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Comparison of several methods of sires evaluation for total milk yield in a herd of Holstein cows in Yemen

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Abstract

A total of 956 lactation records of Holstein cows kept at Kaa Albon station, Imuran Governorate, Yemen during the period from 1991 to 2003 were used to investigate the effect of some genetic and non-genetic factors (Sire, parity, season of calving, year of calving and age at first calving as covariate) on the Total Milk Yield (TMY), Lactation Length (LL), and Dry Period (DP). Components of variance for the random effects (mixed model) were estimated by Restricted Maximum Likelihood (REML) methodology. Sires were evaluated for the TMY by three methods, Best Linear Unbiased Prediction (BLUP) using Harvey program, Transmitting Ability (TA) according to the Least Square Means of sire progeny (TALSMS) and according to Means (TAM). Results showed that TMY and DP were affected significantly ($P < 0.01$) by all factors except season of calving and age at first calving, while LL was affected significantly ($P < 0.01$) only by year of calving and parity. The averages of the TMY, LL, and DP were 3919.66 kg, 298.28 days, and 114.13 days respectively. The corresponding estimates of heritability (h^2) were 0.35, 0.06, and 0.14 respectively. The highest and lowest BLUP values of sires for the TMY were - 542.44 kg and 402.14 kg, while the corresponding estimates for TALSMS and TAM were - 470.38, 380.88 kg and - 370.12, 388.50 kg respectively. The Spearman rank correlation coefficients among BLUP, TALSMS and TAM ranged from 0.81 to 0.67. These results provide evidence that the selection of sires will improve the TMY in this herd because of the wide differences in genetic potential among sires, and a moderate estimation of heritability.

Keywords: BLUP, Genetic evaluation, Heritability, Holstein cows.

Introduction

Milk yield is an important economic trait in livestock species. It represents a major source of income in most dairy enterprises. Economic traits are generally controlled by genetic factors but environmental influences like, year, calving season, age at first calving and parity have significant effects on milk yield (Pirzada, 2011). These environmental factors may suppress the animal's true genetic ability and create a bias in the selection of animals. Therefore these environmental effects have to be taken into account to estimate the genetic factor in milk yield (Djemali and Berger, 1992).

The aim of the animal breeding is not only to produce superior individual animals but also to cause a general improvement in a herd by selecting genetically superior sires and dams as parents for future generations (Bourdon, 1997). Quantitative genetics has a large applicability in animal husbandry. The main goal in animal breeding is to select those cows, which can produce offspring with improved phenotypes. In order to establish effective breeding programs it is necessary to know the genetic inheritance of a certain character (Bugeac *et al.*, 2013). The potential for genetic improvement of a trait

largely depends upon genetic variation existing in the population of interest. The genetic variability for a particular trait in a herd or population is measured by heritability estimate of a trait under given environmental conditions (Goshu *et al.*, 2014).

Thus, the estimation of heritability and evaluation of sires could be one of the best methods to accomplish this aim. The use of an appropriate method for genetic evaluation of sires is an important aspect of dairy cattle improvement, so various methods have been proposed for use in the genetic evaluation of dairy cattle (Kheirabadi *et al.*, 2013).

Heritability is required to calculate genetic evaluations, to predict response to selection, and to help producers decide if it is more efficient to improve traits through management or through selection. In view of these facts, several researchers estimated the heritability of total milk yield in Holstein cows. Estimation ranged from 0.06 to 0.39 (Klopcic *et al.*, 1997; Ojango and Pollott 2001; Hermiz *et al.*, 2005; Cilek and Sahin 2009; Ayied *et al.*, 2011; Usman *et al.*, 2012; Nawaz *et al.*, 2013; Hamrouni *et al.*, 2014), while heritability of LL ranged from 0.02 to 0.49 (Hermiz *et al.*, 2005; Ayied *et al.*, 2011; Usman *et al.*, 2012; Nawaz *et al.*, 2013).

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Estimation of heritability of DP ranged from 0.07 to 0.78 (Funk *et al.*, 1987; Hermiz *et al.*, 2005; Kuhn *et al.*, 2005; Ayied *et al.*, 2011; Usman *et al.*, 2012). The purpose of this research was to investigate the effect of some genetic and non-genetic factors on the productive traits of Holstein cows in Yemen and to estimate the phenotypic trend and heritability of studied traits in addition to utilizing the genetic evaluation of sire for TMY using several methods.

Materials and Methods

Data

The data that included lactation records of 956 belong to 281 cows and 81sires for the period extending from 1991 to 2006. Pedigree information and the data used in this study were obtained from the Kaa Alboon Station, Imuran Governorate, Yemen. Prior to analyses, abnormal records for the lactation length (less than 200 and greater than 400 days) were excluded from the data set (Ayied *et al.*, 2011). As a result of the low number of records for the last three years, -with no specific reason- these records were included into the year of 2003. The calving months were grouped into four seasons: December to February (winter), March to May (spring), June to August (summer), and September to November (autumn). Parity greater than 6 considered as 6.

Statistical analysis

Two models were used to analyze the data: the first was fixed model which included both of genetic and non-genetic effects (sire, parity, season and year of calving and age at first calving as covariate), and the second model was mixed model (considered sire as a random) which included the same effects mentioned in the first model except of season of calving and age at first calving as they are non-significant. This model was used to estimate BLUP of sires for TMY (Harvey, 1990) and heritability. The σ^2_s and σ^2_e were estimated by the Restricted Maximum Likelihood (REML) methodology. Minimum and Maximum No. of daughter per sire were 2 and 8 respectively (with average of 3.47 daughter per sire). Phenotypic trends were estimated from regression for each trait on year of calving.

A formula (Bourdon, 1997) was used for calculating Transmitting Ability (TA) for Least Square Means (LSM) as these means were adjusted for all factors in the employed model and Means (M) of sires (raw means not adjusted) were as follow:

$$TA = b*(P_i - P) \dots\dots (1)$$

$$\text{where } b = (n*h^2) / ((n-1)*h^2 + 4)$$

TA : Transmitting ability of sire

b: Regression coefficient

P_i: Average result of the sire's offspring

P: Average result of the comparison group

h²: Heritability for the trait

n: Number of offspring.

The formula (1) mentioned above was used to estimate the TA of sires according to its progeny Mean (TAM) and according to progeny Least Square Means (TALSM). Best Linear Unbiased Prediction (BLUP) for each sire was estimated using Harvey program (Harvey, 1990). Accuracy was estimated for BLUP using the following equation (Bourdon, 1997):
Accuracy = $\sqrt{(n*h^2) / ((n-1)*h^2 + 4)} \dots\dots (2)$

Results

Total milk yield:

The overall mean of the TMY in the current study was 3919.66 ±42.99 kg (Table 1).

Table 1. Means±SE of some productive traits in Holstein cows.

Trait	No. of records	Max	Min	Mean	SE
Total milk yield	956	5890	1720	3919.66	42.99
Lactation length	956	340	200	298.28	5.48
Dry period	956	165	45	114.13	1.95

The effect of sire, parity and year of calving was significant (P < 0.01) (Table 2), while the effect of season of calving and age at first calving was non-significant.

Table 2. Analysis of variance of factors affecting TMY in Holstein cows.

Sources of variation	DF	Mean square	F value	Pr > F
Sire	80	2112741.2	2.24	<.0001
Parity	5	3804790.0	4.03	0.0013
Season of calving	3	363472.1	0.38	0.7639
Year of calving	13	4028171.1	4.27	<.0001
Age at first calving	1	1783882.1	1.89	0.1696
Error	854	944184		
Corrected Total	956			

Parity 4th had the highest average TMY of 4132.84 kg as compared with other parities. Mean of the TMY fluctuated across years with significant (P < 0.01) reduction in phenotypic trend along with advance years (- 196.92 kg/year). Heritability estimate for the TMY was 0.35 (Table 3). BLUP values of sires were between - 471.88 and 443.80 kg, while the corresponding estimates for TALSM and TAM were between - 470.38 and 380.88 kg and between -370.12 and 338.50 kg respectively (Table 4). The spearman rank correlation coefficients among BLUP, TALSM and TAM were between 0.81and 0.67 (Table 5). The accuracy of the three methods of sire evaluation was between low (0.40) to moderate (0.65) (Table 4).

Table 3. Phenotypic trends and heritability of TMY, LL, and DP in Holstein cows.

Trait	Phenotypic trend	Heritability (h ²)±SE
TMY	-196.92 kg/year**	0.35±0.12
LL	0.35 days/year*	0.06±0.04
DP	-0.26 days/year**	0.14±0.07

TMY= Total milk yield; LL= Lactation length; DP= Dry period.

* (P < 0.05) ** (P < 0.01)

Table 4. Estimates of BLUP, TALSM and TAM of total milk yield for Holstein sires.

BLUP	TALSM	TAM	ACC
-471.88	-470.38	-370.12	0.28 – 0.61
443.80	380.88	388.50	
915.68	851.26	758.62	

BLUP = Best Linear Unbiased Prediction; TALSM = Transmitting ability according least square means; TAM = Transmitting ability according means; ACC = Accuracy of BLUP.

Table 5. Spearman rank correlation coefficients of BLUP, TALSM and TAM for Holstein sires.

	TALSM	TAM
BLUP	0.81**	0.67**
TALSM		0.72**

** P < 0.01

Lactation length:

The result of the present study revealed that the mean of LL was 298.28±5.48 days (Table 1). Parity and year of calving had a significant (P < 0.01) effect on LL, while the effect of sire, season of calving and age at first calving was non-significant (Table 6).

Table 6. Analysis of variance of factors affecting LL in Holstein cows.

Sources of variation	DF	Mean square	F value	Pr > F
Sire	80	197.55751	1.01	0.4540
Parity	5	696.55303	3.57	0.0034
Season of calving	3	449.01616	2.30	0.0760
Year of calving	13	598.66926	3.07	0.0003
Age at first calving	1	19.14333	0.10	0.7543
Error	854	195.2886		
Corrected Total	956			

The highest average of LL was found in 4th parity (303.07 days) and lowest was found in 5th parity (293.34 days). The average LL increased significantly (P < 0.05) along with advance years with positive phenotypic trend (0.35 days/year) and heritability estimate for LL was 0.06 (Table 3).

Dry period:

The mean DP of Holstein cows was 114.13±1.95 days (Table 1). Sire, parity, and year of calving had a significant (P < 0.01) effect on DP while the effect of

season of calving and age at first calving was non-significant (Table 7).

Table 7. Analysis of variance of factors affecting DP in Holstein cows.

Sources of variation	DF	Mean square	F value	Pr > F
Sire	80	9349.4355	1.68	0.0003
Parity	5	30670.5986	5.52	<.0001
Season of calving	3	6756.3321	1.22	0.3031
Year of calving	13	41867.0695	7.53	<.0001
Age at first calving	1	500.3670	0.09	0.7607
Error	830	5559.633		
Corrected Total	932			

Cows had the lowest DP at 5th parity (106.76 days) and the highest DP at 4th parity (126.58 days). Results showed that there was a significant (P < 0.01) decreasing of – 0.26 days/year in phenotypic trend of DP across years. Heritability estimate of DP was 0.14 (Table 3).

Discussion

Total milk yield:

It was reported that the range of the average TMY of Holstein cows in tropical regions was from 2772.76 kg to 3986 kg (Abdullah, 2005; Hermiz *et al.*, 2005; Sattar *et al.*, 2005; Tadesse *et al.*, 2010). TMY in the present study was in line with the above mentioned studies. The significant (P < 0.01) effect of sire on TMY was consistent with Ayied *et al.* (2011) and Nawaz *et al.* (2013). The significant (P < 0.01) effect of parity on TMY was confirmed in previous studies obtained by Lateef *et al.* (2008), Tadesse *et al.* (2010) and Al-Masri *et al.* (2012). Nevertheless, the result differed from that of Habib *et al.* (2003) who found non-significant (P>0.05) effect of parity on milk yield. In the present study, the highest TMY was found in parity 4. Similar finding were reported by Abdel-Gader *et al.* (2007) and Al-Masri *et al.* (2012).

On the other hand the present results disagreed with Lateef *et al.* (2008) who reported that the highest TMY was in 3rd parity. These differences could be attributed to differences between age at first calving and calving intervals. Al-Samarai (1988) stated that "increasing of age at first calving and calving interval will lead the cow to reach high milk yield synchronized with lower parity". Significant (P < 0.01) effect of year of calving on TMY revealed that the management and environment were unstable during these years.

According to Fontaneli *et al.* (2005) differences in performance between years reflected the effects of environmental variations, which had marked effects on the quantity and quality of herbage available. The

effect of year of calving on milk yield was confirmed by Abou-Bakr (2009) who concluded that the variation in milk yield from one year to another could be attributed to the changes in age of the animals, attacks of different diseases and management practices level followed from year to another, e.g. fluctuations in feed availability, and quality and prices. However Tavirimirwa *et al.* (2012) attributed that to the differences in rainfall, which will lead to mark differences between years in quality and quantity of forage available. The non-significant effect of season of calving was in agreement with the results obtained by Abou-Bakr (2009) and Al-Masri *et al.* (2012).

The phenotypic trend of TMY indicated that milk yield decreased significantly ($P < 0.01$) by -196.92 kg/year. This reduction could be caused by several reasons such as involuntary culling of high milking cows, no improvement program was applied and reduction in the level of management. Thus it was very imperative to conduct some studies to investigate reasons of such reduction in TMY. Similarly, Abou-Bakr (2009) detected a significant ($P < 0.02$) negative phenotypic trend in milk yield with an overall rate of -91.6 ± 35.16 kg per year for the same breed in Egypt. The heritability of the TMY ranged widely from 0.06 to 0.39 (Klopcic *et al.*, 1997; Ojango and Pollott, 2001; Hermiz *et al.*, 2005; Cilek and Sahin, 2009; Ayied *et al.*, 2011; Usman *et al.*, 2012; Nawaz *et al.*, 2013; Hamrouni *et al.*, 2014). Differences in heritability estimates among various studies for the same trait of the same breed could be due to differences in the records number used, the correction for different non-genetic factors, the model used and the methodology for estimating heritability of the trait (Abou-Bakr, 2009) in addition to herd size, level of production and region in the same country (Hamrouni *et al.*, 2014).

Moderate heritability (0.35) estimated in this study refers to a considerable genetic variation among sires. Our estimate was close to the estimate of 0.32 reported by Nawaz *et al.* (2013). The estimate of heritability decreased from 0.35 to 0.31 when LL was included as a covariate in the model. Ojango and Pollott (2001) reported that the heritability estimate for milk yield, considering lactation length as a covariate, was moderate (0.25 ± 0.04) and less than the estimate for total milk yield ignoring lactation length (0.30 ± 0.04). Madalena (1988) noted that using lactation length as a covariate in analyses of milk yield tended to reduce differences between animals, making low-producing animals seem to produce more milk.

Although the animal model was more accurate than sire model for genetic evaluation, we used sire model because the required relationship information was not available. The BLUP values of sires for the TMY ranged from -471.88 to 443.80 with marginal

difference of 915.68 kg between lower and higher value.

The corresponding values of TALSM and TAM were -470.38 to 380.88 kg and 851.26 kg, respectively. Similarly, Abubakar *et al.*, (1986) with 15512 lactation records of daughters of 138 sires found that BLUP of 305 milk yield ranged from -400 to 400 kg. Abdel-Glil (1991) with 1653 lactation records of daughters of 163 sires found that BLUP values ranged from -466 to 681 kg. Also, Atil and Khattab (1999) with 1931 lactation records of daughters of 76 sires found that the BLUP values ranged from -506 to 675 kg with marginal difference of 1181 kg and TALSM values ranged from -964 to 895 kg with marginal difference of 1859 kg. Although the accuracy for three methods was not high and this could be attributed to low No. of daughter per sire (3.51), the present study detected the existence of a considerable genetic variation which could be used to improve TMY.

The spearman rank correlation coefficient between BLUP and TALSM (0.81) was higher than 0.71 obtained by Glil and Parmar (1988) and lower than 0.88 and 0.98 reported by Vij and Tiwana (1988) and Atil and Khattab (1999) respectively. Low correlation was found between BLUP and TAM. The differences among estimates of Spearman rank correlation indicated that the three methods were not equal for the evaluation of the sires. The accuracy of the three methods of sire evaluation is between low (0.28) to moderate (0.61) (Table 4). The low estimations of accuracy could be attributed to low number of progeny per sire. Hence it is very imperative to increase the number of progeny per sire to get high estimations of accuracy.

Lactation length:

The range of LL was reported to be from 291.86 to 362 days (Tadesse and Dessie 2003; Hermiz *et al.*, 2005; Sattar *et al.*, 2005; Nawaz *et al.*, 2013). Although, the average LL in the study was within the range, it was lower than the ideal value (305 days). Non-significant effect of sire on LL indicated the importance of non-genetic factors in the variation of this trait.

The significant ($P < 0.01$) effect of parity on LL was reported by several workers (Lakshmi *et al.*, 2009; Topaloğlu and Güneş, 2010). It was found that year of calving had a significant effect ($P < 0.01$) on LL. A similar finding was obtained by Nyamushamba *et al.* (2013) who reported that differences between years were a normal phenomenon which was caused by unforeseen fluctuations in environmental conditions that are difficult to control; particularly this trait had low heritability. Results showed that heritability of LL was low (0.06). The present estimate was parallel to 0.06 that was reported by Lakshmi *et al.* (2009) and close to 0.04 that was recorded by Ayied *et al.* (2011).

The low estimate of heritability indicated that larger proportion of phenotypic variance was due to environment and improvement through direct selection would be slow.

Ojango and Pollott (2001) found that the heritability of LL was 0.09 for the same breed in Kenya. They concluded that low estimation of heritability implied that the variation in lactation length was more a result of variation in management and feeding in the given environment of lactation rather than the genetic factors. On the other hand the effect of season of calving and age at first calving was non-significant. Although, phenotypic trend of LL (0.35 days/year) was positive and significant ($P < 0.05$), more efforts are needed to extend LL as its average was lower than optimum length.

Dry period:

Mean DP of 114.13 days in this study was within the range of 100.26 to 281.33 days obtained by several researches (Abdullah, 2005; Hermiz *et al.*, 2005; Sattar *et al.*, 2005; Suhail *et al.*, 2010; Hossein-Zadeh and Mohit, 2013). Dairy cows are usually dried-off for two months prior to the next calving. This rest period is necessary to maximize milk production in subsequent lactation. It was reported that the dry period was required for the renewal of udder glandular tissue (Capuco *et al.*, 1997; Annen *et al.*, 2004). Two studies that were carried out in Poland by Borkowska *et al.* (2006) and Winnicki *et al.* (2008) indicated that in practice the extended or excessively shortened dry period, caused a reduction in milk production as compared to the recommended optimum.

Hossein-Zadeh and Mohit (2013) divided cows according to DP into 14 classes from < 10 days through > 130 days. They found that cows with group of DP between 51 -60 and 61 - 70 days had the highest milk yield.

Long DP found in this study will decrease the average annual production of the cow by extending the calving interval beyond the normal 13-14 month interval and causing a decrease in the lifetime production of the dairy cow.

DP was affected significantly ($P < 0.01$) by sire. This result was in agreement with Hermiz *et al.* (2005), Ayied *et al.* (2011) and Usman *et al.* (2012). On the contrary some workers (Kuhn *et al.*, 2005; Suhail *et al.*, 2010) observed that sire had a non-significant effect on the DP. Results revealed that DP was affected significantly ($P < 0.01$) by parity. A similar finding was reported by Hossein-Zadeh and Mohit (2013). The differences could be attributed to the differential culling which may account for part of the differences between parities (Kuhn *et al.*, 2005). It was found that DP of 4th parity was the highest while the lowest was at 5th parity. This estimation was parallel to the corresponding estimation of LL. Kuhn

et al., (2005) who reported that the longer lactations were associated with longer dry periods. Year of calving had a significant ($P < 0.01$) effect on DP. Our results confirmed results that were obtained by Hossein-Zadeh and Mohit (2013).

Heritability of DP (0.14) in this study was higher than 0.07 reported by Funk *et al.* (1987) and Kuhn *et al.* (2005) and lower than 0.22 that reported by Hermiz *et al.* (2005). The low estimate of heritability indicated that the large phenotypic variation in DP was due to the environmental factors.

The significance ($P < 0.05$) of each of positive phenotypic trend of DP, positive trend of LL and negative phenotypic trend of TMY, all together was referred to the absence of applying suitable improvement program in this herd. In conclusion, many efforts are required to enhance the productive performance of the herd. The poor production of this herd could be attributed to the sub optimal performance of cows as a result of unplanned breeding and inadequate feeding, management and disease control measures.

Thus, improving environmental conditions and management practices, coupled with improved genetic potential of dairy animals would be more effective approaches for high milk production. Although, the results showed that the values of spearman correlation coefficients for the three methods were moderate, the accuracy of the sire evaluation was low to moderate (0.28 – 0.61). Hence, we recommend to adopt the BLUP for selection of sires.

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