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Heritability, genetic correlation and breeding value for some productive and reproductive traits in Holstein cows

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Abstract

The objective of this study was to estimate the genetic parameters (heritability, genetic correlation) and breeding value for some productive and reproductive traits. Such traits include calving interval (CI), days open (DO), days in milk (DIM), dry period (DP), total milk yield (TMY) and 305-day milk yield (305-DMY). Accurate 3464 records of Holstein (HO) cows were utilized. Animal model was used to estimate heritability and breeding value. Strong negative genetic correlation was estimated for both CI and DP with TMY and 305-DMY ranged from (-0.65 to -0.99). High positive genetic associations were recorded for both CI with DO, DP and DO with DP. Weak heritability was estimated for CI, DO, DP and DIM ranged from 0.002-0.12 while for TMY and 305-DMY, the estimates were medium being 0.34±0.02 and 0.32±0.02 respectively. The range of breeding value for cows and sires were high for most of studied traits. The range of breeding value of cows for TMY and 305-DMY was 4213 and 688.80 kg respectively which was higher than those for sires (3485 and 623 kg respectively) and dams (2281 and 417.80 kg respectively). In conclusion, improvement of reproductive traits (CI, DO) through selection is difficult, but required improvement of managerial and environmental conditions. Higher ranges of breeding values for cows and sires for most of studied traits indicate higher genetic variation and higher opportunity for selection of top cows and sires in breeding value, which would result in rapid genetic progress in the future generations.

Keywords: Heritability; genetic correlation; breeding value; days open; Holstein

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Introduction

Cattle are the predominant dairy species world wide. They produce 83% of all milk, comprising more than 90% in Europe and North America but only 75% and 60% in Africa and Asia respectively (FAO, 2011). During the last two decades, considerable emphasis had been placed upon the importance of Holstein in Egypt for milk production, accordingly the number of large herds had increased either in the governmental or commercial farms through importation from Europe and USA (Shalaby et al., 2001). Milk production and reproductive performance are the dominant factors with respect to profitableness of dairy production systems, and much of attention has been given to fertility traits and their association with milk production (Oltenacu et al., 1991). Fertility problems are the most common reasons for culling in dairy cattle (Philipsson, 1981).

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Numerous authors (Dunklee, 1991; Lyons et al., 1991; Dematawewa and Berger, 1998; Pryce et al., 2004) have reported antagonistic phenotypic or genetic relationships between milk production and fertility. Such relationships can lead to increased semen costs, veterinary costs, days open, number of services and calving interval. Generally most of reproductive traits had heritability estimates below 0.10 (Kadarmideen et al., 2003; Wall et al., 2003). Although, heritabilities were exactly weak, the additive genetic variation for these traits was enough to permit efficient selection for fertility (Boichard and Manfredi, 1994; Weigel and Rekaya, 2000). Therefore, the aim of current study was to estimate heritability, genetic correlation and breeding value for some productive and reproductive traits of Holstein (HO) cows in Egypt, which are of economic importance to the dairy industry.

Materials and Methods

This work was reviewed and approved by the Animal Care and Welfare Committee of Zagzaig University, Egypt (ANWD-206).

Source of data

Recorded data from 1998 to 2010 were gathered for HO cows which belong to Alexandria-Copenhagen farms, 76 km Alexandria-Cairo desert road. A total of 3464 records were analyzed.

Animals and management

Animals were housed free in shaded open yards, supplied with a cool spraying system during hot climate. Animals were grouped according to average daily milk yield, and fed on corn silage mixed with concentrate ration. Feed Accessibility was organized according to milk production and physiological status as recommended by NRC (1989). There is a free access to the water all over the day. Once the heifers attain 350 kg of weight, they were artificially inseminated for the first time and on the day 60 after service; pregnancy was detected by rectal palpation. The cows were machine milked three times daily at 06.00h, 14.00h and 22.00h in herringbone parlor Alfa Lafal 40 point. Recording system used in the farm was computer program systems (Afikim and Dairy Comb 305). Milk yield was recorded individually at each milking for three days per week, then daily and weekly milk averages were calculated for each cow. The cows were dried for two months from the end of current lactation to the next expected calving.

Traits recorded

Traits recoded could be divided into reproductive traits which includes days open and calving interval. Productive traits involved total milk yield (TMY), 305-day milk yield (305-DMY), days in milk (DIM) and dry period (DP). The 305 days milk yield (305-DMY), the total milk yield (TMY) were measured for all first lactation cows present in the herd during the period extend from 1998 to 2010. Only cows that gave at least one calve and complete the first lactation season (305 days) were included in the current study.

Statistical analysis

Heritabilities and breeding values of studied traits were estimated with derivative-free restricted maximum likelihood (REML) procedures using the MTDFREML program according to Boldman et al. (1995), using the following model:

$$y = Xb + Zu + e$$

Where **y**: a vector of observations, **b**: a vector of fixed effects with an incidence matrix **X**, **u**: a vector of random animal effects with incidence matrix **Z**, and **e**: a vector of random residual effects with mean equals zero and variance $\boldsymbol{\sigma^2_e}$.

We estimated the genetic correlation according to (Legates and Warwick, 1990) as:

$$r_{g_1 g_1} = \frac{\mathrm{Cov} g_1 g_1}{\sqrt{(\mathrm{Var} g_1)(\mathrm{Var} g_2)}}$$

Where,

Cov g1 g2 = genetic covariances between the additive breeding values for trait g1 and g2.

Var g1 and Var g2 = genetic variances for the two traits.

The standard error of genetic correlation was calculated (Reeve, 1955; Robertson, 1959) as follows:

$$S.E(r_g) = \frac{1-r_g^2}{\sqrt{2}} \sqrt{\frac{S.E(h_1^2) S.E(h_2^2)}{h_1^2 h_2^2}}$$

Results

Genetic correlation

Genetic correlation coefficients among productive and reproductive traits were represented in the Table 1. Strong positive genetic associations were estimated for CI with DO (0.97 ± 0.02) and DP (0.9 ± 0.01) but, high negative values were estimated between CI and TMY (-0.99 ± 0.01). Positive and low genetic correlations were observed between DO and TMY (0.17 ± 0.09). High negative genetic correlations were estimated for DP with TMY (-0.65 ± 0.09) and 305-DMY (-0.84 ± 0.08). Strong positive genetic correlations were estimated between DIM and TMY (0.64 ± 0.01).

Table 1: Heritability estimates (the diagonal) and genetic correlation coefficients (above the diagonal) for some productive and reproductive traits

	CI	DO	DP	DIM	TMY	305-DMY
CI	0.002±0.01	0.97±0.02	0.9±0.01	-0.84±0.01	-0.99±0.01	-0.99±0.01
DO		0.07±0.02	0.82±0.09	0.81±0.05	0.17±0.09	0.03±0.09
DP			0.12±0.02	-0.06±0.15	-0.65±0.09	-0.84±0.08
DIM				0.10±0.02	0.64±0.01	0.59±0.08
TMY					0.34±0.02	0.89±0.02
305-DMY						0.32±0.02

CI= Calving interval, DO= Days open, DP= Dry period, DIM= Days in milk, TMY= Total milk yield, 305-DMY= Milk yield produced through 305 day lactation period.

Table 2: Range of predicted breeding values of cows for some productive and reproductive traits

Trait	Minimum	Maximum	Range	S.E		Accuracy	
				Min.	Max.	Min.	Max.
CI (day)	-1.00	1.03	2.03	0.36	0.37	0.14	0.06
DP (day)	-36.63	53.71	90.34	2.12	2.29	0.55	0.43
DO (day)	-50.13	144.30	194.43	2.57	2.12	0.52	0.71
DIM (day)	-75.90	78.20	154.10	2.73	3.01	0.34	0.34
TMY (kg)	-2096.00	2117.00	4213.00	0.66	0.58	0.62	0.73
305-DMY (kg)	-372.90	315.90	688.80	0.80	0.82	0.81	0.80

CI= Calving interval, DO= Days open, DP= Dry period, DIM= Days in milk, TMY= Total milk yield, 305-DMY= Milk yield produced through 305 day lactation period, Min. = minimum; Max. = maximum, Range = Maximum minus Minimum.

Table 3: Range of predicted breeding values of sires for some productive and reproductive traits

Trait	Minimum	Maximum	Range	S.E		Accuracy	
				Min.	Max.	Min.	Max.
CI (day)	-1.23	0.95	2.18	0.36	0.36	0.20	0.08
DP (day)	-44.58	34.62	79.20	1.68	1.91	0.75	0.66
DO (day)	-37.59	170.46	208.05	2.45	1.94	0.58	0.76
DIM (day)	-77.41	53.32	130.73	2.50	2.21	0.34	0.34
TMY (kg)	-1372.00	2113.00	3485.00	0.57	0.50	0.74	0.81
305-DMY (kg)	-396.20	226.80	623.00	0.72	0.98	0.85	0.69

CI= Calving interval, DO= Days open, DP= Dry period, DIM= Days in milk, TMY= Total milk yield, 305-DMY= Milk yield produced through 305 day lactation period, Min. = minimum; Max. = maximum, Range = Maximum minus Minimum.

Table 4: Range of predicted breeding values of dams for some productive and reproductive traits

Trait	Minimum	Maximum	Range	S.E		Accuracy	
				Min.	Max.	Min.	Max.
CI (day)	-0.54	0.59	1.13	0.37	0.37	0.06	0.06
DP (day)	-18.36	29.35	47.71	2.33	2.45	0.40	0.26
DO (day)	-24.42	66.31	90.73	2.73	2.23	0.42	0.67
DIM (day)	-34.69	40.62	75.31	3.27	3.37	0.34	0.34
TMY (kg)	-1095.00	1186.00	2281.00	0.77	0.81	0.42	0.28
305-DMY (kg)	-245.90	171.90	417.80	0.86	1.12	0.77	0.56

CI= Calving interval, DO= Days open, DP= Dry period, DIM= Days in milk, TMY= Total milk yield, 305-DMY= Milk yield produced through 305 day lactation period, Min. = minimum; Max. = maximum, Range = Maximum minus Minimum**.**

Heritability estimate

Very low heritability estimates were recorded for CI (0.002 ± 0.01), DO (0.07 ± 0.02), DP (0.12 ± 0.02) and DIM (0.10 ± 0.02). Medium heritability estimates were recorded to TMY (0.34 ± 0.02) and 305-DMY (0.32 ± 0.02) (Table 1).

Breeding Value

Cow breeding values

Minimum, maximum, range, standard errors and accuracy of cows breeding values for the studied traits were presented in Table 2. The ranges based on the first lactation records are 4213.00 kg for TMY, 688.80 kg for 305-DMY, 154.10 days for DIM; 90.34 days for DP, 2.03 days for CI and 194.43 days for DO. The accuracy of minimum and maximum estimates of cow breeding values ranged from 0.06 to 0.81.

Sire breeding values

Minimum, maximum, range, standard errors and accuracy of sires breeding values for the studied traits were summarized in Table 3. The ranges were 3485.00 kg, 623.00 kg, 130.73 days, 79.20 days, 2.18 days and 208.05 days for TMY, 305MY, DIM, DP, CI and DO;

respectively. The accuracies of minimum and maximum estimates for the studied traits ranged from 0.08 to 0.85.

Dam breeding values

Minimum, maximum, range, standard errors and accuracy of dams breeding values for the studied traits were presented in Table 4. The ranges were, 2281.00 kg for TMY, 417.80 kg for 305-DMY, 75.31 days for DIM, 47.71 days for DP, 1.13 days for CI and 90.73 days for DO.

Discussion

The negative genetic correlation between CI and TMY clarifies that genes reduce calving interval positively which affect milk production. The antagonistic relationship between production and fertility was, therefore, due to environmental rather than genetic factors. Supportive findings were cited by previous authors (Ojango and Pollot, 2001) who estimated genetic correlation between 305-DMY and CI as (-0.64). Contradicted results were reported by Makgahlela et al. (2007). Harmonious results were depicted by Goshu et al. (2014) who estimated high positive estimates for service period with DP and CI and DP with CI.

Positive genetic association between DO and TMY must be considered if we decided to select for improvement of TMY, elongation of DO may be manifested. On the contrary, Hammoud (2013) recorded negative estimates between TMY and DO (-0.31). Several investigations support our results (El-Shalmani, 2011; Zink et al., 2012). They depicted high positive estimates of 0.23 to 0.98 among TMY, DIM and DO in the HO.

Negative estimates between DP and milk production traits indicated that selection for shortening DP will be associated with increasing the milk yield. Therefore, if the dairymen ambition was to increase milk production, they should select for shortening DP. Similarly, previous authors reported negative estimates between 305-DMY and DP (EL-Arian et al., 2003; Salem et al., 2006). Contrariwise, Shahroudi et al. (2001) and Alhammad (2005) estimated positive estimates between 305-DMY and DP.

Low heritabilities of CI, DO, DP and DIM imply that they were more affected by environment and management. Proportion of additive genetic variance is low so their improvement through selection is difficult, but improvement of environment and management and selection for anther genetically correlated traits such as certain linear type traits is more effective (Wall et al., 2005). Medium estimates for TMY and 305-DMY indicated that there is a room for improvement in 305-DMY through selection. Tekerli and Kocak (2009) estimated somewhat lower estimates for first lactation TMY and DIM in Turkish HO cows. Pantelic et al. (2011) reported somewhat higher estimates for the first lactation TMY and lower ones for DIM in Simmental cows in Serbia, while Shalaby et al. (2012) reported higher estimates for DO (0.20) in HO cows in Egypt. Heritability estimates for first lactation TMY and DO reported by Zink et al. (2012) for Czech HO cows were in the same range. Estimates of heritability for calving interval were in the same range of those recorded by Ayied et al. (2011). A low estimate for CI in Iranian-Holstein cows was reported by Ghiasi et al. (2011). Similar heritability of dry period was reported by Suhail et al. (2010). In contrast, Ayied et al. (2011) estimated high heritability for dry period by different statistical methods and ranged from 0.32 to 1.00. The difference of heritability values from that estimated by some authors might be due to different environmental, analytical method and sample employed (Warwick et al., 1990).

The range of the cow breeding values for a certain trait gives an idea about the genetic variation among these cows. The wider the range the wider the genetic variation that gives the chance for improvement of the considered trait through selection of superior cows in breeding value. The ranges of estimates for 305-DMY were narrower than those obtained in previous studies (El-Arian et al., 2003; Salem et al., 2006). However, ranges of estimates for DP was longer than recorded by previous authors (El-Arian et al., 2003; Salem et al., 2006). Ranges of estimates for calving interval were shorter than those cited by Salem et al. (2006). Hammoud (2013) reported that for DIM and DO estimates were ranged between -59.10 and 109.70 days and -48.00 and 33.70 days respectively in the HO cattle depending on first lactation records which are similar to our investigation. Salem et al. (2006) recorded accuracy for the same traits which ranged from 0.43 to 0.80.

The ranges of estimates for 305-DMY is higher than those recorded previously (Salem et al., 2006) and were greater than those cited by (El-Arian et al., 2003; Salem et al., 2006) for DIM and DP that might be due to different herds, environment, analytical method and sample employed. Shorter ranges were cited for CI by (Salem et al., 2006). We estimated wider ranges for DO than previous author (Hammoud, 2013). Wider ranges for CI and 305-DMY were cited by Ayied et al. (2011) but reported narrower ranges for DP.

Higher accuracy of sire breeding value than cows and dams indicated the important role of sire as he produce large number of daughters and higher ranges of breeding values of cows and sires for most of studied traits reflected that selection of cows and sires for the future can lead to rapid genetic progress. For the same traits Salem et al. (2006) estimated the accuracies ranged from 0.21 to 0.89, while El-Awady et al. (2011)

estimated accuracy for sire breeding value between 0.12-0.87.

The ranges of estimates for 305-DMY were lower than those obtained in previous work (El-Arian et al., 2003; Salem et al., 2006). In contrast, they estimated narrower ranges for DIM and DP. Hammoud (2013) found that ranges for DIM (-74.7 ± 0.06 and 99.2 ± 0.07) and DO (-27. 4 ± 0.15 and 16.0 ± 0.07) in HO cattle depending on the first lactation records.

Conclusion

The present results suggested that improvement of reproductive traits through selection is difficult, but required enhancement of managerial and environmental conditions. Higher range of the cow breeding values for total milk yield and 305-day milk yield than sires and dams verified a wider genetic variation so there is a better opportunity to select superior cows which leads to rapid genetic progress in future generations.

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