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Evaluation of some genetic and non-genetic factors influencing 305-days in milk, total milk yield and breeding values in Holstein Friesian cows

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ABSTRACT

Productive and reproductive records of 1509 Holstein Friesian were collected from private farm to study the influence of genetic (heritability (h^2), phenotypic correlation ($r\ P$), genetic correlation ($r\ G$), and estimated breeding value (EBV)) and environmental factors such as days in milk (DIM), dry period (DP), calving interval (CI), parity, season of calving, days open (DO) and age at first calving (AFC) on 305-day milk yield (305-DMY) and total milk yield (TMY). This study recorded highly significant ($P \leq 0.01$) effect of all studied variables on TMY trait. DIM and DP had significant effect on 305-DMY. Nevertheless, the effect of parity and DO on 305-DMY were non-significant ($P \geq 0.05$). The average EBV for DP and CI were higher in dam than in cow, and sire. Also, for 305-DMY and DIM, they were higher in cow than in dam and, sire. For TMY, it was higher in sire than in cow and, dam. Medium heritability estimates for TMY, DIM, CI and DO were (0.32, 0.33, 0.29 and 0.29, respectively), while low heritability estimate (0.07) was recorded for DP. Finally, there were positive phenotypic correlation *(r p)* between all studied traits except 305-DMY had negative *r p* with DP and CI**.** Cattle breeders must consider the environmental factors in manage mental program because they greatly affect the farm profitability, and they must select individuals with higher breeding values to be the parents of the next generation.

1. INTRODUCTION

Cow is a dairy animal plays a large role in milk production all over the world (Khan, 2020). In Egypt, the population of cows is continuously increased and was recently estimated to be about 5.1 million heads. This population produces about six million tons of the total milk production and 0.5 million tons of the total red meat production per year (FAO, 2020*)*. Friesian cattle are the most reputed dairy cattle in Egypt. Holstein breed is preferred by breeders, because of their high milk production, good fattening ability, less difficulty in environmental adaptation and good breed selection can be achieved through proper record-keeping (Mundan et al., 2020). In livestock population under computerized recording system, a large size of phenotypic observations is available at low cost, and it is worthwhile to use them in estimation of genetic parameters for economic traits.

Milk production and reproductive traits are the most important economic traits as sources of income for dairy farmers where high producing and fertile cows are usually profitable. Heritability may be the way from claiming hereditary parameter which focus the measure about workable hereditary advance to choose qualities (Usman et al., 2012). A few variables impact the measure for drain generated all the throughout lactation. These incorporate the measure from claiming secretory tissue, days in milk, regular components (photoperiod, heat, and frosty stress) occasional transforms done bolster accessibility. Furthermore, nature of feed, lactation diligence also hereditary foundation of the cow (Watson et al., 2017).

The aim of the current research is to assess the impact of some genetic and non-genetic factors influencing 305-DMY and TMY for Holstein Friesian cows.

2. MATERIAL AND METHODS

The current work was approved by the Committee of Animal Care and Welfare, Benha University, Faculty of Veterinary Medicine, Egypt (BUFVTM: 01-08-21).

2.1. Animals

Productive data of 1509 records were collected from Holstein Friesian cattle belonged to Gammasa private farms for Agricultural investment, located near to Mansoura city.

2.2. Herd Management

All animals were kept under open sheds all over the year; supported by a cool spraying system during the summer season. The animals, all over the year, were fed on total mixed ration (T.M.R) with three different rations for high, medium, and low producing cows depending on dry matter intake (DMI).

2.3. Statistical analysis

The effect of non-genetic factors was analyzed using a one-way analysis of variance with days in milk, age at first

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calving, dry period, calving interval, days open, parity and season of calving (model 1) as a fixed effect in a general linear model (GLM), and phenotypic correlation between traits x and y was calculated using the SAS software ver.9.1.3 (SAS Institute Inc, Cary, NC, USA) (SAS, 2001). (MTDFREML) program of Boldman et al (1995), who used to estimate genetic parameters and breeding value (model 2).

Model 1:
To analyze the factors affecting 305-DMYand TMY, the following model was assumed.

$Y_{ijklmno} = \mu + DIM_i + AFC_j + DP_k + CI_l + P_m + S_n + DO_o + b(AC) + e_{ijklmno}$.

Symbols in the model are defined as the following:-

$Y_{ijklmno}$: The observed value (i.e. 305-DMY).

μ : The overall mean.

***DIM_i* :** The effect of the ith days in milk;(i= 1, 2, and 3: where 1= less than 277 days; 2= 277-350 days, and 3=more than 350 days).

AFC_j : The effect of the age at first calving; (j=1, 2, and 3: whereas 1=less than 24 months; 2= 24-26 months, and 3=more than 26 months).

DP_k: The effect of the kth dry period; (k=1, 2, and 3: whereas 1=less than 61 days; 2=61- 69 days, and 3=more than 69 days).

CI_l: The effect of the lth calving interval; (l=1, 2, and 3: whereas 1= less than 13 months; 2=13 - 19 months, and 3=more than 19 months).

P_m: The effect of the mth parity; (m= 1, 2, 3, and 4: where 1=first parity; 2=second parity; 3=third parity, and 4= fourth parity or more).

S_n: The effect of the nth season of calving; (n=1, 2, 3, and 4: whereas 1= Autumn; 2= Spring; 3= Summer, and 4= Winter).

DO_o: The effect of the Oth dry period; (O=1, 2,3 and 4: whereas 1=less than 96 days; 2=96- 148 days;3=149-218, and 4=more than 218 days).

***b(AC)*:** partial linear regression coefficients of $Y_{ijklmno}$ on age at calving.

$e_{ijklmno}$: random error.

Model 2:
Heritability, genetic correlation and breeding values of studied traits were estimated with derivative free restricted maximum likelihood (DFREML) procedures using (MTDFREML) program of Boldman et al. (1995). The assumed model was:

$Y = Xb + Za + e$

Y: Is the vector of the observed trait.

X: Is the incidence matrix of fixed effect.

b: Is the vector of fixed effect.

Z: Is the incidence matrix of random animal effect.

a: Is the vector of random animal effect.

e: Is the vector of random residual effect.

3. RESULTS

3.1. Effect of non-genetic factors on 305-day milk yield (305-DMY):
The least square means and standard errors for different factors affecting 305-DMY were shown in table 1. DIM had a highly significant effect ($P \leq 0.01$) on 305-DMY. The maximum milk yield was 12296.87 kg when DIM was more than 350 days, while the lowest yield was 10197.59 kg obtained when DIM was less than 277 days. DP had a significant effect ($P \leq 0.05$) on 305-DMY. The highest value of 305-DMY (11837.77 kg) was recorded when DP was less than 61 days and lowest yield (10658.28 kg) was showed when DP was more than 69 days. Parity had a non-significant effect on 305-DMY. Second season of lactation showed the maximum amount of milk (11839.52 kg) followed by the third parity (11644.57kg) then the fourth parity or more (11533.44 kg), andfinally the first lactational season showed the lowest yield (10688.90 kg). Season of calving and calving interval (CI) had a non-significant effect on 305-DMY.

3.2. Effect of non-genetic factors on total milk yield (TMY):
The least square means and standard errors for different factors affecting TMY were shown in table 2. DIM had a highly significant effect ($P \leq 0.01$) on TMY. The maximum milk yield was 12888.71 kg when DIM was more than 350 days, while the lowest obtained yieldwas 9938.64 kg when DIM was less than 277 days. DP had a highly significant effect ($P \leq 0.01$) on TMY. The highest value of TMY (11872.53 kg) was recorded when DP was between 61-69 days and lowest yield (10515.57 kg) was showed when DP was more than 69 days. Parity had a highly significant effect($P \leq 0.01$) on TMY. Third season of lactation showed the maximum amount of milk (11920.77 kg) followed by the second parity (11721.60kg) then the fourth parity or more (11339.13 kg), while the first lactational season showed the lowest yield (10405.68 kg).
DO had a highly significant effect ($P \leq 0.01$) on TMY. The highest value of TMY (13717.70 kg) was recorded when DO was more than 218 days and lowest yield (10284.47kg) was showed when DO was less than 96 days. CI had a highly significant effect($P \leq 0.01$)on TMY,the maximum milk yield was 13198.83 kg when CI was more than 19 months, while the lowest obtained yield was 11537.76 kg when CI was less than 13 months. However, season of calving and age at first calving had a non-significant effect on TMY.

3.3. Estimation of breeding value for some productive and reproductive traits.
Estimated breeding value for different studied productive and reproductive traits for cow, sire, and dam were shown in table 3.The average EBV for DP, and CI were higher (1.2 and -0.0009, respectively) in dam than in cow, and sire.For 305-MY and DIM, they were higher (26.4 and 0.64, respectively) in cow than in dam, and sire.And finallyfor TMY, they were higher(1.8) in sire than in cow, and dam.

3.4. Estimation of genetic parameters for some productive and reproductive traits.
3.4.1. Heritability estimate.
Heritability estimates among different studied productive and reproductive traits were shown in table 4.Heritability estimate is essential for the breeder to choose the program of breeding, the type of selection to be followed and to predict the genetic gain afterwards (Cobuci *et al.*, 2007). High heritability was estimated for TMY and DIM were 0.32 and 0.33 respectively. Medium heritability estimates for CI and DO were o.29 and 0.29 respectively. However, low heritability estimates for DP was 0.07.

3.4.2. Phenotypic and genetic correlations .
Phenotypic (above diagonal) and genetic correlations (below diagonal) among different productive and reproductive traits were shown in table 5. There are positive *r p* between all studied traits except 305-DMY had negative *r p* with DP and CI. TMY had high positive *r G*

with DP (0.97) and CI (0.98). While it had negative r G with 305-DMY, DIM and DO (-1.00, -0.88 and -1.00, respectively), Moreover, 305-DMY had positive *r G* with DIM, CI, and DP (0.99, 0.01 and 0.64, respectively), but had negative *r G* with DO (-0.22). However, negative *r G* were found between other traits except for DO with DP and CI it was positive.

4. DISCUSSION

This study aimed to evaluate the effect of some genetic (h^2, *r G*, *r P* and EBV) and non-genetic factors (DIM, DO, DP, CI, parity, and season of calving) on 305-DMY and TMY traits. DIM had a highly significant (P≤ 0.01) effect on 305-DMY and TMY. This result was in accordance with Zienab et al. (2021) who stated that days in milk had a significant effect (P≤ 0.05) on 305-DMY. The maximum milk yield was 9438 kg when DIM was more than 357 days, while the lowest yield was 8153.88 kg obtained when DIM was less than 211 days. Also, it agreed with Sevinc et al. (2020), who recorded that high milk yield with high lactation length. However, it disagreed with Vijayakumar et al. (2017), who observed that those most elevated milk yield with lactation period of 55 to 90 days during a 4 time milking frequency per day, and the lowest milk yield was observed in more than 201 days in Holstein cows and this might be expected of the transforms of hormones making crumbling of the mammary gland, supplement necessities of the embryo and insufficient nutrition for milk production. while, Abd-El Hamed and Kamel (2021) reported that the highest 305-DMY values were attained at DIM 301-330 days, then milk yield decreased. Parity had a highly significant effect (P≤ 0.01) on TMY. The obtained results were in the same line of those obtained by Manzi et al. (2020), who found that the lowest milk yield was obtained in first parity cows with an increase till the fourth parity. This may be due to the increasing in the development and size of the udder with a resulting increase of secretory cells (Sorensen et al., 2006). Other purposes behind high drain yield may be the increased parity, which plays a significant role in the control of the tissue mobilization between the primiparous and multiparous cows, and includes increasing body weight of dairy cattle over that of first lactation. (Wathes et al., 2007).

These results disagreed with Bolacali and Öztürk (2018), who stated that the maximum amount of 305-DMY was in the 1st and 2nd parity in Simmental cattle. This might be expected due to the presence of high secretory cells on the mammary gland, which keep up their secretory action to more extended the long run over to start with lactation as compared to subsequent lactations and within later parities, the cow exposed to subsequent mammary infection, so lead to decrease milk production (Koloi *et al.*, 2018).

Table 1 Least-square means (±SE) of various factors affecting 305-day milk yield (305-DMY).

Classification	N	L.S.M ± S.E
1.Age at first calving(months)		
<24	263	11020.70±401.50^{b}
24-26	498	11975.34±286.55^{a}
>26	405	11283.77±314.49^{a}
2. Days in milk		
<277	277	10197.59±416.53^{b}
277-350	438	11785.36±357.01^{a}
>350	451	12296.87±383.58^{a}
3.Days open		
<96	329	11359.60±406.38
96-148	299	11497.80 ±396.27
149-218	223	11519.26±450.37
>218	315	11329.77±458.64
4. Dry Period (days).		
<61	449	11837.77±303.19^{a}
61-69	377	11783.77±329.27^{a}
>69	340	10658.28±349.68^{b}
5. Parity.		
The 1st lactation	214	10688.90±653.39
The 2nd lactation	361	11839.52±366.15
The 3rd lactation	293	11644.57±389.01
The 4th lactation and more.	298	11533.44±565.27
6. Season of Calving.		
Autumn	394	11837.41±328.46
Spring	177	11409.21±471.33
Summer	299	11473.04±357.68
Winter	296	10986.78±391.27
7. Calving interval (months)		
<13	402	11907.21±331.20
13-19	413	11754.35±326.52
>19	137	11884.19±569.32

Within the same classification, the appearances of least square means with the different letters are significantly different (p ≤ 0.05). Otherwise, they do not.

Table 2 Least-square means (±SE) of various factors affecting total milk yield (TMY).

Classification	**N**	**L.S.M ± S.E**
1.Age at first calving(months)		
<24	154	11271.35±228.71
24-26	348	11350.22±174.95
>26	312	11418.81±174.78
2. Days in milk		
<277	65	9938.64±372.65^{c}
277-350	380	11213.02±200.14^{b}
>350	369	12888.71±187.59^{a}
3.Days open		
<96	272	10284.47±195.40^{b}
96-148	196	10609.33±212.55^{b}
149-218	151	10775.67±294.84^{b}
>218	195	13717.70±313.48^{a}
4. Dry Period (days).		
<61	305	11652.28±199.95^{a}
61-69	263	11872.53±187.23^{a}
>69	246	10515.57 ±184.88^{b}
5. Parity.		
The 1st lactation	214	10405.68±268.75^{c}
The 2nd lactation	218	11721.60±205.59^{ab}
The 3rd lactation	197	11920.77±221.55^{a}
The 4th lactation and more.	185	11339.13±291.43^{b}
6. Season of Calving.		
Autumn	275	11610.28±184.84^{a}
Spring	126	11177.62±246.20^{ab}
Summer	183	111073.29±209.32^{b}
Winter	230	11525.97±199.89^{ab}
Calving interval (months)		
<13	264	1153776±189.64^{c}
13-19	251	12399.02±194.26^{b}
>19	85	13198.83±334.75^{a}

Within the same classification, the appearances of least square means with the different letters are significantly different (p ≤ 0.05). Otherwise, they do not.

Table 3 Estimated breeding value for different studied productive traits and reproductive traits for Cow, Sire and Dam.

Trait	Estimated Breeding Value								
	Cow			Sire			Dam		
	Min	Max	Average	Min	Max	Average	Min	Max	Average
Days in milk	-20.7	55.087	.645077	24.9	33.451	-0.11	-15.9	27.5	-0.0483
Calving interval	-10.03	12.2	-0.42	-8.538	6.1	-0.04	-5.02	8.34	-0.0009
Dray period	-8.8	12.1	-0.39	-5.93	6.7	-0.053	-4.43	5.4	1.2
305-day milk yield	-142.19	525.022	26	-71.09	339.90	-0.117	-71.09	236.71	-1.54
Total milk yield	-22.5	13.4	0.14	-16.6	9.9	1.8	-15.4	8.6	-1.1

Table 4 Heritability estimates among different studied productive and reproductive traits.

Trait	h^2± S.E
Total milk yield	0.32±0.01
Days in milk	0.33 ±0.1
Dray period	0.07 ±0.03
Calving interval	0.29 ±0.03
Days open	0.29±0.02

Table 5 Phenotypic (above diagonal) and genetic correlations (below diagonal) among different productive and reproductive traits.

Trait	TMY	305-DMY	DIM	DP	CI	DO
Total milk yield	-	0.23	0.68	0.04	0.17	0.61
305-day milk yield	-1.00	-	0.09	-0.08	-0.01	0.03
Days in milk	-0.88	.99	-	0.13	0.02	0.71
Dray period	0.97	0.64	-1.00	-	0.10	0.29
Calving interval	0.98	.01	-0.08	-0.55	-	0.04
Days open	-1.00	-0.22	-.94	0.03	1.00	-

Regarding DO, it had a highly significant effect ($P \leq 0.01$) on TMY. In agreement with present study, Ali *et al.* (2003), who found highly significant effect ($P \leq 0.0001$) of DO on TMY. The highest yield was 8865.18 kg which obtained during 100 –185 day of days open, however, the lowest value of milk yield was 8057.51 kg obtained at ≥ 186 day.

Dry period had a significant effect on 305-DMY ($P \leq 0.05$). Also, it had a highly significant effect ($P \leq 0.01$) on TMY. In a similar study, Boujenane (2019), stated that dry period had a significant effect on 305-DMY in Holstein cows and maximize milk yield at dry period of 40 to 80 days. In contrary, Kiyici *et al.* (2020*)* noted that dry period had a non-significant effect on 305-DMY. The lowest milk yield (7529.4 kg) was obtained from DP group with lower than 40 days in Holstein Cows. The reason for low milk yield in cows with short DP may be due to the smaller number of udder epithelial cells in these cows. As, the DP provides an opportunity to repair the damage to the mammary gland of the cow and the cells of both alveolar and canal system, in addition cows store mineral and vitamin for the next lactation during dry period. Season of calving had a non-significant effect on 305-DMY and TMY. Manzi *et al*. (2020) found similar results in Simmental cattle and Ankole crossbreds. This result may be attributed to animals were fed on TMR ration all over the year and due to using evaporative cooling system (Hammoud and Salem 2013) However, Abd-El Hamed and Kamel (2021) noted that season of calving had a significant effect on 305-DMY and the highest milk yield was obtained in winter season. The current study showed significant effect of AC on 305-DMY and TMY. Waska *et al*. (2010) confirmed that milk yield increases with age up to maturity due to increase body weight, then declined due to degeneration of secretory tissue of mammary gland and decrease physiological activity of the body.

Regarding breeding values for DIM and DP, Abdel-Hamid *et al*. (2017) found that cow, sire, and dam breeding values for DIM were ranged between (- 70.82 and 86.27 days), (-69.31 and 62.98 days) and (-37.97 and 62.02 days), respectively in Holstein Friesian cows. Also, Zienab *et al.* (2021) reported that the breeding values for DIM and DP of the cows were ranged between -84.1 and 141.5 and between -3.4 and 4.2 days, respectively. While the corresponding values for sires were between -122.8 and 104.7 and between -2.9 and 2.9 days, respectively. Moreover, the values for dams were between -40.2 and 82.7 and between -2.1 and 2.1 days, respectively.

The range of breeding value for CI obtained in the present study was lower than those reported by Abdel-Hamid *et al*. (2017), who noted that breeding values for CI of cows, sires and dams ranged between -14.43 and 15.58, -16.55 and 12.65 and between - 5.92 and 10.56 days, respectively in Holstein cows. The breeding values for 305-DMY of cows were lower than those reported by El-Awady *et al.* (2011), who reported that the range of predicted sire breeding values ranged from -391 to 700 kg for 305-DMY. Moreover, the sire breeding value for total milk ranged between -8.34 and 11.68 kg in Holstein Friesian Cows (Radwan *et al*., 2015). The range of the cow breeding values for a trait in a given herd indicated the amount of genetic variation among cows. The wider the range is the wider the genetic variation and this gives the opportunity for improving the considered trait through selection according to the superiority of the cow breeding value (Abdel-Hamid *et al*., 2017).

Medium heritability estimated for TMY, DIM, CI and DO. These results were in accordance with Canaza-Cayo *et al*. (2018), who found that heritability for CI was 0.28 in Girolando cattle in Brazil and for DO was 0.27 (Kassahun *et al*., 2020). Moreover, Zienab *et al*. (2021) recorded medium heritability estimates for TMY was 0.24.medium heritability estimates for CI, DO, DIM and TMY indicated possibility of improvement through both genetic selection and by good management and environment conditions (Zurwan *et al*., 2017). The above results were in disagreement with those reported by Awady *et al.* (2016), who found that heritability estimates for CI, DO and DP were 0.16, 0.11 and 0.14, respectively.

There are positive *r p* between all studied traits except 305 -DMY had negative *r p* with DP and CI. These results agreed with Ratwan *et al*. (2016), who noted that TMY had positive *r p* with DIM(0.72) and 305-DMY (0.90)in Jersey crossbred cattle. Also, Salem and Hammoud, (2019) reported positive *r p* between DIM and TMY (0.96). However, Canaza-Cayo *et al*. (2018) found that there was negative correlation between DP and 305-DMY (-0.37). Montaldo *et al*. (2010) indicated that CI had low positive *r p* with 305-DMY (0.07) and (0.15), respectively. The opposite results obtained by Awady *et al*. (2016), who showed that CI had positive *r p* with DP (0.19) and (0.51), respectively. Ebrahim, (2018) noted that CI had negative correlation with TMY (-0.34).On the contrary, Awady *et al*. (2016) stated that DO had positive *r p* with DP (0.07).There were negative *r p* of DO with TMY (-0.06) (Ebrahim, 2019).

TMY had high positive genetic correlation with DP and CI but had negative *r G* with 305-DMY, DIM and DO. These results disagreed with Canaza-Cayo *et al.* (2018) and Ebrahim (2019), who stated that DO had positive correlation with TMY (0.08) in Friesian cows, there is positive genetic correlation between CI with TMY and DO in Friesian cows. Also obtained negative *r G*in Holstein cows (*r G*=-0.31) between TMY and DO.305-DMY had positive *r G* with DIM, CI, and DP, but had negative *r G* with DO. *r G* between 305-DMY and DP were positive (*r G*=0.54 and 0.29) as mentioned by Hammoud (2013).

5. CONCLUSION

From these results, the effect of genetic and non-genetic factors must be taken into consideration, when evaluating dairy cows. The highest milk production was obtained when DIM are more than 350 days and in the 2^{nd} lactation. Also, lactation performance in dairy cattle depends upon genetic and environmental factors. Higher range of the sire breeding values than either cows or dams for TMY revealed a wider genetic variation and a good chance of selecting the superior sires. Also, medium to low heritability as well as phenotypic and genetic correlation for some productive and reproductive traits must be taken into consideration.

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