *et al*., 2020).

Consequently, the objectives of the current study were to assess the longevity and lifetime production traits in Egyptian buffalo and to evaluate the influence of AFC, FLMY, and other environmental factors on these traits.

MATERIALS AND METHODS

Ethics statement:

All procedures of the present study have been approved by the Institutional Animal Care and Use Committee (IACUC) at Cairo University, Egypt (Endorsement number: CU-II-R-F-3-24).

Data collection:

Data comprised of 307 Egyptian buffalo with 1769 lactation records related to longevity and lifetime production traits were utilized. The buffalo were daughters of 86 sires and 245 dams. The data were collected from the history databases from three herds located at different governorates namely, Kafr El-Sheikh, Giza, and Alexandria. The buffalo used in the study were born between 1996 and 2013, first calved between 1999 and 2016, and were culled from their herds during the period from 2009 to 2022. For each buffalo, the data available included: the buffalo ID, pedigree, date of birth, dates of calving, dates of drying off, milk production in the first and subsequent lactations, and date of culling. The previous data was used to calculate the studied traits. In the case of buffalo with an unknown culling date, the date of the end of the last known lactation was considered as the culling date (Djedović *et al.*, 2023). The buffalo with missed or unreliable values for various traits were excluded from the dataset. At every herd, buffalo are culled periodically due to poor milk production, and reproductive and health problems.

Management of animals:

In general, in all three herds, the lactating buffalo were raised under similar routine management practices. Animals were housed in semi-open sheds with a sandy floor. Throughout the year, buffalo located in Kafr El-Sheikh and Alexandria Governorates were fed using total mixed ration (TMR) based on the National Research Council (NRC) recommendations. The TMR is composed of soybean meal, wheat bran, Egyptian clover, alfalfa hay, rice straw, yellow corn, corn silage, and minerals and vitamins additions, whereas those located in Giza's herd were fed based on traditional separate feeding of concentrate and roughage diets.

Water was accessible to animals all day, while rations were offered three times daily for Alexandria's herd and twice daily for the rest herds. The quantity of feed was distributed between the animals based on their level of milk production. Animals were routinely machine milked twice a day except animals belonging to Alexandria's herd which were machine milked three times daily. The milk recording was conducted daily in all herds. Animals were usually milked until 60-90 days before the anticipated calving date based on their pregnancy period and their milk production. Buffalo were artificially inseminated while buffalo belonging to Giza's herd were naturally served. The heifers were mated for the first time when reached 18 months of age or at a body weight of 375 kg. Successful conceptions were assured by rectal palpation after 45 days from the last bred.

Studied traits:

Longevity traits:

1. Herd life (HL, days): the number of days between the date of birth and the date of culling or death (Tamboli *et al*., 2022).
2. Productive life (PL, days): the number of days between the date of first calving and the date of culling or death (Tamboli *et al*., 2022).
3. Buffalo efficiency index (BEI, %): calculated as productive life divided by the herd life ×100 (Petrović *et al*., 2019).
4. Number of lactations (NL, lactations): the number of lactations of buffalo during the productive life (EL-Hedainy *et al*., 2020).

Lifetime production traits:

1. Lifetime days in milk (LDIM, days): the number of days between the date of first calving and the date

of culling or death without dry periods, thus it expresses the milking life of a buffalo (Hu *et al*., 2021).

2. Lifetime milk yield (LMY, kg): the accumulated milk yield produced by a buffalo from the first day in milk until the last one during its productive life (Tamboli *et al*., 2021).

3. Lifetime daily milk yield (LDMY, kg): calculated as the lifetime milk yield divided by the lifetime days in milk (Tamboli *et al*., 2021).

4. Coefficient of lactation (CL, %): calculated as lifetime days in milk divided by productive life×100 (Siriak *et al*., 2022).

5. Milk yield per day of herd life (MY/HL, kg/day): calculated as the lifetime milk yield divided by the herd life (Tamboli *et al*., 2022).

6. Milk yield per day of productive life (MY/PL, kg/day): calculated as the lifetime milk yield divided by the productive life (Tamboli *et al*., 2022).

7. Longevity index (LI, %): calculated as lifetime days in milk divided by herd life ×100 (Dallago *et al*., 2021).

Statistical and data analysis:

Data were statistically analyzed by least squares means (LSMs) procedure using univariate analysis of variance in general linear model (GLM) of IBM SPSS Statistics software (Version 22, Armonk, NY, USA) to test the significance of the fixed factors effects. The fixed factors effects fitted were herd (three levels), period of first calving (four levels), and season of first calving (four levels), in addition to AFC and FLMY. To test the effect of AFC on studied traits, buffalo were distinguished into three groups according to their AFC as follows: group one: < 36 months, group two: 36-42 months, and group three: > 42 months. Likewise, the buffalo were classified into four groups according to their FLMY as follows: group one (≤ 500 kg), group two (501-1000 kg), group three (1001-1500 kg), and group four (> 1500 kg). Bonferroni adjustment for multiple comparisons test was utilized to examine the differences between least squares means of the levels of each fixed effect. The differences between least squares means of levels of all fixed effects were considered statistically significant at P-value < 0.05. The results were exhibited as LSM ± standard error (SE). In this regard, the statistical model considered was as follows:

$$\mathbf{Y_{ijklmn} = \mu + H_i + A_j + F_k + P_l + S_m + e_{ijklmn}}$$

Where, $\mathbf{Y_{ijklmn}}$ is the observation on the nth buffalo for the studied traits; $\mathbf{\mu}$ stands for the overall mean of observations; $\mathbf{H_i}$ refers to the fixed effect of the ith herd, (i=1, 2, and 3), where, 1: the herd located in Kafr El-Sheikh Governorate, 2: the herd located in Giza Governorate, and 3: the herd located in Alexandria Governorate; $\mathbf{A_j}$ is the fixed effect of the jth age at first calving (j= 1, 2, and 3), where, 1: < 36, 2: 36-42, and 3: > 42 months; $\mathbf{F_k}$ signifies the fixed effect of the kth first lactation milk yield (k=1, 2, 3, and 4),where, 1 : ≤ 500 kg, 2: 501-1000 kg, 3: 1001-1500 kg, and 4: > 1500 kg; $\mathbf{P_l}$ stands for the fixed effect of the lth period of first calving (l= 1, 2, 3, and 4), where, 1: 1999-2002, 2: 2003-2006, 3: 2007-2011, and 4: 2012-2016; $\mathbf{S_m}$ is the fixed effect of the mth season of the first calving (m= 1, 2, 3 and 4) depends on climate characteristics, where, 1: winter (December through February), 2: spring (March through May), 3: summer (June through August), and 4: autumn (September through November); and $\mathbf{e_{ijklmn}}$ is random residual error, assumed to be normally independently distributed with mean zero and constant variance, N I D (0, σ^2e).

RESULTS AND DISCUSSION

Longevity traits:

The least squares means and their standard errors for longevity traits in the Egyptian buffalo are presented in Table 1. The overall mean of HL was 3898.4±31.1 days. The current estimate is almost similar to the finding of Bashir *et al.* (2007) in Nili-Ravi buffalo (3989.7 days), Abdel–Baray *et al.* (2017) in Egyptian buffalo (125 months), and Tamboli *et al.* (2023) in Nili-Ravi buffalo (3779.8 days). However, the current estimate is higher than the means of HL reported by Dev *et al*. (2016) in Murrah buffalo (3340.22 days), Thiruvenkadan *et al*. (2015) in Indian buffalo (3078.4 days), and Joshi *et al*. (2017) in Mehsana buffalo (2909.10 days).

The overall mean of PL was 2732.8±30.8 days. This estimate is higher than the means mentioned by Bashir *et al*. (2007) in Nili-Ravi buffalo (1137.6 days), Dev *et al*. (2016) in Murrah buffalo (1161.59 days), and EL-Hedainy *et al*. (2020) in Egyptian buffalo (952.95 days). Also, Thiruvenkadan *et al*. (2015), Joshi *et al*. (2017), and Tamboli *et al*. (2023) reported that the means of PL were 1520.7, 1574.19, and 2078.5 days in Murrah buffalo, Mehsana buffalo, and Nili-Ravi buffalo, respectively.

Based on HL and PL estimates, BEI was estimated to be 65.6±0.3%. No literature is available for BEI in buffalo; while the cow efficiency index (CEI) was assessed in dairy cattle breeds. The current BEI estimate is higher than the CEI value reported in Simmental cows which was found to be 58.68% (Petrović *et al*., 2019). However, in accordance with our finding, Almasri *et al*. (2023) reported that the mean of CEI was 64.9% in Shami cows compared to Holstein ones (56.4%) in Syria. This indicates that the local livestock revealed more efficiency for longevity under tropical and subtropical environmental conditions.

The least squares mean of NL was 6.9±0.1 lactations which is higher than the findings of Abdel–Baray *et al*. (2017), and EL-Hedainy *et al*. (2020) who reported that the NL was 5.97 and 5.64 lactations in Egyptian buffalo, respectively. Otherwise, El-Awady *et al.* (2021) noted that Egyptian buffalo recorded 8.43 complete lactations during their herd life.

Table 1. Least squares means (LSMs) and their standard errors (SEs) of factors affecting the longevity traits in the Egyptian buffalo

Classification	No.	LSM ± SE			
		HL (days)	PL (days)	BEI (%)	NL (lactations)
Overall mean	307	3898.4±31.1	2732.8±30.8	65.6±0.3	6.9±0.1
Herd		***	***	***	***
Kafr El-Sheikh	230	4336.1±27.9[b]	3143.9±27.6[b]	68.0±0.3[b]	7.7±0.1[b]
Giza	39	4521.8±47.6[a]	3321.1±47.1[a]	71.4±0.5[a]	8.2±0.1[a]
Alexandria	38	2837.2±53.3[c]	1733.3±52.8[c]	57.6±0.6[c]	4.9±0.1[c]
Age at first calving (AFC, months)		***	***	***	*
< 36	137	3625.1±30.2[c]	2674.4±30.1[b]	69.1±0.3[a]	6.9±0.1[ab]
36-42	120	3764.1±33.9[b]	2615.5±33.5[b]	64.2±0.4[b]	6.8±0.1[b]
> 42	50	4306.2±60.1[a]	2908.3±59.4[a]	63.5±0.7[b]	7.2±0.2[a]
First lactation milk yield (FLMY, kg)		**	**	*	**
≤ 500	33	3598.7±95.7[a]	2525.1±95.4[a]	66.2±0.1[a]	6.3±0.2[a]
501-1000	73	3489.2±64.3[b]	2393.6±64.2[ab]	64.5±0.7[ab]	6.1±0.2[ab]
1001-1500	107	3328.7±53.1[abc]	2251.5±53.1[ab]	63.3±0.6[ab]	5.6±0.1[bc]
> 1500	94	3260.1±53.1[c]	2169.7±56.5[bc]	62.8±0.6[b]	5.5±0.1[c]
Period of first calving		***	***	***	***
1999-2002	16	5939.6±69.2[a]	4772.3±68.5[a]	79.8±0.8[a]	12.1±0.2[a]
2003-2006	67	4585.6±38.4[b]	3436.1±38.0[b]	74.7±0.4[b]	8.4±0.1[b]
2007-2011	136	3206.8±33.7[c]	2030.8±33.4[c]	63.3±0.4[c]	5.3±0.1[c]
2012-2016	88	1861.4±35.7[d]	691.8±35.4[d]	44.7±0.4[d]	2.1±0.1[d]
Season of first calving		***	***	***	***
Winter	58	3973.5±43.3[ad]	2812.7±42.9[a]	66.3±0.5[a]	7.2±0.1[a]
Spring	74	3993.1±40.8[a]	2829.3±40.4[a]	66.7±0.5[a]	7.1±0.1[ab]
Summer	90	3864.6±39.0[cd]	2686.1±38.7[b]	64.7±0.4[b]	6.8±0.1[bd]
Autumn	85	3762.3±36.8[bc]	2603.1±36.5[b]	64.5±0.4[b]	6.7±0.1[cd]

Within each classification in the same column, means followed by different superscript letters differ significantly; * ($P < 0.05$); ** ($P < 0.01$); *** ($P < 0.001$); No.: Number of observations; HL: Herd life; PL: Productive life; BEI: Buffalo efficiency index; and NL: Number of lactations.

Environmental factors affecting longevity traits:

Effect of herd:

Herd had a highly significant effect on all longevity traits ($P < 0.001$) with the highest estimates recorded for the herd located in Giza Governorate with means of 4521.8±47.6 days, 3321.1±47.1 days, 71.4±0.5%, and 8.2±0.1 lactations for HL, PL, BEI, and NL, respectively (Table 1). However, the herd located in Alexandria Governorate scored the lowest means of 2837.2±53.3 days, 1733.3±52.8 days, 57.6±0.6%, and 4.9±0.1 lactations for HL, PL, BEI, and NL, respectively. The significant differences between the herds may be due to the dissemblance of some management practices between herds (milking frequency, and feeding routine), the variation in the proper reproduction and health care, geographic location, and fluctuation in the herd size as well as the genetic differences between individuals which effect on the culling rates between herds (Rakhshani Nejad *et al*., 2021). The current findings are in accordance with the results obtained by Bashir *et al*. (2007) and EL-Hedainy *et al*. (2020) who found a significant effect of the herd on HL, PL, and NL in Nili-Ravi buffalo and Egyptian buffalo, respectively.

Effect of age at first calving (AFC):

The AFC of buffalo caused significant ($P < 0.05$ and $P < 0.001$) differences in their longevity traits (Table 1). Among the categories of buffalo based on AFC, the significantly highest means for HL, PL, and NL were scored in buffalo with an AFC > 42 months of age (4306.2±60.1 days, 2908.3±59.4 days, and 7.2±0.2 lactations, respectively).

The lower longevity performance in terms of HL, PL, and NL for buffalo with an AFC of < 36 months compared with those with an AFC > 42 months may be attributed to the fact that these buffalo with early AFC are characterized by incomplete body growth and udder development and the dietary energy is diverted from milk production to support growth and mammary gland development. These factors are often associated with impaired milk performance in their first lactation and the subsequent lactations which causes their early culling from the herd (Tamboli *et al*., 2023). However, the buffalo with an AFC of < 36 months had the highest BEI (69.1±0.3%) compared to other groups because those animals calved for the first time at an early age and consequently had longer PL during their HL.A similar trend was recorded by Tamboli *et al*. (2023) who reported that HL was significantly increased as AFC increased in Nili-Ravi buffaloes. Also, Thiruvenkadan *et al*. (2015) found that AFC significantly affected both HL and PL in Murrah buffalo. On the contrary, Dev *et al*. (2016) demonstrated that the AFC had no significant effect on HL, and PL in Murrah buffalo.

Effect of first lactation milk yield (FLMY):

The effect of FLMY was estimated and showed a significant effect for HL, PL, BEI, and NL ($P < 0.05$ and $P < 0.01$). All longevity traits exhibited a continuous decline tendency as FLMY increased (Table 1). Buffalo produced ≤ 500 kg in their first lactation had the highest means of 3598.7±95.7 days, 2525.1±95.4 days, 66.2±0.1%, and 6.3±0.2 lactations for HL, PL, BEI, and NL, respectively. However, primiparous buffalo produced > 1500 kg were characterized by the lowest means of 3260.1±53.1 days, 2169.7±56.5 days, 62.8±0.6%, and 5.5±0.1 lactations for HL, PL, BEI, and NL, respectively. Thus, high milk producing primiparous buffalo are subjected to a high rate of early culling relative to low milk producing ones. They are vulnerable to stress and probably health problems which increase their chance of being early culled. More important, the negative correlation between high milk production and fertility (Easa *et al*., 2022), makes high milk producing buffalo might be involuntary culled at higher rate than low producers due to fertility problems. The present result is in agreement with those of Pytlewski *et al*. (2010), and Sawa and Bogucki (2017) who found that excessive FLMY was associated with shorter HL, and PL, and reduced NL in dairy cattle.

Effect of period of first calving:

The effect of period of first calving was highly significant on HL, PL, BEI, and NL ($P < 0.001$). Buffalo calved for the first time in the period 1999-2002 had significantly greater HL, PL, BEI, and NL compared to other periods. This may be due to the differences in the climatic conditions, feeding system, and managerial conditions over the years. Similar results were found by Bashir *et al*. (2007) who mentioned a significant effect of the year of first calving on HL and PL in Nili-Ravi buffalo. Also, EL-Hedainy *et al*. (2020) found that PL, and NL were affected significantly by the year of first calving in Egyptian buffalo. Tamboli *et al*. (2023) observed that HL was significantly influenced by the period of first calving, whereas, its effect was non-significant for PL in Nili-Ravi buffalo. On the other hand, Dev *et al*. (2016) observed no significant effect of the year of first calving on HL, and PL in Murrah buffalo.

Effect of season of first calving:

Considering the effect of the season of first calving, it was observed that the longevity traits were significantly ($P < 0.001$) affected by the season of first calving. Buffalo calved for the first time in the winter and spring had significantly higher means of HL, PL, BEI, and NL compared to buffalo that calved for the first time during the other seasons (Table 1). The significant effect of the season of the first calving on the studied longevity traits may be due to the dissimilarity of managerial conditions especially the feed quality and quantity across the different seasons.

Similar to the current result, Tamboli *et al*. (2023) noted a significantly higher HL and PL for animals that calved for the first time during the winter in Nili-Ravi buffaloes. By contrast, Dev *et al*. (2016) and EL-Hedainy *et al*. (2020) noticed that HL, PL, and NL were not significantly affected by the season of first calving in Murrah and Egyptian buffalo, respectively.

Lifetime production traits:

The least squares means and their standard errors for lifetime production traits in the Egyptian buffalo are shown in Table 2. The overall LSM of LDIM was 1522.2±19.2 days. This mean is higher than the estimates obtained by Abdel–Baray *et al*. (2017), and Joshi *et al*. (2017) who found that the mean of LDIM was 1174 days and 993.14 days in Egyptian buffalo and Mehsana buffalo, respectively. The overall means of LMY and LDMY were estimated to be 12045.6±160.8 kg and 7.5±0.1 kg/day, respectively. The current mean of LMY is higher than those of Thiruvenkadan *et al*. (2015), Dev *et al*. (2016), Joshi *et al*. (2017), and Tamboli *et al.* (2023) who found that the mean of LMY was 5441.6 kg, 8607.93 kg, 6913.21 kg, and 10229.7 kg in Murrah, Mehsana, and in Nili-Ravi buffalo, respectively. Also, in previous studies in Egyptian buffalo, Abdel–Baray *et al*. (2017), and EL-Hedainy *et al*. (2020) mentioned that the mean of LMY was 10551 kg and 6905.04 kg, respectively. Tamboli *et al*. (2023) reported that LDMY was estimated to be 6.4 kg/day in Nili-Ravi buffalo.

CL was estimated to be 60.4±0.5%. The current estimate of CL is closer to the mean estimated by Joshi *et al*. (2017) in the Mehsana buffalo (63%). However, the estimation of CL was ranged between 80 and 90% in dairy cattle (De Vries and Marcondes, 2020, and Siriak *et al*., 2022). CL expresses the days in milk in the buffalo's productive life. The current lower estimate of CL compared to dairy cattle is attributed to the longer dry-off periods of Egyptian buffalo during their productive life which may extend to 210 days per lactation (Easa *et al*., 2022).

The overall mean of MY/HL was 3.0±0.03 kg/day. This value is higher than those of Thiruvenkadan *et al*. (2015), Dev *et al*. (2016), and Joshi *et al*. (2017) who reported that MY/HL was 1.41 kg/day, 2.55 kg/day, and 2.04 kg/day in Murrah, and Mehsana buffalo, respectively. However, higher means than our estimation for MY/HL were reported by Ahmad, (2004), and Kumar *et* al. (2007) in Nili-Ravi (3.5 kg/day), and Murrah buffalo (4.7 kg/day), respectively.

The LSM of MY/PL was 4.7±0.1 kg/day which is almost similar to the values obtained by Ahmad, (2004), and Joshi *et al*. (2017) who mentioned that the mean MY/PL was 4.07 and 4.33 kg/day, respectively, in various buffalo breeds. On the other side, the current value of MY/PL is lower than that of Dev *et al*. (2016), who found that the MY/PL was 5.59 kg/day in Murrah buffalo. However, Thiruvenkadan *et al*. (2015) noted that the MY/PL was 2.89 kg/day in Indian buffalo.

For LI, the overall mean was 39.1±0.4%. LI is an informative indicator for the buffalo's lifetime efficiency in dairy farms because it reflects the proportion of buffalo's herd life spent in producing milk and consequently accounts fully for the nonproductive periods of life (Brickell and Wathes, 2011). In this respect, Siriak *et al*. (2022) reported that the LI estimation was 57.9% in dairy cattle.

Tble 2. Least squares means (LSMs) and their standard errors (SEs) of factors affecting the lifetime production traits in the Egyptian buffalo

Classification	No.	LSM ± SE						
		LDIM (days)	LMY (kg)	LDMY (kg/day)	CL (%)	MY/HL (kg/day)	MY/PL (kg/day)	LI (%)
Overall mean	307	1522.2±19.2	12045.6±160.8	7.5±0.1	60.4±0.5	3.0±0.03	4.7±0.1	39.1±0.4
Herd		***	***	***	***	***	***	***
Kafr El-Sheikh	230	1405.7±17.3[b]	12033.5±144.6[b]	8.2±0.1[a]	45.1±0.4[c]	2.5±0.03[c]	3.7±0.4[c]	30.1±0.3[c]
Giza	39	1830.4±29.4[a]	13362.0±246.1[a]	6.8±0.1[c]	61.1±0.8[b]	2.9±0.1[b]	4.2±0.1[b]	41.4±0.6[b]
Alexandria	38	1330.5±33.1[b]	10741.3±275.8[c]	7.5±0.1[b]	75.1±0.9[a]	3.6±0.1[a]	6.1±0.1[a]	46.1±0.6[a]
Age at first calving (AFC, months)		**	***	***	**	***	***	***
< 36	137	1537.6±18.7[a]	11890.0±156.5[b]	7.3±0.1[c]	61.3±0.5[a]	3.1±0.03[a]	4.6±0.1[b]	42.1±0.4[a]
36-42	120	1481.2±21.1[b]	11529.8±175.3[b]	7.4±0.1[b]	59.9±0.5[ab]	2.9±0.04[b]	4.6±0.1[b]	38.7±0.4[b]
> 42	50	1548.0±39.1[ab]	12716.9±310.4[a]	8.0±0.1[a]	60.2±0.9[b]	2.9±0.1[b]	4.9±0.1[a]	36.7±0.7[c]
First lactation milk yield (FLMY, kg)		***	***	***	***	***	***	***
≤ 500	33	1386.7±33.2[b]	10462.3±278.1[c]	6.8±0.1[d]	55.8±0.9[c]	2.6±0.1[d]	4.1±0.1[d]	36.2±0.6[c]
501-1000	73	1542.3±25.9[a]	11847.2±216.6[b]	7.2±0.1[c]	60.1±0.7[b]	3.0±0.04[c]	4.5±0.1[c]	39.2±0.5[b]
1001-1500	107	1574.6±23.6[a]	12471.8±197.4[b]	7.6±0.1[b]	63.0±0.6[a]	3.1±0.04[b]	4.8±0.1[b]	40.6±0.4[a]
> 1500	94	1585.4±19.6[a]	13401.0±163.6[a]	8.4±0.1[a]	63.1±0.5[a]	3.4±0.03[a]	5.3±0.1[a]	40.6±0.4[a]
Period of first calving		***	***	***	***	***	***	***
1999-2002	16	2684.8±42.8[a]	21666.5±358.3[a]	8.2±0.1[a]	63.7±1.1[a]	4.0±0.1[a]	5.2±0.1[a]	48.1±0.8[a]
2003-2006	67	1787.0±23.8[b]	14660.5±198.9[b]	8.1±0.1[a]	56.4±0.6[c]	3.4±0.04[b]	4.6±0.1[b]	42.1±0.4[b]
2007-2011	136	1161.5±20.9[c]	8264.4±174.6[c]	7.1±0.1[b]	59.1±0.5[b]	2.7±0.03[c]	4.4±0.1[c]	37.8±0.4[c]
2012-2016	88	555.6±22.1[d]	3650.8±184.8[d]	6.7±0.1[c]	62.6±0.6[a]	2.1±0.03[d]	4.4±0.1[bc]	30.0±0.4[d]
Season of first calving		***	***	***	**	***	**NS**	***
Winter	58	1538.6±26.8[ad]	12017.5±224.1[b]	7.3±0.1[b]	62.0±0.7[a]	2.9±0.1[b]	4.6±0.1	39.7±0.5[a]
Spring	74	1591.4±25.2[a]	12623.0±211.1[a]	7.7±0.1[a]	60.3±0.6[ab]	3.1±0.04[a]	4.7±0.1	39.8±0.5[a]
Summer	90	1505.1±24.2[cd]	11927.1±202.3[b]	7.5±0.1[ab]	60.5±0.6[ab]	2.9±0.04[b]	4.7±0.1	39.0±0.5[ab]
Autumn	85	1454.0±22.8[bc]	11615.1±190.6[b]	7.6±0.1[a]	59.1±0.6[bc]	2.9±0.03[b]	4.6±0.1	38.0±0.4[bc]

Within each classification in the same column, means followed by different superscript letters differ significantly; ** (P<0.01); *** (P < 0.001); No.: Number of observations; NS: not significant; LDIM: Lifetime days in milk; LMY: Lifetime milk yield; LDMY: Lifetime daily milk yield; CL: Coefficient of lactation; MY/HL: Milk yield per day of herd life; MY/PL: Milk yield per day of productive life; and LI: Longevity index.

Environmental factors affecting lifetime production traits:

Effect of herd:

The effect of the herd showed a highly significant variation for all lifetime production traits in the Egyptian buffalo (P < 0.001) (Table 2). The highest LSMs estimates for CL, MY/HL, MY/PL, and LI were scored in the herd located in Alexandria Governorate with means of 75.1±0.9%, 3.6±0.1 kg/day, 6.1±0.1 kg/day, and 46.1±0.6%, respectively. The herd located in Giza Governorate was characterized by significantly higher estimates for LDIM and LMY with means of 1830.4±29.4 days and 13362.0±246.1 kg, respectively, whereas, LDMY was significantly higher in the herd of Kafr El-Sheikh Governorate with 8.2±0.1 kg/day. The significant effect of the herd on lifetime production traits was reported by Bashir *et al*. (2007) in Nili-Ravi buffalo.

Effect of age at first calving (AFC):

AFC affected significantly (P < 0.01 and P < 0.001) all the studied lifetime production traits in the Egyptian buffalo (Table 2). Buffalo calved at the age of > 42 months for the first time scored significantly the highest means of 12716.9±310.4 kg, 8.0±0.1 kg/day, and 4.9±0.1 kg/day for LMY, LDMY, and MY/PL, respectively. Also, this group of buffalo had a slightly higher estimate for LDIM (1548.0±39.1 days) compared to those calved at AFC < 36 months

(1537.6±18.7 days). On the other side, buffalo with an AFC < 36 months of age revealed more efficiency for lifetime production traits in terms of CL, MY/HL, and LI with means of 61.3±0.5%, 3.1±0.03 kg/day, 42.1±0.4%, respectively.

Contradictory to the advantages of early first calving, buffalo calving for the first time at the highest age category (> 42 months) had a better chance to achieve more appropriate growth and well-built body composition and conformation, in addition to having sufficiently developed udder at the time of first calving. This will allow for abundant metabolized energy to divert towards milk production and other biological body functions which guarantees an outstanding performance in the first and the subsequent lactations, and consequently enhances the lifetime production traits of buffalo having AFC of > 42 months.

Our results follow those of Tamboli *et al*. (2023) who found that Nili-Ravi buffalo with AFC of 42-48 months have significantly higher LDIM, LMY, LDMY, and MY/PL. Likewise, Thiruvenkadan *et al*. (2015) mentioned that buffalo calved at AFC >1700-1850 days had significantly higher LMY; however, AFC had a non-significant effect on MY/PL in Murrah buffalo. Also, Abdel–Baray *et al*. (2017) found that the AFC had a significant effect on LDIM; however, it had a non-significant effect on LMY in Egyptian buffalo. In contrast to our results, El-Awady *et al*. (2021) reported that buffalo calved at AFC ≤ 30 months had the highest lifetime production traits compared to buffalo that calved at AFC greater than 55 months in Egyptian buffalo. Dev *et al*. (2016) mentioned that AFC had a non-significant effect on lifetime production traits in Indian Murrah buffalo.

Effect of first lactation milk yield (FLMY):

FLMY affected significantly all lifetime production traits under study (P < 0.001; Table 2). In the opposite trend of longevity traits, the estimated means of lifetime production traits gradually increased as FLMY increased. The highest LSMs for lifetime production traits were the characteristics of buffalo produced >1500 kg in their first lactation with means of 1585.4±19.6 days, 13401.0±163.6 kg, 8.4±0.1 kg/day, 63.1±0.5%,3.4±0.03 kg/day, 5.3±0.1 kg/day, and 40.6±0.4% for LDIM, LMY, LDMY, CL, MY/HL, MY/PL, and LI, respectively. On the contrary, the lowest LSMs were scored by buffalo that yielded ≤500 kg as primiparous buffaloes. This result agrees with the findings in different dairy cattle breeds (Dinesh *et al*., 2014, Almasri *et al*., 2020, and Almasri *et al*., 2023). Hence, FLMY can be used as a key performance parameter for the early identification of primiparous buffalo with better potential for such traits.

Effect of period of first calving:

The effect of period of first calving was highly significant on all studied lifetime production traits (P < 0.001). As in longevity traits, the greater values for lifetime traits were recorded for buffalo calved for the first time in the period of years of calving between 1999 and 2002 compared to other periods. This result agrees with Abdel–Baray *et al*. (2017) who mentioned that the year of first calving had a significant effect on LMY, and LDIM in Egyptian buffalo. Likewise, Tamboli *et al*. (2023) observed that LMY, LDMY, LDIM, MY/HL, and MY/PL were significantly influenced by the period of first calving in Nili-Ravi buffalo.

Effect of season of first calving:

Season of the first calving significantly affected all studied lifetime production traits (P < 0.05 and P <0.001), whereas, MY/PL, was not significantly different (P = 0.244) across seasons of the first calving (Table 2). In agreement with our results, Tamboli *et al*. (2023) noted that the season of first calving had a non-significant effect on MY/PL; whereas, its effect was significant for LDIM in Nili-Ravi buffalo. The current results differ from the findings of Dev *et al*. (2016) and Tamboli *et al*. (2023) who found that the season of the first calving had no significant effect on LMY, LDMY, and MY/HL in Murrah and Nili-Ravi buffalo, respectively.

CONCLUSION

It can be concluded that the environmental factors that have been tested in this study must be considered when establishing management policy and should be adjusted occasionally to allow room for accurate prediction of the genetic values of the selected buffalo for tested traits based on their early performance. Despite the advantages of early AFC, the current results revealed a positive association between the increase in AFC with longevity and high lifetime production which necessitates testing thoroughly such relationship to depict the within herd optimal AFC that combines the beneficial features of buffalo since the longevity and lifetime production data become available only after culling the animal, while selection decisions are taken during the animal life. Therefore, because of this dilemma, FLMY seems to be a reliable indicator of the early prediction for the potential of the primiparous buffalo for longevity and lifetime productivity.

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تقييم صفات طول العمر والحياة الإنتاجية في الجاموس المصري

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أجريت هذه الدراسة بهدف تقدير صفات طول العمر والحياة الإنتاجية في الجاموس المصري، وتقييم تأثير العمر عند أول ولادة وإنتاج اللبن في الموسم الأول وعوامل بيئية أخري على هذه الصفات. تم إستخدام بيانات عدد ١٧٦٩ سجل لبن لعدد ٣٠٧ جاموسة تم جمعها من قواعد البيانات الموجودة في ثلاث قطعان في الفترة مابين ١٩٩٦-٢٠٢٢. تضمنت صفات طول العمر: طول الحياة داخل القطيع، الحياة الإنتاجية، دليل كفاءة الجاموس، وعدد المواسم، بينما تضمنت صفات طول الحياة الإنتاجية: عدد أيام الحليب طول الحياة، إنتاج اللبن طول الحياة، إنتاج اللبن اليومي طول الحياة، معامل الحليب، إنتاج اللبن لكل يوم من حياة الحيوان داخل القطيع، إنتاج اللبن لكل يوم من الحياة الإنتاجية، ودليل الحياة الإنتاجية.

كانت متوسطات صفات طول العمر ٣٨٩٨,٤±٣١,١ يوم، ٢٧٣٢,٨±٣٠,٨ يوم، ٦٥,٦±٠,٣٪، و٦,٩±٠,١ موسم للصفات طول الحياة داخل القطيع، الحياة الإنتاجية، دليل كفاءة الجاموس، وعدد المواسم بالترتيب. بينما كانت متوسطات صفات طول الحياة الإنتاجية ١٥٢٢,٢±١٩,٢ يوم، ١٢٠٤٥,٦±١٦٠,٨ كجم، ٧,٥±٠,١ كجم/ يوم، ٦٠,٤±٠,٥٪، ٣,٠±٠,٠٣ كجم/يوم، ٤,٧±٠,١ كجم/ يوم، و٣٩,١±٠,٤٪ للصفات عدد أيام الحليب طول الحياة، إنتاج اللبن طول الحياة، إنتاج اللبن اليومي طول الحياة، معامل الحليب، إنتاج اللبن لكل يوم من حياة الحيوان داخل القطيع، إنتاج اللبن لكل يوم من الحياة الإنتاجية، ودليل الحياة الإنتاجية بالترتيب.

كان تأثير القطيع، العمر عند أول ولادة، إنتاج اللبن في الموسم الأول، وفترة أول ولادة معنوياً (P < 0.05, P < 0.01, and P < 0.001) على جميع الصفات تحت الدراسة. كان تأثير موسم أول ولادة معنوياً على جميع الصفات ماعدا صفة إنتاج اللبن لكل يوم من الحياة الإنتاجية. نستنتج من الدراسة ضرورة الأخذ في الإعتبار العوامل البيئية المعنوية الموثرة على صفات طول العمر والحياة الإنتاجية في برامج الرعاية وتصحيحها لزيادة الدقة أثناء التقييم الوراثي للجاموس المصري لتلك الصفات.