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Selection indices for improving the production and reproduction of Friesian cows

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ABSTRACT

The present study contained total of 670 first lactation parity complete records of Friesian cows sired by 77 bulls, raised in south of Alexandria during the period from 1985 to 2014. These records were used to estimate genetic and phenotypic parameters by using MTDFREML for total milk yield (TMY), Daily milk yield (DMY), persistency (PER), Age at first calving (AFC) and calving to first service (CFS) in addition to establishment of many combinations of selection indices. Analysis of variance showed that sire and year of calving had significant effect on all studied traits (P< 0.01), however month of calving had significant effect on DMY and CFS only. Heritability estimates were 0.37, 0.27, 0.03, 0.38 and 0.11 for the previous traits respectively, the genetic correlations ranged from -0.92 to 0.94 and phenotypic correlation ranged from -0.25 to 0.64. Comparison between twenty-two selection indices showed that the maximum return can be achieved when applying the indices, I_{10} and I_6 which includes three or four traits. These indices are simple and easy to construct. Therefore, it is recommended to apply selection at the end of first lactation based on these indices.

Keywords: cows, reproduction, milk, selection index. economic-genetic improvement.

Introduction

Milk yield is the most economic important trait in the dairy cattle breeding. The demand for animal products is assumed to increase considerably. For instance, dairy production is an important component of livestock production. Miglior *et al.*, (2005) surveyed the selection indexes of 15 countries from different geographical regions and showed that the average relative emphasis for production across all countries was 59.5%. This finding indicates that production is still the most important component of selection indexes used in dairy cattle. Selection for milk production traits has traditionally received most emphasis in national breeding programs of dairy cattle in many countries. Although, conventional selection for milk yield has made animals more profitable producers in the farm, Indexes containing functional traits contribute to higher selection efficiency. Numerous studies in dairy animals have shown that selection for higher milk yield alone is associated with reduced health and

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fertility. In addition to milk yield, reproductive and health traits are among the major traits that should be improved genetically in dairy cattle (Lucy 2001; Van Raden, 2004 and Abosaq *et al*., 2017). The reproductive traits measure the ability of what cows show heat in the early breeding period and the probability of the success of insemination and confirmation of pregnancy were derived. Some of these traits included the calving to first service (CFS) and age at first service (AFC). Functionality describes the ability of the cow of producing milk in an efficient way, i.e. producing the same output of products reducing input costs (Biffani *et al*., 2005). Selection programs represent a great opportunity to improve genetically most of these relevant traits. Fertility is economically important as it brings cows into lactation, reduces reproductive disorders, and maximizes the profitability. Hence it is argued that enhancing both productive and reproductive potential of dairy animals should be the main objective of an animal breeder .

Hazel (1943) developed the selection index theory, which allows multiple-trait selection of animals, using economically important trait information or other measureable correlated traits that were directly obtained from individuals or their relatives and weighted by their economic values (EVs). Selection indexes have been implemented in several developed countries; consequently, dairy industries have considerably improved. Initially, production traits were emphasized in these breeding programs. One of the important breeding program processes is the estimation of genetic parameters using appropriate models. Although, some investigations have been carried out in dairy cows in regard to the estimation of genetic parameters of milk yield traits, fertility traits still need further work (Shalaby *et al.,* 2013; Hammoud *et al*., 2014 and Rushdi *et al.,* 2014). Production traits are evaluated genetically with MTDFREML "animal model" proposed by (Boldman *et al.,* 1995) which include fixed group effects and random effects represented in sire and dam within sire, animal, and residual effects .

To implement any animal breeding program, it is important to define the production circumstances of the animals of interest to determine which traits are economically interesting (breeding goals) and will be measured (selection criteria), (Prata *et al*., 2015). Considering the actual selection strategy, breeding values and economic values for total milk yield, daily milk yield, persistency, Age at first calving (AFC) and the period from calving to first service (CFS) are the key breeding parameters for Friesian cattle in Egypt. The aim of this study was to design a group of selection indices including combinations of the mentioned traits in Friesian heifers.

Materials and methods

The present study contained total of 670 first lactation parity complete records of Frisian cows sired by 77 bulls, during the period between 1985 and 2014 raised near of Alexandria. Heifers were artificially inseminated using frozen semen. Pregnancy was detected by rectal palpation 60 days after last insemination. Animals reared under semi-open sheds. The lactating Cows were machine milked twice daily. Animals were fed ad–libitum on clover and rice straw from November to May and on Sorgum and berseem hay from June till October.

TRAITS

Traits studied were milk traits represented in total milk yield (TMY, kg), Daily milk yield (DMY, kg) and the persistency (PER %) was determined according to (Lean *et al.*, 1989) as follows: =(305 day milk yield (kg))/(daily peak yield (kg) * 305 (days)) , Daily milk yield (DMY), is defined by the International Committee for Animal Recording (ICAR, 2011) as (milk production over 24 hours). Milking twice a day is a common practice in many countries. In that case, DMY is the sum of the yields over 2 milkings. Reproductive traits represent the functionality involves Age at first calving, which is defined as number of months between date of birth and date at first parturition of a cow (AFC, months), and calving to first service which describe the post-partum period Anestrus (CFS, day).

Derivation of relative economic value:

Prior to computing the complete index, the relative economic values REV were calculated by using One phenotypic standard deviation according to (Falconer and Mackay1996), The calculated (REV) depending on the phenotypic standard deviation where, REV = 1/σp , σp is the phenotypic standard deviation of the trait.

DATA ANALYSIS

Preliminary analysis of data were made by statistical analysis system (SAS, 2002) version 9.1 to study the effect of month and year of calving as fixed effects and the sire as random effect on all studied traits. The 30-years period studied (1985-2014) was classified into 10 categories of three years as follows:1985-1987, 1988-1990, 1991- 1993, 1994-1996, 1997-1999, 2000-2002, 2003-2005, 2006-2008, 2009-2011 and 2012-2014. The statistical model was used as follows:

$$Yijkl = \mu + S_i + M_j + Y_k + e_{ijkl} \quad (1)$$

Where: Y_{ijkl} = the individual observations,

μ = the overall means,

S_i = the random effect of the sire i^{th}

Mj = the fixed effect of the month of calving (j= 1-12),

Y_k = the fixed effect of the year of calving (k=1-10),

and, e_{ijkl} = the residual effect with $e_{ijkl} \sim N(0, \sigma 2_e)$.

The edited data were set for the estimation of genetic parameters of milk yield and fertility traits for the establishment of selection indices. It contained 670 records from Frisian cows, sired by 77 bulls, the cows calved between 1985 and 2014. Heritability, genetic and phenotypic correlations and Co-variance components of studied traits were estimated using the MTDFREML proposed by (Boldman, *et al.*, 1995) using multiple trait animal model (MTAM), the assumed model was:

$$y = Xb + Zu + e \quad (2)$$

where, y= observations vector of records, b = fixed effects vector (year of calving from 1985 to 2014 and month of calving, from January to December), a = animal direct effect vector, and e = residual effect vector, X and Z are incidence relating records to fixed and animal effects, respectively.

Establishment of many combinations of selection indices, having in focus milk production and fertility, includes traits of primary importance, such as, total milk yield (TMY), daily milk yield (DMY), persistency (PERS), age at first calving (AFC) and calving to first service (CFS). Production results for the observed traits are adjusted to a standard lactation.

Breeding value, estimated by the use of selection index method, and can be presented with the following general equation for the selection index:

$$I = b_1(y_1 - \bar{y}) + b_2 (y_2 - \bar{y}) + \ldots\ldots + b_n (y_n - \bar{y}) \qquad (3)$$

Where I is the value of selection index or relative breeding value evaluated by selection index determined for a certain head of cattle; bi is multiple regression coefficients for each trait included in the selection index; $(yi - \bar{y})$ is difference between phenotypic value of trait included in selection index for certain individual

Index weight:

$$b` = p^{-1} Ga \qquad (4)$$

Where b` is an index coefficient, P, is the phenotypic co-variance matrix, G is generic co-variance matrix and (a) is known relative economic values. According to Van der Werf and Goddard (2003), direct expected gain $\Delta G = (i{*}b' {*}G)/\sigma I$, and to Falconer and Mackay (1996), correlated response selection (CRY) for one trait were calculated as:

$$CRY = i\, h_x\, h_y\, r_g\, \sigma_{py} \qquad (5)$$

Assuming a selection intensity 1

Results and discussion

The descriptive statistics of first lactation economic traits, total milk yield (TMY, kg), daily milk yield (DMY, kg), persistency (PER, %), age at first calving (AFC, month) and calving to first service (CFS, day) of Friesian heifers in Egypt are presented in table (1)

Table 1. Descriptive Statistics of the first parity.

Trait	No.	Mean	SD	C.V%	Min	Max	REV($1/\sigma_p$)
TMY	670	4709	1701.4	36.13	564	11310	1
DMY	670	13.94	3.94	28.3	3.7	28.6	431.83
PERS	669	64.7	9.96	15.39	28	100	170.82
AFC	670	30.9	6.3	20.51	21	36	-270.06
CFS	654	88.82	53.83	60.61	12	394	-31.61

The present overall mean of TMY was 4709 kg, similar results were 4736 kg found by Tawfiq *et al.*, (2000) working on Friesian cows, and higher than the published values on Friesian cattle in Egypt 3530 kg by El-Awady (2009), and 3950 kg by Hammoud *et al.*(2014) and lower than those published by Shalaby *et al.*, (2013) Being 5387 kg; the overall mean of DMY 13.94 kg and the average milk yield varied from 3.7 to 28.6 kg, the present mean was higher than that reported by Abdel-Gader *et al.*, (2007) and Hammoud *et al.* (2014) being 12.29 kg and 13 kg respectively in Friesian cows; the overall mean of PERS 64.7%, it's varied from 28 to 100%; many authors estimated persistency by other methods.

The present overall mean of AFC was 30.9 months, Hammoud *et al.,* (2010) and Abdel-Gader *et al.,* (2007) recorded almost similar results 30.7 and 30 months respectively in Friesian cows.

The C.V % ranged from 15.39 % for PER and 60.61% for CFS (Table 1), such large coefficients of variation are indicative leaders for opportunities for improvement in these traits. The difference between the present results and other publications may be related to genetic factors, climatic condition, managerial practices and/or feeding system and differences in statistical models. The economic values of the traits studied were relative to TMY.

All studied traits were significantly influenced (P<0.01) by the sire and year of calving; daily milk yield and calving to 1st service period were significantly affected by month of calving while TMY, PERS. and AFC were not influenced (P>0.05) by month of calving as mentioned in table (2).

Having in mind the heritability of observed milk traits in standard lactation and reproductive traits in available literature sources can be considered values that have a wide interval of variation. Table (3) shows estimates of heritability (h^2) as well as phenotypic and genetic correlations and variance components among different milk production and reproductive traits, values of the heritability estimates ranged from 0.03 (having in focus the PERS), to 0.38 for the AFC. These estimates are in agreement with most of the previous references. These estimates indicated considerably low to moderate genetic to environmental variance ratio for these traits and reflected differences in the cows' response to the existing environmental conditions.

The heritability estimate for TMY (0.37) was in consonance with (0.35) and (0.22-0.46 which obtained by El-Awady (2009) and Hammoud *et al.* (2014), respectively in the same breed in Egypt and (0.35) by Al-Smarai (2015) in Holstein breed in Iraq.

Table 2: Analysis of variance for genetic and non-genetic factors affecting on TMY, DMY, PER, AFC and CFS in Friesian cows.

S.O.V	df	F-Value				
		TMY	DMY	PER	AFC	CFS
Sire	76	2.05 **	3.17**	1.67**	1.78 **	1.61 **
Month of calving	11	1.72 ns	2.68**	1.75 ns	1.21 ns	2.63 **
Year of calving	9	5.36 **	6.44**	3.75 **	6.32 **	3.39 **
Residual	573					

increased if the index was constructed with three or four of these facts which agree with those found by (El-Arian, 2005).

Comparison between twenty-two selection indices showed the original selection I_1 which included TMY, DMY, PER, AFC and CFS, was suggested to be used for improving milk production and keep the fertility at appropriate levels. The original index which included all five traits ranked the 14th (RE=100%), and Its accuracy (R= 0.581). The equation original selection index was:

I_T= 0.624 *TMY* + 8.834 *DMY* + 67.178 *PER* - 102.566 *AFC* - 4.693 *CFS* . (6)

Comparison of selection indices indicates that if index was constructed with three or four traits, when TMY or CFS were omitted from original index resulted in considerable increase in RE values. The most effective indices were I_2 which incorporate TMY, DMY, PER and AFC (RE=113.77), the second index in rank I_{10} incorporated DMY, PER and AFC (RE=113.25) and the third index I_6 which incorporate DMY, PER, AFC and CFS (RE=112.39), therefore the rank increases to the top, 1st, 2ed and 3rd respectively. Severe decline in RE values occurred in I_{21}, which when TMY, DMY and CFS were dropped from original index and therefore, the ranking decreased to be 20th (R_{IH}=0.340) and (RE=58.52%).

A noticeable decrease in (RE) value occurred when AFC was dropped from the original index, since the ranking were decline to later order this result agree with *El-Arian* (2005) which found that the drop AFC from original index lead to decrease of its efficiency (RE=58.7 and R_{IH}=0.405). The breeders are interested in any desirable decrease in AFC and CFS because this will increase directly the income of milk and calves sale, as well as reduce the generation interval and then increase the annual genetic gain. It would be desirable to reduce AFC and CFS in an index incorporating DMY and/or PER with one of the previous reproductive traits at the least yielded comparable improvement in I_6, I_{10}, I_{18}, I_{19}

The expected genetic change in one generation through original index +468.9 kg for TMY, + 0.784 kg for DMY, +0.58 % for PER, -1.07 month and undesirable gain +0.54 day for CFS. It appears that the difference in the expected genetic change for all indices can be accounted for largely by the differences in the genetic correlation between the traits. When criteria were dropped from the index, the genetic gain ΔG of the remaining criteria changed, for instance when TMY was dropped, the direct and indirect predicted genetic change from positive to negative value and from negative to high negative value. Omitting TMY caused high accuracy in I_2 and I_{10} associated with desired-gain in the traits, however the index I_{10} seem appropriate and simple with only three candidates DMY, PER and AFC as follows:

I_{10}= 231.056 ***DMY*** – 48.156 ***PER*** – 97.284 ***AFC*** (R_{IH}=0.653 and RE=113.25%) (7)

I_{10} lead to desired gain milk production and fertility traits, on the other hand selection based on I_{10} would lead to deterioration in persistency the equation of I_6 was:

Table 4. Selection criteria, weighting factors (b's), expected genetic change (ΔG), accuracy (R_{IH}) and relative efficiency (RE) in general index I_1 and reduced indices $I_2 - I_{22}$ to improve TMY, DMY, PER, AFC and CFS in Friesian cows.

Index	Rank	TMY kg		DMY kg		PER %		AFC month		CFS day		R_{IH}	RE%
		B	ΔG	b	ΔG	b	ΔG	b	ΔG	B	ΔG		
I_1	14	0.624	468.9	8.834	0.784	67.178	0.58	-102.566	-1.07	-4.693	0.54	0.581	100
I_2	1	0.575	477.8	172.632	0.893	-39.997	0.36	-108.449	-1.35	-	4.17	0.661	113.77
I_3	12	0.441	473.5	227.808	1.050	-39.027	0.91	-	-0.17	-10.217	-0.08	0.601	103.44
I_4	6	0.405	416.1	160.838	0.848	-	0.88	-121.461	-1.47	-5.946	0.11	0.632	108.77
I_5	13	0.4877	395.0	-	0.845	-8.0762	0.46	-98.3314	-1.62	-6.4057	1.5	0.590	101.55
I_6	3	-	376.5	305.25	0.859	-69.929	0.24	-99.532	-1.71	-11.677	-2.7	0.653	112.39
I_7	8	0.577	523.2	116.48	0.933	-16.069	0.74	-	-0.174	-	4.17	0.616	106.02
I_8	13	0.36	471.5	155.409	0.974	-	0.88	-	-0.174	-5.575	-.007	0.590	101.55
I_9	7	0.358	339.5	-	0.845	-	0.89	-113.004	-1.72	`-3.489	1.39	0.617	106.20
I_{10}	2	-	376.5	231.056	0.753	-48.156	-0.13	-97.284	-1.86	-	-1.22	0.658	113.25
I_{11}	19	-	140.4	-	0.160	-5.5293	-0.27	-86.7415	-1.99	-5.3316	-2.34	0.507	87.26
I_{12}	5	0.537	457.5	97.662	0.804	-	0.88	-121.67	-1.45	-	4.17	0.644	110.84
I_{13}	10	0.4948	552.0	92.1892	0.915	-	0.88	-	-0.17	-	4.17	0.608	104.65
I_{14}	10	0.46306	526.3	-	0.845	4.2074	0.81	-	-0.17	-	4.17	0.608	104.65
I_{15}	4	0.42	391.3	-	0.845	-	0.88	-113.416	-1.78	-	4.17	0.648	111.53
I_{16}	17	0.30536	493.6	-	0.845	-	0.88	-	-0.17	-3.125	2.2	0.527	90.71
I_{17}	16	-	376.45	176.817	0.943	-24.74	0.38	-	-0.26	-	-1.22	0.544	93.63
I_{18}	9	-	376.45	132.186	0.540	-	0.45	-110.195	-1.94	-	-1.22	0.609	104.82
I_{19}	18	-	376..45	139.308	0.820	-	0.45	-	-0.26	-5.32	-4.09	0.516	88.81
I_{20}	11	-	140.4	-	0.160	-7.9138	-0.57	-86.7194	-2.24	-	-2.66	0.606	104.30
I_{21}	20	-	140.4	-	0.160	7.4947	0.51	-	0.33	-4.7375	-5.6	0.340	58.52
I_{22}	15	-	-42.5	-	-0.143	-	0.52	-102.623	-2.12	-3.397	-1.51	0.564	97.07

I_6= 305.25***DMY*** – 69.929 ***PER*** – 99.532 ***AFC*** - 11.677***CFS*** (8)

(R_{IH}=0.658 and RE=112.39%), noticeable in order to minimize CFS duration, adequate index has to ignore those indices containing TMY, I_{10} and I_6 when omitting TMY or CFS, the ΔG were +376.5 and +376.5 kg for TMY as correlated response, +0.753 and +0.859 kg for DMY, -0.13 and + 0.24 % for PER, -1.86 and – 1.71 month for AFC and -1.22 and -2.7 days for CFS when using I_{10} and I_6 respectively.

The present estimates for AFC are higher than those reported by Atil (2006) working on 2133 normal first lactation of Holstein-Friesian cows constructed four selection indices involving all combinations of two or three traits (TMY, LP and age at first calving, reported that the expected genetic gain per generation for AFC ranged from 0.62 to -1.75. and using another set of that herd by (Atil *et al* 2005) reported that ΔG ranged from -0.35 to -0.65 month for AFC. (Kaushik and khanna 2003) when including LP, DP and CFS they found that the maximum genetic improvement for CFS was -20.74 days.

The results illustrate the importance of including DMY with either AFC and/or CFS in any selection index to improve the total merit of dairy cows in that herd and reach more profitability through shifting the fertility levels.

CONCLUSION

The study has demonstrated that selection to reduce age at first calving and calving to first service periods is justified. From the economic point of view, the profitability depends on introducing one or two traits of fertility with traits of milk production, the maximum return can be achieved by applying the indices I_{10} and I_6 which include three or four traits, because these indices are simple and easy to construct. The results illustrate the importance of including DMY with either AFC and/or CFS in any selection index to improve the total merit of dairy cows in that herd. It's recommended to apply selection at the end of first lactation based on these indices.

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ورقة أصيلة

الأدلة الإنتخابية لتحسين إنتاجية وتناسل أبقار الفريزيان

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المستخلص

استخدمت الدراسة المقدمة 670 سجل إدرار لعجلات في الموسم الأول تم تلقيحها بـ 77 طلوقة خلال الفترة 1985 – 2014 وذلك لتقدير المعايير الوراثية والمظهرية باستخدام MTDFREML ومنها تم عمل مجموعة من الأدلة الانتخابية تضمن عدة توافيق من صفات إنتاج الحليب الكلي (TMY) وإنتاج الحليب اليومي (DMY) والمثابرة (PER) والعمر عند أول وضع (AFC) والفترة بين الوضع وأول تلقيح (CFS) . وقد أظهرت النتائج أن عامل الأب وسنة الوضع لهما تأثير عالي المعنوية على كل الصفات المدروسة أما شهر الوضع فكان له تأثير عالي المعنوية على صفتي إنتاج الحليب الكلي والفترة بين الوضع وأول تلقيح فقط . كما أن تقديرات المكافئ الوراثي كانت 0.37 , 0.27 , 0.03 , 0.38 , 0.11 للصفات المدروسة على التوالي. وتراوحت قيم الارتباط الوراثي من – 0.92 إلى 0.94 أما قيم الارتباط المظهري فتراوحت من – 0.25 إلى 0.64 . وعند مقارنة 22 دليل انتخابي تبين أنه عند تطبيق الدليل I_{10} والدليل I_6 سيعود ذلك بأقصى مردود من حيث القيمة الوراثية الكلية للحيوان, ولذلك توصي هذه الدراسة بتطبيق أحد هاذان الدليلان عند إجراء الانتخاب في العجلات في نهاية الموسم الأول.

الكلمات الدالة: أبقار، تناسل، حليب، دليل انتخاب، اقتصاد، تحسين وراثي.

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