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Assessment of Friesian Cattle Performance Sustainability Through the Evaluation of Phenotypic and Genetic Parameters and Trends of some Economic Traits Under Egyptian Conditions

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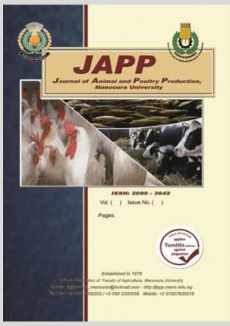

ABSTRACT

Total of 3380 records from 1635 Friesian cows kept in Sakha and El Karada farms between 1988 and 2020 were utilized to measure their sustainability in performance by estimating the genetic and phenotypic parameters and trends for 305-day milk yield (MY), calving interval (CI), and age at first calving (AFC) . Fixed effects are farm, year of calving – season, and animal parity. The VCE program was used to estimate variance components and genetic parameters. The MY, CI and AFC averages were 3280 kg, 15 mo and 32 mo and their heritability estimates were 0.20, 0.07 and 0.34, respectively. Genetic and phenotypic correlations among the traits ranged from 0.03 to 0.05 and from -0.04 to 0.04, respectively. The corresponding genetic (GT) and phenotypic trends for the studied traits showed deterioration in the overall rates and the ranges of breeding values were from -57 to +105 kg, -0.15 to + 0.25 mo and -0.35 to +0.30 mo for MY, CI and AFC, respectively. Strong intervention in selection and management powers may alter defects by using modern reproductive techniques in breeding programs for future generations. The farm's financial aspects were disturbed by delaying AFC or extending CI. The low CI produced more profit for the farm but prolonging it even for one day caused a financial loss. Also, as AFC expanded, MY increased, but overall farm profits decreased due to the high cost of rearing and replacements after AFC of 24 months.

Keywords: Genetic aspects and trends, sustainability, economic traits, farm profits, Friesian.

INTRODUCTION

Friesian cattle are the most widespread and highly productive exotic dairy breed that was introduced to Egypt. It is ranked as the most important source of milk. Moreover, this breed adepts well at sustainable high levels of performance under various management systems and harsh conditions due to its high adaptability to local environments in Egypt (Amr, 2013). Therefore, the breed should be evaluated regularly to predict the future genetic control of its performance along with its genetic and phenotypic trends for economically important traits. On top of the list, milk production received the most apparent improvement among all production traits because historically, it acquired high attention in the selection indexes and producers were primarily paid for increased production (Guinan *et al*., 2023).

The estimates of genetic parameters for a given group of traits determine the method of selection to be used for predicting the direct and correlated responses, choosing the breeding system to be adopted for future improvement and the expected genetic gains (Missanjo *et al*., 2013; Goshu *et al*., 2014). Knowing the values of genetic parameters, genetic trends, and inbreeding depression is essential, as it helps to justify the decision-making process for the adopted selection procedure, management plans, and nutritional requirements necessary to improve the productive efficiency of cows (Caivio-Nasner *et al*., 2021).

Moreover, genetic and phenotypic correlations between traits are useful to formulate the breeding programs, since they determine the direction and magnitude of genetic improvement in other traits when selection is directed to the trait of concern (Tesfa, 2015). Keeping track of the amplitude progress of any genetic improvement program is very important for optimizing the genetic gain and, consequently farm profitability (Canaza-Cayo *et al*., 2016) and helps to judge the quality of the breeding programs implemented in the herd (Grosu *et al*.,2014; El-Awady *et al*.,2017).

Samaraweera *et al*. (2022) revealed that the genetic improvements in the set of milk yield, age at first calving, calving interval, number of services per conception, and resistance to mastitis traits have a positive impact on the profitability of dairy farms. The derived economic values of these traits are adequate enough to define the relative importance of the breeding objective for each trait and use them as economic weights in a selection index of genetic improvement programs to achieve progress in dairy cattle. Meyer *et al*. (2004) concluded that optimal AFC promotes the reduction of breeding costs and the extension of the herd life of dairy cows. Also, Vargas-Leitón *et al*. (2023) stated that the reduction in AFC contributes to a significant increase in the production and reproduction efficiency of pasture-based dairy herds.

The objectives of the current study were to assess the sustainability of Friesian cattle by estimating their genetic and phenotypic parameters and trends over time for some economic traits. Also, the impact of extended lactations on farm economy and profitability was studied.

MATERIALS AND METHODS

Data and management

A total of 3380 records from 1635 multiparous Friesian cow's daughters of 132 sires were collected

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between 1988 and 2020. Cows were kept in Sakha and El-Karada experimental stations belonging to the Animal Production Research Institute, Agriculture Research Center, Ministry of Agriculture and Land Reclamation.

Animals were grazed on berseem (Egyptian clover: *Trifolium alexandrinum*) from December to May, and fed on a concentrate mixture and rice straw mixed with a limited amount of hay (if available) during the rest of the year. Cows producing more than 10 kg of milk per day and those in the last two months of pregnancy were supplemented with an extra concentrate ration. Artificial insemination with frozen semen was routinely practiced on the two farms. Sires having fewer than five daughters were excluded from the data. Cows were machine- milked twice a day. The studied traits were: 305-day milk yield (MY), age at the first calving (AFC) and calving interval (CI). Table 1 presents a summary of the data description.

Table1. Description of the data set for the studied traits

Traits	No. of records	Mean	SD	Min.	Max.
MY(kg)	3380	3297.5	1163.6	1053	7808
CI (mo)	3380	15.0	3.3	11	29
AFC (mo)	3380	31.6	3.3	26	39

MY= 305-day milk yield; CI= calving interval; AFC= age at first calving; SD =standard deviation

Statistical analysis

Data were statistically analyzed using the REML procedure to estimate (co)variance components by the VCE6 program (Groeneveld *et al.*, 2010) using the repeatability animal model. The studied fixed effects were farm, year of calving- season, and animal parity. The applied model was as follows:

$$Y_{ijklmn} = \mu + F_i + R_j + S_k + P_l + pe_n + a_m + e_{ijklmn} \qquad (1)$$

Where,

Y_{ijklmn} = the individual observation on each of the studied traits,
μ =the overall mean,
F_i = the fixed effect of the i^{th} farm (i= 1 or 2),
R_j = the fixed effect of the j^{th} year of calving season (j = 1 to 32),
S_k= the fixed effect of k^{th} season of calving (k = 1 (cold) or 2 (hot)),
P_l =the fixed effect of l^{th} parity (l= 1 to 9),
pe_n= random permanent environmental effect on the animal and
a_m= random additive genetic effect
e_{ijlkmn}= error as a random effect.

It was assumed that the covariance between additive, permanent environmental and residual effects was zero. Multivariate estimated breeding values (EBV) were estimated by the PEST program (Groeneveld *et al.*, 2010) by fitting an animal model and using genetic parameters obtained as described below. In matrix notation, the general model for genetic analysis can be expressed as:

$$Y = X_b + Za_a + Zpe_{pe} + e \qquad (2)$$

Where:

Y is the vector of observations,
b = a vector of fixed effects
a = a vector related to animal additive genetic effects
pe = a vector of permanent environmental effects
e = a vector of residuals.

X, Za and Zpe are incidence matrices that relate the fixed effects, animal additive genetic effects and permanent environmental effects to the vector of observations, respectively. Genetic (r_G) and phenotypic (r_p) correlations among the studied traits were calculated.

The genetic trend (GT) was estimated as the linear regression of the yearly means of EBV on years of birth for all traits. The phenotypic trend (PT) was estimated by regressing the yearly means of phenotypic values on years of birth using the SAS program (SAS, 2011). The expectations and variances of the model are presented in equation 2.

$$\begin{pmatrix} a \\ P_e \\ e \end{pmatrix} \sim N(0,V) \quad where, \qquad V = Var\begin{pmatrix} a \\ P_e \\ e \end{pmatrix} = \begin{pmatrix} G\otimes A & 0 & 0 \\ 0 & I\sigma^2_{Pe} & 0 \\ 0 & 0 & R \end{pmatrix}$$

$$\begin{pmatrix} a \\ P_e \\ e \end{pmatrix} \sim N(0,V) \quad where, \qquad V = Var\begin{pmatrix} a \\ P_e \\ e \end{pmatrix} = \begin{pmatrix} G\otimes A & 0 & 0 \\ 0 & I\sigma^2_{Pe} & 0 \\ 0 & 0 & R \end{pmatrix}$$

$$v = \begin{pmatrix} X`R^{-1}X & X`R^{-1}Z & X`R^{-1}W \\ Z`R^{-1}X & Z`R^{-1}Z + G^{-1}\otimes A^{-1} & Z`R^{-1}W \\ W`R^{-1}X & W`R^{-1}Z & W`R^{-1}W + I\otimes Pe^{-1} \end{pmatrix} \begin{pmatrix} \hat{b} \\ \hat{a} \\ \hat{p}_e \end{pmatrix} = \begin{pmatrix} X`R^{-1}Y \\ Z`R^{-1}Y \\ W`R^{-1}Y \end{pmatrix}$$

$$h^2 = \frac{\sigma^2{}_{gi}}{\sigma^2{}_{gi} + \sigma^2{}_{pei} + \sigma^2{}_{ei}}$$

$$E\begin{bmatrix} Y \\ u \\ pe \\ e \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \qquad Var\begin{bmatrix} u \\ pe \\ e \end{bmatrix} = \begin{pmatrix} A\sigma_u^2 & 0 & 0 \\ 0 & I_c\sigma^2{}_{pe} & 0 \\ 0 & 0 & I_n\sigma_e^2 \end{pmatrix}$$

$$\begin{pmatrix} X'X & X'Z & X'W \\ Z'X & Z'Z + A^{-1}\sigma^2_e/\sigma^2_u & Z'W \\ W'X & W'Z & W'W + I_c\sigma^2_e/\sigma^2_{pe} \end{pmatrix} \begin{bmatrix} \hat{\beta} \\ \hat{u} \\ \hat{p} \end{bmatrix} = \begin{bmatrix} X'Y \\ Z'Y \\ W'Y \end{bmatrix}$$

The General Linear Model (GLM) procedure (SAS program) was used to estimate least squares means for the 305- day milk yield under many classes of AFC and CIs. Relationships between MY and each of AFC or CI traits as classes were estimated by the model:

$$Y = \mu + F_i + P_j + S_k + AFC_l + CI_m + e_{ijklmn} \qquad (3)$$

Where,

Y_{ijklmn} = the individual observation of the 305-day milk yield trait (kg),
μ = the overall mean of MY,
F_i = the fixed effect of i^{th} farm (i = 1 or 2),
P_j = the fixed effect of parity (j = 1 to 9),
S_k = the fixed effect of the k^{th} season of calving (k = 1 (cold) or 2 (hot),
AFC_l = the fixed effect of the l^{th} age at the first calving classes (l = 1 to 15),
CI_m = the fixed effect of the m^{th} calving interval classes (m = 1 to 27),
e_{ijklmn} = error as a random effect.

RESULTS AND DISCUSSION

Means and standard deviations

Table 1 shows that, the least square mean (LSM) of MY (3297.5 kg ± 1163.6 kg) was higher than those of 2632, 3103 and 2939 kg reported by El–Awady *et al.* (2017), Abdelharith and Genena (2017) and Sanad *et al.* (2020), respectively, but lower than 7387.70 and 4646 kg estimated by Kamal El-Den *et al.* (2020) and Abou saque *et al.* (2021), respectively. The differences among the averages of milk production in different studies may be attributed to the diverted genetic potentiality and/or management practices in different herds, in addition to the subtle variability of environmental conditions.

The LSM of CI (15 ±3.3 months) was within the range of 12-15 months stated by El–Awady *et al.* (2017), Hermiz and Hadad (2020), Farrag *et al.* (2020), Sanad *et al.* (2020), Habib *et al.* (2020) and Refaey *et al. (*2022), but shorter than 15.7 mo interval obtained by Farrag *et al.* (2017).

Regarding AFC, the current LSM (31.6 ±3.3 mo) was higher than that of 27 mo reported by Hermiz and Hadad (2020) and Farrag *et al*. (2020), but was close to 30.6 mo interval as obtained by Faid-Allah (2015).

Heritability estimates

Table 2 displays the estimates of genetic variance ($\sigma^2{}_a$); permanent environmental variance ($\sigma^2{}_{pe}$**)**; phenotypic variance **(**$\sigma^2{}_p$) ; residual variance ($\sigma^2{}_e$) and heritability estimates (h^2) for the studied traits.

Table 2. Variance components, heritability estimates ±SE for the studied traits

Traits	σ^2_a	σ^2_{pe}	σ^2_e	σ^2_p	h^2 (SE)
MY	270774.7	310613.1	0.7567	1338087.9	0.20 (0.002)
CI	1.3	1.0	15.85	18.15	0.07 (0.001)
AFC	4.1	-	7.9	12.0	0.34 (0.002)

MY = 305-day milk yield; CI =calving interval; AFC = age at first calving; σ^2a = additive genetic variance; σ^2pe = permanent environmental effect; σ^2e = residual variance; σ^2_P = phenotype variance; h^2 = heritability; SE = standard error.

The h^2 estimate of MY (0.20 ± 0.002) was similar to that of 0.19 obtained by Arango and Echeverri (2014), lower than the range of 0.24 to 0.33 found by Rashad (2013), El–Awady *et al.* (2017), Öztürk *et al.* (2021) and Shalan *et al.* (2022), and higher than the range of 0.14 - 0.18 stated by Faid Allah (2015), Vasquez *et al.* (2021) and Pangmao *et al.* (2022). The current low h^2 estimate of MY relative to some of those reported above may indicate a small additive genetic variance and/or high residual variance, which suggests that this trait was highly affected by some environmental factors such as farm, feed, management and climatic changes. Moreover, the size and structure of different data sets and the analytical model utilized may influence the estimates.

The h^2 estimate of CI was low (0.07 ± 0. 0.001) close to estimates of 0.04 as obtained by Sigurdsson and Jonmundsson, (2011), Abdel-Hamid *et al.* (2017), Zahed *et al.* (2019) ,Lopez *et al.* (2019) , Þ´orarinsd´ottir *et al.* (2021) and Refaey *et al.* (2022) , and lower than the range of 0.11 - 0.29 as stated by Hammoud *et al.* (2014), Ayalew *et al.* (2017), El–Awady *et al.* (2017), Öztürk *et al.* (2021) and Shalan *et al.* (2022).

The h^2 estimate of AFC (0.34±0.002) was higher than the range from 0.11 to 0.27 reported by Buaban *et al.* (2015), Zahed *et al.* (2020) and Stefani *et al.* (2021), and lower than a range from 0.36 to 0.47 as obtained by Ayied *et al.* (2011), Abdel-Hamid *et al.* (2017) and Ayalew *et al.* (2017).

Genetic correlations (r_G):

The r_G estimate between MY and CI (0.05) was close to an estimate of 0.01 (Table 3) as reported by Shalan *et al.* (2022), and lower than 0.28 and 0.17 (El-Awady *et al.*, 2017 and Sagwa *et al.*, 2019, respectively) and a range from 0.35 to 0.75 as revealed by Eaglen *et al.* (2013), Hammoud *et al.* (2014), Abdel-Hamid *et al.* (2017) and Habib *et al.* (2020).

Table 3. Genetic (SE) (above diagonal) and phenotypic (below the diagonal) correlations among the studied traits .

Traits	MY	CI	AFC
MY		0.05 (0.007)	0.04 (0.004)
CI	-0.04		0.03 (0.004)
AFC	0.04	0.01	

MY: 305-day milk yield; CI: calving interval; AFC: age at first calving

Also, the r_G of AFC with MY estimated 0.04 being lower than 0.20 as recorded by Sagwa *et al.* (2019), but was close to a range from 0.01 to -0.18 obtained by Faid-Allah (2015), Brito *et al.* (2020) and Stefani *et al.* (2021) . Concurrent results were confirmed with those of Shalan *et al.* (2022), who revealed that increasing MY is not associated with deteriorated CI or AFC, and the selection for it seems to have no merit for genetically improving reproductive performance.

The present rG estimate between AFC and CI (0.03) was within a range from -0.06 to 0.08 reported by Do et al. (2013) for the first and second CI with AFC, but lower than 0.11 obtained by Abu El Naser et al. (2019). However, Kelleher et al. (2016) and Ebrahim (2018) revealed negative rG estimates of -0.12 and -0.40, respectively, between CL and AFC.

Phenotypic correlations (r_P)

As presented in Table 3, the r_p between MY and CI (-0.04) was similar to the values of -0.04 and -0.01 reported by Zahed *et al*. (2019) and Shalan *et al*. (2022), respectively, but lower than a range from 0.06 to 0.29 as obtained by Hammoud *et al.* (2014), El–Awady *et al.* (2017), Sagwa *et al.* (2019) and Habib *et al.* (2020).

The r_p estimate between MY and AFC was 0.04 compared to 0.16 and -0.21 obtained by Salem and Hammoud (2016a) and Sagwa *et al.* (2019), respectively, and within a range of -0.05 to 0.08 as estimated by Brito *et al.*(2020) and Stefani *et al.* (2021) .

Also, CI showed a low rp estimate with AFC (0.01) which was in accordance with the results of 0.09 and 0.04 as reported by Abu El Naser et al. (2019) and Farrag et al. (2020), and close to -0.02 as revealed by Kelleher et al. (2016).

Genetic (GT) and phenotypic (PT) trends for the studied traits

Figures 1-6 present GT and PT for each studied trait over the years of study (1988-2020). The GT was estimated by regressing the yearly average of EBV for each trait over the same period, while the PT was estimated by regressing the yearly phenotypic averages of each trait over the same years.

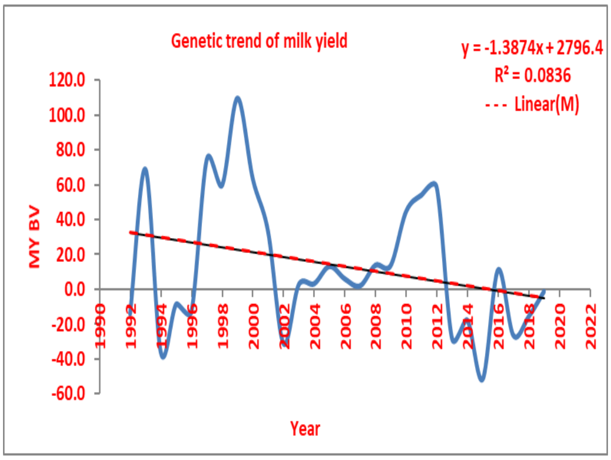

Fig.1. Genetic changes in 305-day milk yield (MY) in years (1990-2020)

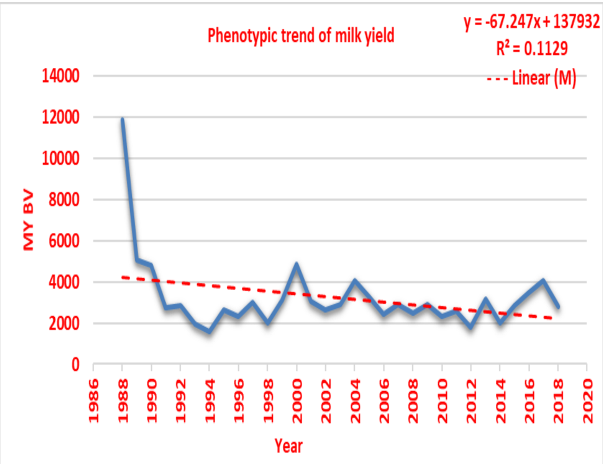

Fig. 2 . Phenotypic changes in 305-day milk yield in years (1990-2020).

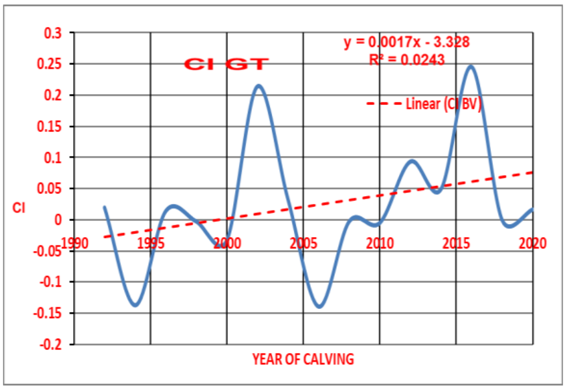

Fig. 3. Genetic changes in calving intervals in years (1990-2020).

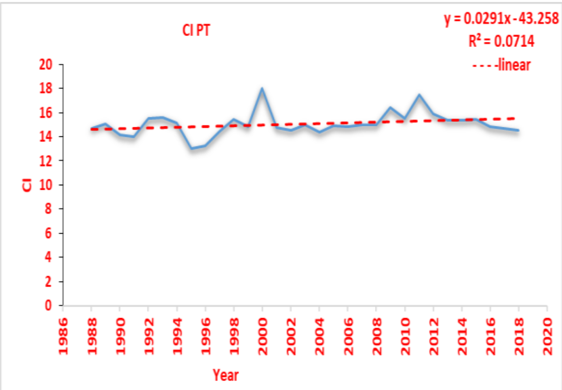

Fig. 4. Phenotypic changes of calving interval in years (1990-2020).

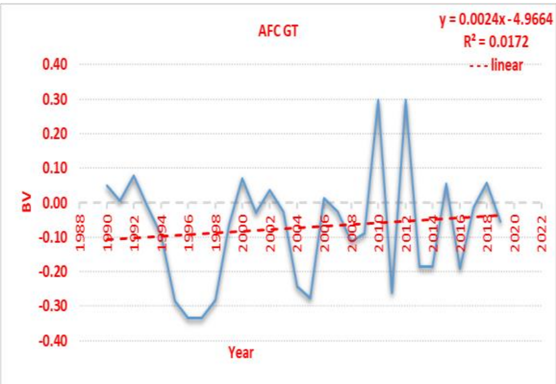

Fig.5. Genetic changes of age at first calving in years (1990-2020) Phenotypic trend of age at first calving

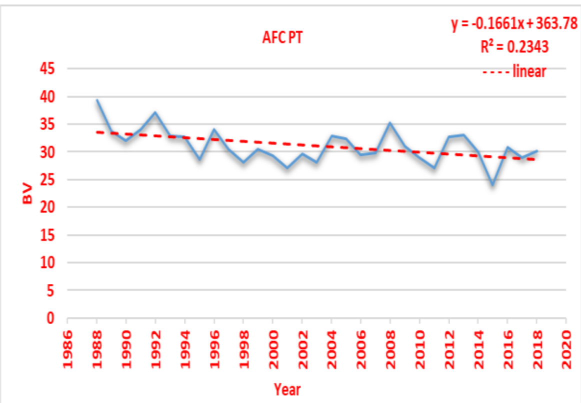

Fig. 6. Phenotypic changes of age at first calving through (1990-2020).

Genetic trend of milk yield

Estimates of GT of MY increased positively throughout the periods 1992-1994, 1996-2000 and showed a gradual increase up to 2012,then showed irregular and fluctuated decreased up to 2020. This trend indicated that the applied selection criterion wasn't satisfactory for improving the trait overtime.

The current range of EBVs for MY (-57 to 105 kg) was shorter than the ranges -1698.0 to 1337.8 kg/year in Frisian and -2598 to 1709 kg/year in Holstein cows as reported by Salem and Hammoud (2016b) and Abdel-Hamid *et al.* (2017), respectively.

The present GT for MY in the years of study, being -1.39 kg/year was close to − 2.46 kg/year (Şahin *et al.*,2012;Vasquez *et al.*,2021) and is in agreement with the results of Effa *et al.* (2011) and Shalan *et al.* (2022), who revealed that a negative GT of milk production traits occurred under the tropical conditions. However, Hossein-Zadeh (2011), Chegini *et al.* (2013), Haiduck *et al.* (2019) and Abou Saq and Ben Naser (2021) reported significant ($p<0.0001$) positive estimates of GT, ranging from +4.15 to +21 kg/year for MY which probably as a result of selecting bulls with high genetic value.

According to Araújo *et al.* (2003), an explanation for the variation in GT estimates is the disorganized flow of genetic stimuli, that is, each breeder adopts his own selection objectives independent from the others. Similarly, the selection objectives in the current study have varied through the years due to the utilization of frozen semen from different sources and years. However, Pangmao *et al.* (2022) claimed that some factors might impact the expected genetic gain to accelerate or slow down improvement in milk production such as financial support, inconsistent management and feeding practices .Moreover, the restrictions of selection, semen used with an ineffective breeding plan and involuntary culling due to health problems in high producing cows may impact the genetic progress. Thus, investigating the previous issues under research farm management conditions and developing a long-term breeding strategy can enhance the performance status of these herds.

Phenotypic trend of milk yield

The PT of MY was -67.2 kg/year (R^2 = 0.11) throughout the period of study. The highest MY was obtained in the first two years of the study, but descended rapidly thereafter, showing irregular fluctuations, and increased slightly from 2012 until the end of the experiment. Similarly, Abou-Bakr (2009) reported a significant ($P< 0.02$) negative PT for MY (-91.6 ± 35.16 kg/ year) in Holstein cattle.

The relatively high MY in the first 2 years was associated with general conditions more convenient to good productivity in the herd, including breeding plans and good environments. However, in general, the diminished MY could be attributed to the involuntary culling of high- milking cows, a lack of long-term improvement plans, bad management systems and nutrition, and an unfavourable climate. The negative PT was in accordance with the results of Katok and Yanar (2012), who revealed that the decrease in MY was due to adverse environmental factors, the presence of diseases, insufficient feeding, and harsh climatic situations.

On the other hand, Abou Saq and Ben Naser (2021) obtained a large positive ($p<0.0001$) PT of + 65.71 kg/ year presenting phenotypic values between 915 and 13845.6 kg/year in Friesian cattle. Also, Dash *et al*. (2016), Konkruea *et al*. (2017) and Vasquez *et al*. (2021) obtained positive trends of +18.71, 21.3 and 294.3 kg/year, respectively, for the milk of Holstein cows and suggested that yield improvement is a result of the applied selection policy emphasizing exclusively the production trait and improvements in management . According to M'hamdi *et al.* (2012), changes in herd size, age of cows, and management practices introduced from one year to another could be responsible for variation in milk production.

Genetic trend of calving interval

The GT for CI in the current study (Fig.3) ranged between -0.15 and +0.25 month/year, but showed considerable positive and negative irregular fluctuations throughout the experimental period. These trend revealed an increase in CI by advancing time, ascending from 1994-1996; 2001-2005 and 2011 -2017 with a slope towards the end of the studied years which, indicated a deteriorated genetic change in CI overall the years of the current study.

The current range of BVs for CI was shorter than the ranges from -8.14 to 11.91, -5.72 to 10.60 and -5.92 to 10.6 days obtained by Ayied *et al.* (2011), El-Awady *et al.* (2017) and Abdel-Hamid *et al*. (2017), respectively. However, the slight positive improvement in GT was close to the values of 0.03, 0.06, 1.34 and 0.82 d/yr, as reported by Abdelharith (2008), Ibrahim *et al*. (2009), Ramatsoma *et al*. *(*2014) and Zahed *et al*. (2019), respectively.

Conversely, Atil and Khattab (2005), Rahbar *et al*. (2016) and Ghiasi and Honarvar (2016) estimated a favourable negative GT between -0.01 and -0.95 d/yr for CI. Such unfavorable positive GT could be attributed to inaccurate culling procedures, increasing selection pressure or a possible increase in the percentage of inbreeding. Haile-Mariam *et al.* (2014) stated that a 1% increase in inbreeding in the herd was associated with a prolongation of $+0.22 \pm 0.17$ days in Cl, suggesting that applying inbreeding control programs to Friesian cattle was essential for keeping their genetic resources.

Since the h^2 estimate of this trait is low, it could be more preferable to issue strict management instructions to perform the right technical operations in the herd instead of applying insufficient selection programs to reduce CI (Öztürk *et al.*, 2021). However, genomic selection could help in practicing improvement in low- h^2 traits like fertility and reproduction (Berry *et al*., 2014).

Phenotypic trend of calving interval

As presented in Fig. 4, the PT of CI ranged from 12 to 18 months during the period of this study, showed slight positive fluctuations due to selection pressure for reproductive efficiency and variations in PT among years probably revealing management alterations and feed accessibility (M'hamdi *et al*., 2012) and extensive use of supported technologies during the latest years.

The current positive PT for CI (0.03 mo/yr) was confirmed with the value of 0.82 d/yr reported by Zahed *et al*. (2019), while, Abdelharith (2008), Ibrahim *et al*. (2009) and Rahbar *et al*. (2016) obtained negative PTs of -0.48 , -0.09 and -2.54 d/yr, respectively. Moreover, El-Awady *et al*. (2017) reported PT for CI between -22.47 and 43.44 d/yr.

Genetic trend of age at first calving

As presented in Fig. 5, the GT of AFC ranged from -0.35 to +0.30 mo/yr and was shorter than the ranges of -2.10 to 2.3 and -5.75 to 5.09 mo/yr reported by Ayied *et al.* (2011) and Abdel-Hamid *et al.* (2017), respectively , showing below- zero fluctuations between 1992 and 2008; then fluctuated irregularly positive or negative until 2019. The regression coefficient of AFC average BVs per year on years of study was close to zero (0.0024 mo/yr), indicating a lack of trend, and close to the values of 0.020 and -0.002 mo/yr, as stated by Abdel-Hamid *et al.* (2017) and Zahed *et al*.(2020), respectively.

The PT of AFC (Fig. 6) ranged between 24 and 40 months, showing gradually a fluctuated decrease with a slight descending slope throughout the years of study. A desirable decrease of -0.17 mo/yr in AFC was obtained. This might be due to favourable farm environmental conditions and to making the right decisions to breed heifers as soon as being ready for first mating. The descending PT reveals early maturity of calves by time due to enhanced rearing and feeding conditions, offering enough feed requirements with high quality to the growing heifers, preceded by good suckling systems that accelerate the attainment of puberty and consequently reduce AFC (Shortle, 2014).

The moderately high h^2 estimate of AFC suggested that it could be advisable to practice genetic improvement by selection. However, being associated with reproductive efficiency traits, reducing AFC might inversely affect MY because of the negative correlation between MY and fertility (Kgari *et al.* 2023).Yet, the regression of the yearly mean of AFC on years of study was generally small (-0.17 mo/yr), but higher than the regression of 0.02 mo/yr, as obtained by Zahed *et al*. (2020).

The impact of extended AFC on the herd milk production

Fig. 7 showed that the highest MY (3808 kg) was obtained from cows calving for the first time at the age of 32 months, while those calving at 24 mo produced the lowest MY (3244kg). Moreover, the early first calving below 24 mo of age may cause the heifers to suffer from a frequent incidence of dystocia. However, the rearing costs for each extra month /heifer calving above 24 mo of age were about 2484 LE. In addition, the costs of producing one kg of milk increased by increasing AFC (Table 4). Low production costs per kg of milk were obtained from heifers having an AFC of < 25 mo/yr, but those costs increased sharply from heifers calving for the first time at older ages.

On the contrary, Almasri *et al*. (2020), Ilhan *et al*. (2022) and Vargas-Leitón *et al.* (2023) claimed that the optimum AFC to achieve the maximum lifetime milk yield, productive life, and lactation number was below 26 months relative to those calving above this age. According to Atashi *et al*. (2021), decreasing AFC below 27 months had no effect on subsequent CI, but maximizing or diminishing it induced a multiplied risk of dystocia, which showed r_G values of 0.30 with AFC (Stefani *et al.*,2021). Also, calves birth weights increased curvelinearly with increasing AFC (Kamal *et al*., 2014).

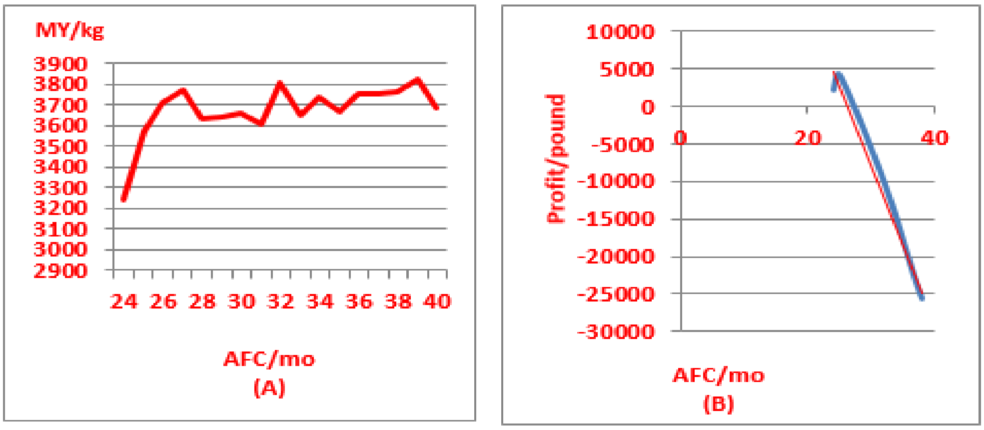

Fig.7. Milk yield (A) and gains (L.E. /cow) (B) with different categories of AFC

Table 4 .The total costs (L.E.) /per head and per 1kg milk /cow with different categories of AFC.

AFC(mo)	MY(kg)	Total cost (L.E./head)	Cost (L.E.)/1kg milk
24	3244	51683	15.9
25	3570	54167	15.2
32	3808	71555	18.8
37	3750	83975	22.4
38	3764	86459	23.0

The impact of length of CI on milk yield

The average daily milk yield decreased with the prolongation of CI, causing an obvious increase in the costs of producing each kg of milk and a consequent decrease in the dairy farm's net income from the sale of milk (Fig. 8, Table 5). In contrary, Samaraweera *et al.* (2022) revealed that prolonging the CI of lactating cows permits lactations to extend, but the low daily milk yield diminishes the annual income for MY, and therefore, selection for short CIs benefits dairy farms. Moreover, Zahed *et al.* (2019) reported that reducing CI is more profitable for the farms, but expanding it even for one extra day will cause financial loss, while reducing it between 7 and 23 days will increase the annual gross margin per cow (Bekara *et al.*, 2017).

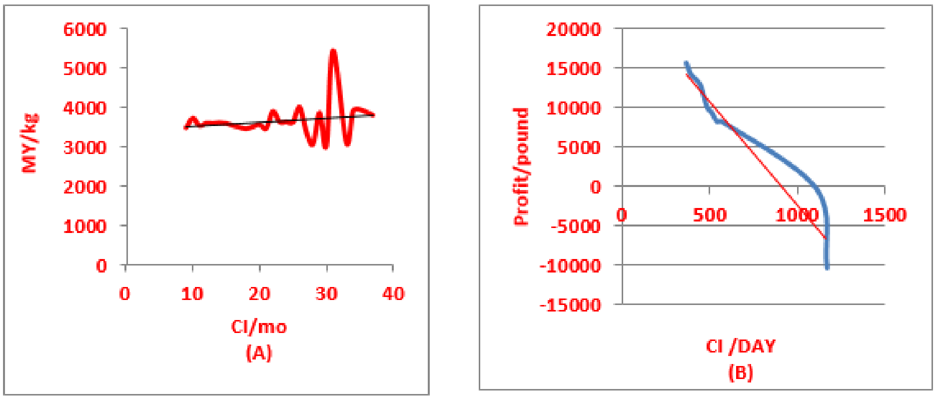

Fig. 8. Milk yield (A) and gains (L.E. /cow) (B) with different CI categories.

Table 5. The total cost and final profits (L.E.) of milk production /cow with different categories of CI.

CI /days	TMY /kg	Daily MY	Total cost/L.E.	Cost (L.E.)/ Kg MY	Final Profit (L.E.)
365	3593	11.78	37725	9.15	15637
390	3586	10.87	39047	9.54	14212
425	3602	9.87	40002	9.76	13460
450	3578	9.18	40632	10	12534
480	3530	8.41	42346	10.62	10172
510	3487	7.75	42601	10.83	9313
540	3449	7.19	43223	11.13	8201
570	3501	6.87	43754	11.14	8189
1105	3795	3.6	56334	13.57	-271
1165	3968	2.69	55128	16.95	-10277

Also, Dono *et al.* (2013) reported that the highest profitability was achieved when reducing CI, which presented the best performance model and economic feeding efficiency. The longest CI, however, was associated with 8.58 % calves loss ($P<0.05$) and the economic advantage of reducing CI by culling non-pregnant cows was balanced by the costs combined with boosted herd income. Kvapilík *et al.* (2015) and Němečková *et al.*(2015) reported that a long CI above the optimal length of 400 d decreased the average daily milk yield and led to a smaller number of calves per lifetime without a positive economic impact on the herd. Also, Krpálková *et al.* (2017) reported that herds with a low CI below 389 d caused low cow depreciation costs and high total costs per kg of milk. However, Shalloo *et al.* (2014) claimed that the expansion of CI was more profitable than shortening it.

On the other hand, most investigators revealed that 12 months CI was generally considered optimal for dairy cows from an economic point of view (Steeneveld and Hogeveen, 2012; Kok *et al.*, 2019; Burgers *et al.*, 2022). Although, recently, some dairy farmers have been deliberately extending the voluntary waiting period for insemination, which extends the CI (Lehmann *et al.*, 2017; Burgers *et al.*, 2021). Burgers *et al.* (2022) stated that extended CI through expanding the voluntary waiting period for insemination for 50 days or 6 weeks was more strongly associated with a greater maximum yearly yield of cows ,which means higher yearly revenues, costs, and net partial cash flow.

CONCLUSION

Estimating the genetic and phenotypic trends for MY, CI and AFC demonstrated very short ranges for the breeding values, which reflected low genetic diversity among cows for the studied traits and indicated deterioration in the overall rate of genetic progress. There is an urgent need for improving breeding strategies and applying selection based on reliable measures of breeding value for the studied traits. Also, ensuring the absence of inbreeding and accurate future performance recording can offer a great opportunity to maximize productivity. Moreover, the declining phenotypic values of the studied traits over time require strict management decisions to be taken at an early age to ensure optimal performance in order to achieve more profit per year.

Strong intervention of selection and management powers can alter defects and shorten generation intervals using modern reproductive technologies in breeding programs in a connection between the fields of animal research authorities. Such coordination achieves high potential for the sustainably continuous genetic development of this breed under the local conditions for future generations. At that time, the dairy industry will then benefit from the new developments to enlarge the herds profits. However, the ambiguity of the overlap between MY and CI and/or AFC suggests further cost- benefit analysis to increase the economic efficiency of dairy farms.

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تقييم استدامه أداء ماشية الفريزيان من خلال تقدير المعالم المظهرية والوراثية و اتجاهاتها لبعض الصفات الاقتصاديه تحت الظروف المصرية

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الملخص

استخدم ٣٣٨٠ سجلاً لعدد ١٦٣٥ بقرة فريزيان من مزرعتي سخا والقرضا لقياس مدى استدامتها في الأداء الانتاجي بين عامي ١٩٨٨ و٢٠٢٠ من خلال تقدير المعالم والاتجاهات الوراثية والمظهرية لصفات: إنتاج الحليب ل ٣٠٥ يوم كصفة إنتاجية والفترة بين ولادتين والعمر عند أول ولادة كصفات تناسليه. كانت التأثيرات الثابتة هي المزرعة والسنة وموسم الولادة وعدد المواسم وقد أستخدم برنامج VCE لتقدير مكونات التباين والمعالم الوراثية و برنامج Best لتقدير القيم التربوية. كانت أقل متوسطات للمربعات لمحصول اللبن في ٣٠٥ يوم والفترة بين ولادتين والعمر عند أول ولادة ٣٢٨٠ كجم و١٥ و٣٢ شهرًا على التوالي وكانت تقديرات المكافيء الوراثي ٠,٢٠ و٠,٠٧ و٠,٣٤ للصفات السابقة علي الترتيب. وتراوحت قيم الارتباطات الوراثية و المظهريه بين الصفات المدروسة من ٠,٠٣ إلى ٠,٠٥. ومن - ٠,٠٤ إلى ٠,٠٤ على التوالي. أظهرتقدير معدل الاتجاهات الوراثية والمظهرية للصفات المدروسة تدهورا واضحا مع تقدم سنوات الدراسة حيث تراوحت القيم التربوية للصفات المدروسة من -٥٧ إلى +١٠٥ كج، -٠,١٥ إلى +٠,٢٥ شهر، -٠,٣٥ إلى. +٠,٣٠ شهرًا للصفات السابقة علي الترتيب . يمكن تحقيق أفضل تقدم وراثي للحفاظ على استدامة أداء هذه السلالة من خلال التداخل القوي بين الانتخاب وعوامل الادارة والرعاية في القطيع وتطبيق أستخدام تقنيات التكاثر الحديثة في برامج التربية للأجيال القادمة. وقد ظهر زيادة لمحصول اللبن بتمديد كل من الفترة بين ولادتين والعمر عند أول ولادة. ولكن إطالة الاولي حتي و ليوم واحد وكذلك الثانيه أحدثت زيادة في مصاريف الانتاج للمزرعة لارتفاع تكلفة تربية البدائل لعمر أكبر من ٢٤ شهرًا عند أول ولادة (٢٤٨٤ جنيهًا لكل شهر إضافي) لكل عجله في القطعان المدروسة.