The Journal of Animal & Plant Sciences, 29(1): 2019, Page: 48-57
ISSN: 1018-7081

MOST PROBABLE PRODUCING ABILITY AS A WITHIN-HERD MANAGEMENT AND CULLING TOOL

N. Mikail[1,*], R. Cue[2] and G. Bakir[1]

[1]Department of Animal Science, Faculty of Agriculture, Siirt University, Siirt, Turkey
[2]Department of Animal Science, Faculty of Agriculture, McGill University, Quebec, Canada

[*]Corresponding author's email: naziremikail@siirt.edu.tr

ABSTRACT

The objectives of this study were to examine the effects of management and environmental effects on milk yield (factors such as herd, year of calving, parity and age at calving), total and 305-dayand to examine the magnitude of the variability amongst cows. Data were obtained from three state farms. Data set consisted of records from 1004 Holstein-Friesian and 6690Brown Swiss cows. The average total milk yield, days in milk and 305 day milk yield were 5760 kg, 316 days and 5420 kg, respectively. Repeatability of total milk yield, 305 day milk yield and most probable producing ability of each cow were calculated. Repeatability of total and 305 day milk yield was estimated to be 0.31. The results of this study suggest positive trends for lactation milk yield and the significant repeatability shows that it is possible to rank cows, on a within-herd basis, on the basis of their Most Probable Producing Ability, and hence use this as a phenotypic selection and culling criteria for herd management.

Keywords: cow; farm; management; culling criteria.

INTRODUCTION

It would be useful for a livestock owner to predict a cow's future producing ability in terms of her milk production. Age at first calving determines the beginning of the cow's productive life and influences her lifetime productivity (Ojango and Pollott 2001; Ruiz-Sanchez *et al*. 2007). Cows that calved at younger ages in lactations 1 and 2 produced less milk compared to cows calving at older ages over the entire lactation. Second and later parity cows had higher test-day yields than heifers for most stages of the lactation. These estimates can be used to adjust test-day and cumulative yields for the effect of age class, thereby enabling the determination of herd levels (Mostert *et al*. 2001). Expected from dairy cattle is a high level of milk production throughout the lactation and a calf per year (Sehar *et al*. 2011). It is important to use an appropriate statistical method in working to analyse milk yield to provide information to assist producers in increasing and improving milk production. For herds with regular yield recording, repeatability (r) and most probable production ability (MPPA) are commonly used statistical estimates used in methods to evaluate cows (Soysal and Tuna 2000). Repeatability, and MPPA, account for the genetic effect of an animal plus the permanent environmental effects on that animal; the classical formula for MPPA is: MPPA = $(nr/(1+[n-1]r)\ ^{*}$ Average Deviation, where n is the number of records of a cow, r is the repeatability, and the Average Deviation is the average of the cow's records expressed as deviations from the appropriate known population means. An MPPA value can be considered as a deviation of a cow's predicted performance from an average value for the herd. In this sense, MPPA can be used by the individual livestock producer as a means of ranking and culling cows within a herd. It cannot be used as a method of comparison among cows in different herds since it is a deviation from a herd average (Itulya, 1980).Repeatability is an important parameter in selection and culling. It indicates the propensity for a cow with an above average production to have a continued above average production in subsequent lactations, or conversely a cow with below average production to continue to have a below average production. In traits with a low repeatability, the value of the first lactation production is not a good indicator of future performance, it is better to decide based on the average of more than one lactation, by waiting a year or two more to identify the animals to be selected, or conversely culled (Arıtürk and Yalçın 1996; Sehar *et al*. 2011).

Lactation length, lactation milk yield and 305 day milk yield of Holstein-Friesian cattle grown in different herds in Turkey has been reported as 241to 349 days,2021to 7161 kg, and 2235to 6776 kg, respectively (Atay *et al*. 1995; Güneş 1996; Kumlu and Akman 1999; Bakır and Çetin 2003). Many studies on milk yield of Brown Swiss cows have been carried out at herds in different regions of Turkey (Özbeyaz and Küçük 1999; Çakıllı and Güneş 2007; Çilek and Tekin 2007; Şeker *et al*. 2009). Milk yield of Brown Swiss cows was reported to be between 3300 kg and 6000 kg, lactation lengths of Brown Swiss cattle were found to be between 300 and 323 days. Milk yield levels of dairy cows reared in Turkey are affected by genetic structure and environmental conditions and vary across different regions and different herds. These differences are due to a mixture of regional (environmental) differences and herd to herd differences (due to management and/or breeding) (Kutlu *et al*. 2003; Erdem *et al*. 2007; Bakır *et al*. 2009). We are interested in examining the management and environmental effects because this information can be useful to dairy producers and advisors so that they can know what production could typically be expected from cows of a given parity and age, i.e. these results will provide benchmark statistics suitable for allowing producers to compare their herds against. The interest in the magnitude of the between cow variability (repeatability) is because if the between cow variability is a significant proportion of the overall variability then it means that there is a useful repeatability and hence will indicate that we could rank cows on a within-herd basis to allow producers to select or cull animals based on their MPPA (Lush 1945), i.e. a useful on-farm management tool.

MATERIALS AND METHODS

Data on total lactation milk production and 305-day milk production were obtained from Tahirova, Konuklar and Malya farms. These farms are state enterprises belonging to the General Directorate of Agricultural Enterprises (Fig. 1).

Figure 1. Locations of investigated farms

Konuklar Farm is located in the Sarayönü district, 57 km from Konya. The climate is a typical continental climate of Central Anatolia; summers are hot and dry, winters are cold and rainy (GDA 2016). The average annual rainfall is 322.4 mm, and the altitude is 1050 m.The average annual temperature is 11.6°C (GDM 2017). Malya Farm is located 27 km north east of Kırşehir, 200 km from Ankara. This farm is located in a cup-shaped Malya Plains, 1100 meters above sea level, surrounded by high mountains and hills in the Central Kızılırmak Basin of Central Anatolia Region, at an altitude of 985 m. Again, the climate is the typical continental climate of Central Anatolia, summers are hot and dry and winters are cold and rainy (GDA 2016). The average annual rainfall is 378.4 mm. The average annual temperature is 11.4°C (GDM 2017). Tahirova Farm is located in Balıkesir province, Southern Marmara Region; the farm is situated at an altitude of 166 m. The Farm is on the Gönen River Delta. Summers are hot, winters are rainy. The average annual rainfall is 583.7 mm. The average annual temperature is 14.6°C(GDM 2017). There is an alluvial and in the south a colluvial soil. Marmara Crossing climate prevails in the region. In terms of climate, soil, water and irrigation the farm has favorable conditions (İnan and Yaşar 2015). At all three farms the cows were grazed and winter supplement was also provided. Records covered the period of calving from 1985 to 2009, although (as with most field recorded data) there were some obvious data entry errors (2 cows were recorded as being born in 1921 and 1971). The criteria for excluding records were based on those reported in major dairy research journals, discussion amongst the authors concerning what limits were biologically sensible given the level of production and the types of production systems in the three herds as well as a visual inspection of the data. Only records up to parity 7 were retained, the number of records from parities 8 and above was too few to provide meaningful statistical analyses. Very short (< 130 days) or very long lactations (> 650 days) were excluded as being not biologically useful or meaningful.

The average lactation milk yield was some 5000kg; based on this and a visual inspection of the raw data we excluded records where the recorded total lactation milk production was greater than 12.000 kg (for first lactation animals), or greater than 13.000 kg for subsequent lactations; there were some recorded lactation yields as high as 68.000 kg, which we consider to be unrealistic.

Of the total number of records the main reason for exclusion of records was due to missing milk yield, Table 1.

Table 1. Numbers of records, exclusion reasons and numbers of records deleted for each reason.

Total number of records	**10849**
Reasons for exclusion	Number of records removed
Total lactation milk yield missing	2506
Unknown date of birth or calving	92
Year of birth before 1985, or after 2005	38
Year of calving before 1986	4
Parity less than 1, or greater than 7	94
Days in milk less than 130	12
Days in milk greater than 650	12
Calving date before the birth date	9
Duplicate records	9
Nonsensical total lactation milk yields	45

The various other edit criteria removed 649 records, which is an acceptable error rate and broadly comparable to exclusions reported in other population studies. Table 2 shows the number of records for each parity.

Table 2. Number of records for each parity.

Parity	Number of records
1	2433
2	1880
3	1360
4	928
5	598
6	340
7	155

For any study involving repeatability it is important that a substantial number of cows have multiple records, otherwise the repeatability estimate will be very imprecisely estimated. In this study (Table 3) we see that 75% of the cows had 2 or more records, indeed 53% of cows had 3+ records, which is quite impressive and indicates good longevity.145 records were lost from cows which did not have a 305-day record (which record is the lactation milk yield up to, but not past 305 days).

Table 3. Number of cows with various numbers of records available.

Number of records per cow	Number of cows
1	633
2	550
3	438
4	330
5	270
6	179
7	129

The concept of MPPA was first introduced by Lush (1945) as a means of estimating the producing ability of each cow under standard conditions within a herd. MPPA allows the comparison of cows with different numbers of records. MPPA measures both genetic and permanent environmental effects. Use of lifetime records reduces the effects of the temporary environment. The classical (selection index theory) MPPA predicts a cow's MPPA as the regression of MPPA on the average of the cow's lactation records, adjusted for all the fixed effects. This assumes and presumes that the means of all the fixed effects are known without error, which will rarely be the case. Thus, mixed models equations (Henderson, 1984) are more appropriate, in that they allow simultaneous estimation of both the fixed effects and the random effects and account for the uncertainty of estimation.

Data were analyzed using R Version 3.2.4 (DCT, 2008) and the lmerTest (Kuznetsova *et al*. 2014) package (which provides a mixed model framework for analyses, broadly comparable to SAS proc mixed).

The following statistical model was used for both total lactation milk yield and for 305-day milk yield:

$$Y_{ijkmnp} = \mu + Herd_i + Parity_j + YoC_k + Age_m + Herd_i \times Parity_j + Herd_i \times YoC_k + Parity_j \times YoC_k + Herd_i \times Age_m + Herd_i \times Parity_j \times YoC_k + Cow_{in} + e_{ijkmnp} \quad (1)$$

Where Y_{ijkmn} is the recorded milk yield (total or 305-day) of the nth cow from the i^{th} herd of the j^{th} parity, the k^{th} year of calving and the m^{th} age at calving,

$Herd_i$ = the fixed effect of the i^{th} herd, i = 1, 2 or 3

$Parity_j$ = the fixed effect of the j^{th} parity, j = 1,..,7

YoC_k = the fixed effect of the k^{th} year of calving, k = 1985 to 2009

Age_m = the fixed effect of the m^{th} age at calving, m = 22 to 109

Cow_{in} = the random effect of the n^{th} cow within the i^{th} herd;

$Cow_{in} \sim N(0,\sigma^2_{cow})$, n = 1 to 2528

e_{ijkmn} = the random residual observation associated with the observation (recorded milk yield)) of the nth cow from the i^{th} herd of the j^{th} parity, the k^{th} year of calving and the m^{th} age at calving,$e_{ijkmn} \sim N(0,\sigma^2_e)$

The effects of cow (nested within herd), and residual were random effects, all other effects were fixed effects terms. Initial analyses showed that the effect of age at first calving (over and above the fitted effect of Age at Calving of each parity) was non-significant. Likewise, the effect of Year of Birth, over and above the effects of Age at Calving and Year of Calving (YoC), was non-significant. This is not surprising when we remember that Year of Calving – Age at Calving = Year of Birth, i.e. that there are 3 factors, but only two of them are independent, the third is a linear function of the other two effects. Fitting Year of Calving explains more variability than Year of Birth, hence the analyses used YoC. Examination of the estimates of the Herd by Age at Calving least squares means and their associated standard errors, combined with counts of the numbers of records in each age class showed that the age classes above 108 months had only one to 5 records each and hence large standard errors, consequently we pooled all observations above 108 months into a single Age at Calving class (designated as 109 months). The random effect solutions (for cows) can be extracted from the object returned from the lmerTest package using the ranef () function and correspond to the MPPA, and the prediction error variance of the cow solutions can be used to calculate the accuracy of each cow MPPA. We note in passing that the MPPA corresponds to the sum of the genetic effect of a cow plus its permanent environmental effects. In most genetic evaluation systems making use of animal models and full pedigree information then the combination of the Best Linear Unbiased Prediction (BLUP) of a cow's EBV (Estimated Breeding Value) and her permanent environmental effect will correspond to the MPPA.

RESULTS AND DISCUSSION

It was considered that it is useful and informative to present the number of data records in the original files and the various counts of numbers of records removed for each reason; to provide the reader with an understanding of the data quality and the reasons and criteria for record exclusions. Without this information, if we had simply indicated that 7694 records were available then the reader would not have any idea whether there had been many records with missing values or values outside of biologically sensible limits. Subsequent researchers might think that if they had to delete some records due to missing values etc, that they were poor researchers. It is important to have an appreciation of field-recorded data and its quality, hence our deliberate presentation of this information.

An initial model was fitted including the random effect of sires; there were 307 sires, with the majority of sires having less than 10 progeny each. Including the random effect of sire accounted for only 2% of the phenotypic variance. We consider that this is not helpful to include in our presented models. An objective of this presented research is to suggest that producers can use the records on cows for a within-herd phenotypic cow ranking, without reference to any external pedigree. Including sire, when commercial producers may in all likelihood not record sire identification consistently would therefore be counterproductive. In addition if one is going to include the sire effect one should also include the dam effect, which information was lacking in these data. Producers who do consistently record both sire and dam are likely to already be participating in a breed association recording and genetic evaluation programme and will therefore probably already be receiving genetic evaluations (Estimated Breeding Values), and hence not have need of such within-herd cow rankings. Thus subsequent analyses did not retain the sire effect.

Fig. 2 shows the least-squares means and 95% confidence intervals for each Age at Calving class (23 to 109 months), the actual least squares means, standard errors and associated degrees of freedom for each Age at Calving class are provided in the Supplemental table.

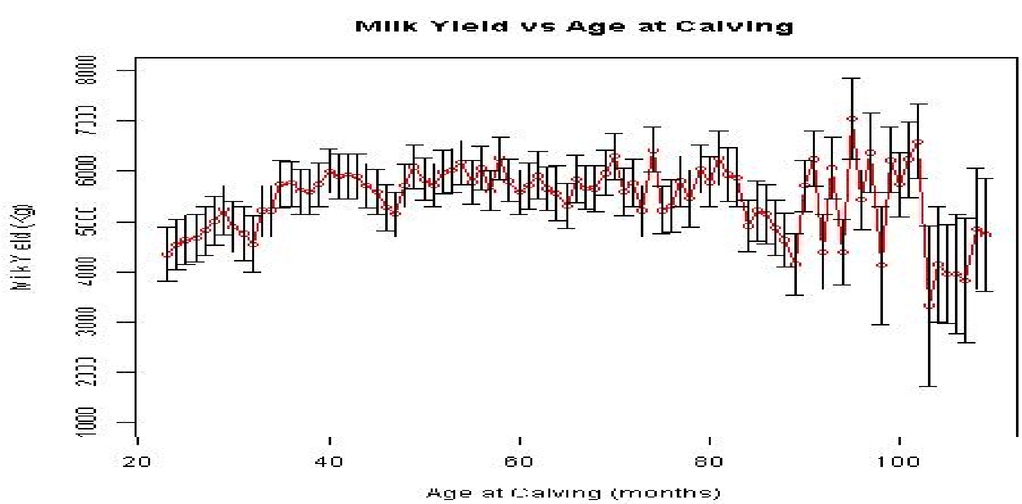

Figure 2.Total lactation milk yield vs Age at calving

There appears that there may be an approximately quadratic relationship between milk yield and age. Thus these least squares means were used in a weighted regression analysis to determine whether or not there was indeed a quadratic relationship between total lactation milk yield and Age at Calving. The weights were the inverse of the sampling variance of each least squares mean. There was a significant curvilinear effect, with an intermediate maximum yield, when cows were approximately 66 months of age.

The curvilinear relationship between total lactation milk yield (MY) and Age at Calving (Age) was thus described by

$$MY = 3.3288 + 0.078099 \times Age - 0.000601 \times Age^2 \quad (2)$$

Where, Age is measured in months, and MY has been divided by 1000 for ease of computation. This gives a maximum lactation yield of 5.860 (= 5860 kg) at 65 months of age, an expected lactation yield of 4.810 kg at 23 months and an expected yield of 5.130 kg at 100 months. If we consider that the yield at 66 months corresponds to that of a mature cow, then we can see that a cow calving for the first time at 23 months of age is producing only 82% of the expected mature yield. This proportion is similar to that reported for heifers in many previous studies (Bakır and Çetin 2003; Bakır *et al*. 2009; Çilek and Bakır 2010). What we consider important and interesting here is that the pattern is similar to elsewhere, all be it that the absolute level of production (Table 4) is lower than that reported in many North American scientific articles (Pietersma *et al*. 2006).

Table 4. Basic descriptive statistics.

Traits	Number of records	Number of cows	Mean (×1000 kg)	S.D.	Min.	Max.
Total Milk Yield	7694	2528	5.760	2.015	0.755	12.874
305-day Yield	7549	2244	5.420	1.744	0.304	11.712

It is interesting that our results suggest that the maximum, mature milk yield is attained at between the 4th and 5th parities, whereas conventionally received wisdom considers 3rd lactation to correspond to mature yield. It would be useful, in further studies involving a larger number of herds, to corroborate this.

Continuing this analysis of Age at Calving, a model was fitted including Age as linear and quadratic regression coefficients, as well as a classification factor (an over-parameterized model) to determine whether a factor (classification) model can explain more of the variation, or whether a simpler model fitting linear and quadratic regressions on Age would suffice. The classification model still provided a statistically significant improvement in the goodness of fit (as determined by a F-test) over and above linear and quadratic regressions, which were therefore dropped for subsequent analyses.

The least squares means for Parity×Year are presented in Fig. 3 and were used in a similar manner to the above analyses of Age at Calving effects, likewise in a weighted regression analysis by parity, to examine whether there were any linear trends, over time (years), for total lactation milk yield within each parity. The least squares means, standard errors and degrees of freedom are available in the supplemental table.

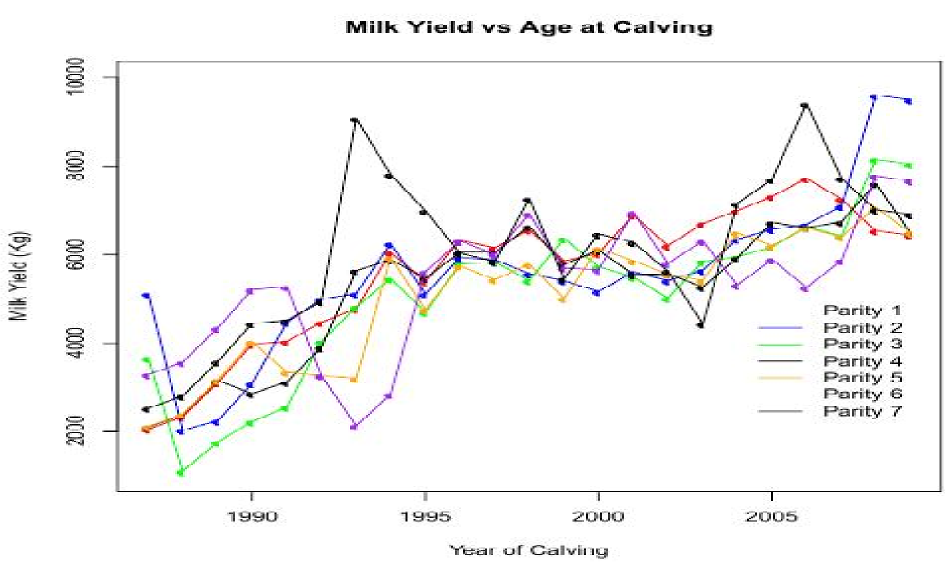

Figure 3. The least squares means for Parity×Year

Table 5 shows the analysis of variance table of type III with Kenward-Roger approximation for degrees of freedom of Total milk yield. We can conclude that there are herd-by-age at calving and herd-by-parity-year interaction effects, over and above the lower order interactions. The interpretation of this is that the differences between the parity effects vary from year to year, and vary amongst herds.

Table 5. Analysis of Variance Table of type III with Kenward-Roger approximation for degrees of freedom of Total milk yield.

	DF	SS	MS	Denominator DF	F value	Pr>F
Herd	2	34.34	17.168	4753.7	9.5701	7.114e-05***
IAgeMCalve	98	395.19	4.033	6240.1	2.2479	3.910e-11***
Parity	6	13.53	2.255	6461.6	1.2568	0.2738892
YoC	22	702.65	31.939	6542.5	17.8039	<2.2e-16***
Herd:IAgeMCalve	176	508.14	2.887	6207.9	1.6094	8.439e-07***
Herd:Parity	12	31.45	2.621	6440.3	1.4609	0.1310598
Herd:YoC	30	334.93	11.164	6403.5	6.2234	<2.2e-16***
Parity:YoC	107	286.50	2.678	6482.4	1.4926	0.0008223***
Herd:Parity:YoC	119	362.52	3.046	6529.7	1.6982	4.071e-06***

***: $p < 0.001$

Since the interactions were statistically significant we can equivalently look at the above effects as interactions, or alternatively we could consider the various effects to be nested within herd; both would produce the same least squares means and explain the same amount of variation (Sums of Squares). We choose to present the above effects as main effects and interaction as we consider this to be more informative. If the fixed effects (Parity, Age, Year of Calving) are directly fitted as nested within herds, then this precludes testing the significance of the main effects and the interaction, thus we find it more useful (see Table 7) to retain the formulated mode with the main effects and interactions.

A similar analysis of 305-day milk yield revealed very similar overall results and trends, albeit with a slightly lower repeatability (0.306). Consequently we do not repeat the results.

The linear regression coefficients (over time) indicate that the trend for milk production was between 120 kg improvement per year and 200 kg improvement per year increase, with larger trends for younger animals, see Fig. 4, 5, 6 and 7 for plots of least squares means for parities 1 to 4 respectively.

These results indicate improving milk production over time, which can be considered a desirable outcome since increase increasing milk yield is typically associated with improved productivity and efficiency. It should be noted that this study cannot determine what proportion of this phenotypic improvement might be due to genetic improvement and what might be due to improved nutrition and management. Table 6 presents the cow and residual variances.

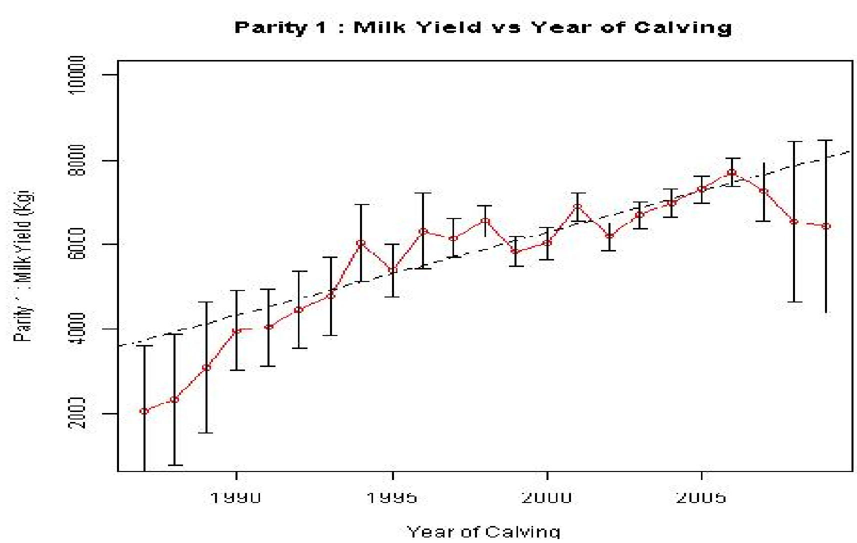

Figure 4. Total lactation milk yield vs year of calving, parity 1

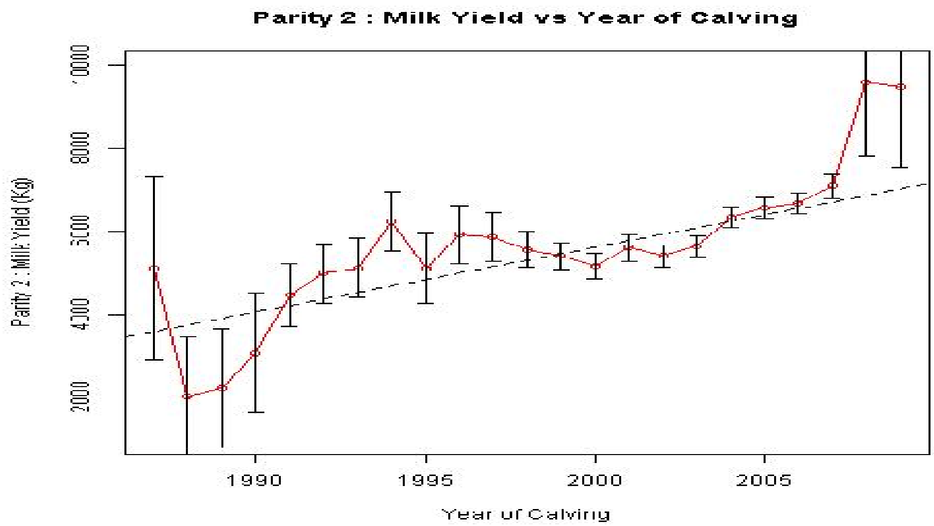

Figure 5. Total lactation milk yield vs year of calving, parity 2

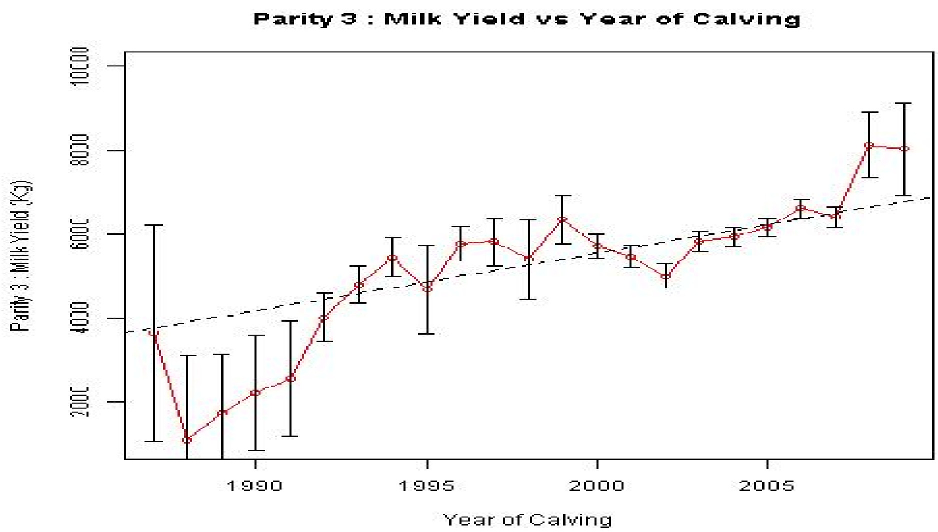

Figure 6. Total lactation milk yield vs year of calving, parity 3.

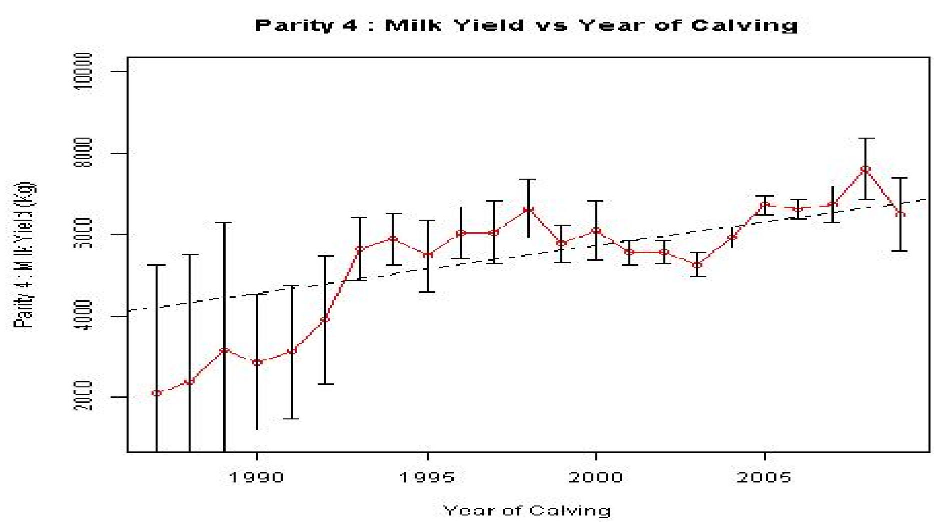

Figure 7. Total lactation milk yield vs year of calving, parity 4

Table 6. Variance components and repeatabilities.

Parameter	Total Milk Yield	305-day Milk Yield
σ_{cow}^2	0.79779	0.51085
σ_e^2	1.79391	1.15916
Repeatability $\sigma_{cow}^2/(\sigma_{cow}^2+\sigma_e^2)$	0.3078	0.3059

For total lactation milk yield the repeatability (ratio of cow variance to total phenotypic variance) was 30%. This indicates that a substantial proportion of the variability is due to cow difference, indeed the repeatability is normally taken as an upper limit to the heritability of a trait (Falconer and Mackay 2004); thus one can use the random effects solutions to rank cows (on a within-herd basis) for within-herd management decisions about which cows to retain and which cows to cull. The predicted value for each cow will be the MPPA (Lush 1945), accounting for the various effects of Parity, Age at Calving, Herd and Year of Calving. An example will assist to demonstrate; Table 7 presents the raw data from two cows, which have 6 records and 3 records respectively.

Table 7. Example of data and MPPA for two sample cows.

Cow	Date of Birth	Parity	Date of Calving	MY	Average Milk yield	MPPA	Prediction Error Variance	Accuracy
1	2001/2/13	1	2003/6/10	4.837	6.836	0.4423	.2175	.726
		2	2004/6/20	5.166				
		3	2005/6/12	7.388				
		4	2006/5/19	8.280				
		5	2007/6/25	8.144				
		6	2008/6/22	7.204				
2	2000/1/3	1	2002/1/26	7.309	6.693	0.9212	.3414	.569
		2	2003/10/27	5.485				
		3	2005/3/12	7.285				

The simple averages are quite comparable (6.839 and 6.693 x 1000 kg), indeed the raw average for Cow 1 is slightly greater than that of Cow 2. However, from the mixed model analyses, once adjusted for the Age at Calving and the Year of Calving of each lactation, we see that the MPPA of Cow 1 is only 0.4423 vs 0.9212 for Cow 2; in other words Cow 2 ranks significantly higher than Cow 1. The interpretation of this information is that we would expect Cow 2 to produce 921 kg (0.9212* 1000) more than the average in future lactations, whereas Cow 1 would only be expected to produce 442 kg (0.4423* 1000) more than the average; thus in a choice between these two cows we should select to keep Cow 2 rather than Cow 1. Mixed models, and the lmerTest package specifically, allow us to obtain the prediction error variance, from which we can calculate the accuracy (both presented in Table 6). Sharma *et al* (2011) proposed a web-based tool for computing MPPA's for cows, using the classical selection index/regression approach. This approach does not account for the uncertainty of estimation of the various fixed effects; now, with the availability of Open Source mixed models software (R, lmerTest) it is more appropriate to use a mixed model to predict the random (cow) effects and their prediction error variances, and thus accuracy. These MPPAs are BLUPs where cow (within herd) is the only random effect in addition to the residual. In the Appendix we provide a skeleton outline of the R code necessary to fit the model we have used and to extract the cow solutions (BLUPs) and Prediction Error Variances. These mixed model equations are essentially Best Linear Unbiased Predictions (BLUP). Effect of age at first calving, year of calving and parity on milk yield was found significant in most papers (Bakır and Kaygısız 2004; İnci *et al*. 2007; Bakır and Kaygısız 2009).

When results about milk production characteristics of Holstein cows raised in Tahirova State Farm were compared with other state farms in Turkey, it can be concluded that milk yield of Holstein cows reared at this farm (Aegean region of Turkey) is very good (Bakır and Kaygısız 2009).

Calculated average milk yield per year from 1987-1993 data was less than semi state farm averages (Falconer and Mackay 2004) and other state farm averages located in the same region (İnci *et al*. 2007). Milk yield fluctuated with years, the trend was usually positive. It is thought that the fluctuation in milk yield seen over years could be a result of variations in environmental factors (Bakır and Kaygısız 2009); these environmental factors could be such effects as management differences, nutritional differences from year to year due to feed and forage quality differences as well as weather-related environmental effects per se.

Repeatability was estimated to be 0.31 for total milk yield and 305 day milk yield. In another study (Şahin and Ulutaş 2010), repeatabilities for both total milk yield and 305 days milk yield were estimated to be 0.34 and 0.36, respectively, in Holstein Friesian cattle reared in state farms, for Brown Swiss cattle repeatability of 305-day milk yield was estimated to be 0.36 (Bakır and Kaygısız 2009). In the work of (Sehar *et al*, 2011) repeatability of lactation yield was found as 0.289 for Holstein cattle. There was no significant difference between the breed means. The analyses fitting herd effects will account for any breed differences.

Positive trends for lactation milk yield (improvements of 120 to 200 kg per annum) and the significant repeatability shows that it is possible to rank cows, on a within-herd basis, on the basis of their Most Probable Producing Ability (estimated from the mixed model predictions of the random effects for each cow), and hence use this as a phenotypic selection and culling criteria for herd management.

The model used here, and the proposal that this methodology can be used for within-herd ranking of cows, using R, lmer Test and mixed model methodologies is not meant to imply that this is a tool that can be, nor should be, used directly by an individual producer on his/her own farm unaided; we consider that this software requires some expertise to use, and since it needs a reliable data source then we posit that milk recording, and/or a trained advisor would be the most sensible manner to use this approach. The term within-herd only indicates that the individual herds are completely separate sub-sets, since there are no genetic linkages being considered across herds. We suggest that whichever organization is carrying out the milk recording, data processing and data storage, recording the information on dates of birth, calving and drying off, and milk composition, checking and validating the records etc, would be a suitable organization to be able to run such analyses whenever an individual producer wished to obtain his/her rankings of cows for management decision purposes. It is obvious that in an actual implementation of this approach there would be additional data processing required. For example, once the cows in a herd were ranked, then it would be necessary to merge these results back with the original data to eliminate any cows which had already been culled/ sold, so as to produce only a list of currently active cows. The use of MPPA to rank cows is not to be considered as a substitute for EBVs and genetic evaluations, but rather as a tool for commercial producers who want to make use of milk recording, but are not at the level of complete pedigree recording and supervised milk recording.

Conclusion: Lactation milk production records can be used, with mixed models methods, to predict the production ability of cows, which can thus be used for ranking cows within herds. Such an approach is a complement to the use of Estimated Breeding Values (EBVs) from genetic evaluation systems. EBVs allow us to rank animals to use for breeding (selection) to produce the animals of the next generation, whilst MPPA allows us to ranking animals for immediate culling and current herd management.

Acknowledgements: The authors acknowledge YÖK (Yüksek Öğretim Kurulu) for the financial support to Nazire MİKAİL for a study leave at McGill University.

REFERENCES

Arıtürk E. and B.C. Yalçın (1996). Selection in Animal Breeding. Ankara University, Veterinary Faculty Publications: No 194, Ankara (Turkey).

Atay O., S.M. Yener, G. Bakır and A. Kaygısız (1995). Estimates of genetic and phenotypic parameters of milk production characteristics of Holstein cows raised at the Ankara Atatürk Forestry Farm in Ankara. Turkish J. Vet. Anim. Sci., 19: 441-447.

Bakır G. and M. Çetin (2003). Breeding characteristics and milk yield traits of Holstein Cattle in Reyhanlı Agricultural Facility. Turkish J. Vet. Anim. Sci. 27: 173-180.

Bakır G. and A. Kaygısız (2004). Estimates of trends components of 305 days milk yield at Holstein Cattle's. J. Biological Sciences 4: 486-488.

Bakır G., A. Kaygısız and S. Çilek (2009). Milk yield traits of Holstein cattle reared at Tahirova State Farm in Balıkesir Province in Turkey. J. Anim. Vet. Adv. 8: 2369-2374.

Çakıllı F. and H. Güneş (2007). Studies on the milk production traits of Brown Swiss cattle. J. The Faculty of Veterinary Medicine, İstanbul University33: 43-58.

Çilek S. and G. Bakır (2010). Milk yield traits of Brown cows reared at Malya State Farm and effects of some environmental factors on these traits. J. Faculty of Veterinary Medicine, Kafkas University 16: 347-350.

Çilek S. and M.E. Tekin (2007). Environmental factors affecting milk yield traits of Brown Swiss cows raised at Ulaş State Farm and phenotypic correlations between milk yield and fertility traits. Indian J. Anim. Sci., 77: 154-157.

Erdem H., S. Atasever and E. Kul (2007). Milk yield and fertility traits of Holstein cows raised at Gökhöyük State Farm. 1. Milk Yield Traits. J. Faculty of Agriculture, Ondokuz Mayıs University 22: 41-46.

Falconer D.S. and T.F.C. Mackay (2004). Introduction to Quantitative Genetics. USA: New York pp. 1529-1536.

GDA (2016). General Directorate of Agriculture. https://www.tigem.gov.tr-/Isletmeler.aspx (Date of access: 14.07.2016).

GDM (2017). Official statistics. General Directorate of Meteorology. https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx (Date of access: 04.05.2017).

Güneş H. (1996). Investigationson ten-year Holstein Cattlebreeding in Kumkale Agricultural Farm (Milk yield traits). J. The Faculty of Veterinary Medicine, İstanbul University 22: 225-240.

Henderson C. R. (1984). Applications of linear models in animal breeding. University of Guelph. ISBN 0-88955-030-1

Itulya S.B. (1980). Most probable producing ability, fertility and related selection criteria for Hereford cows. PhD Thesis, University of Arizona (Unpublished), USA.

İnan H. and O. Yaşar (2015). An examination aiming at the socio-economical effects of agricultural facilities: Tahirova Agricultural Facility. Marmara Geographical Review 32: 270-305.

İnci S., A. Kaygısız, E. Efe and S. Baş (2007). Milk yield and reproductive traits in Brown Swiss cattle raised at Altınova State Farm. J. Agricultural Sciences13: 203-212.

Kumlu S. and N. Akman (1999). Milk yield and reproductive traits of Holstein Friesian breeding herds in Turkey. J. Lalahan Livestock Research Institute 36: 1-15.

Kutlu H.R., A. Gül and M. Görgülü (2003). Problems of Turkish livestock and solutions. 1. Breeding Animals. Feed Magazine J. 34: 40-46.

Kuznetsova A., P.B. Brockhoff, R. Haubo and B. Christensen (2014). lmerTest: Tests for random and fixed effects for linear mixed effect models (lmer objects of lme4 package). R package version 2.0-13/r71.

Lush J.L. (1945). Animal Breeding Plans. USA: Iowa State University Press.

Mostert B.E., H.E. Theron and F.H.J. Kanfer (2001). The effect of calving season and age at calving on production traits of South African dairy cattle. South African J. Anim. Sci., 31: 205-214.

Ojango J.M.K. and G.E. Pollott (2001). Genetics of milk yield and fertility traits in Holstein-Friesian cattle on large-scale Kenyan farms. J. Anim. Sciences 79:1742–1750.

Özbeyaz C. and M. Küçük (1999). Milk yield traits in Brown Swiss herd at Malya State Farm. J. Lalahan Livestock Res. Institute 39: 7-16.

Pietersma D., R. Lacroix, D. Lefebvre, R. Cue and K.M. Wade (2006). Trends in growth and age at first calving for Holstein and Ayrshire heifers in Quebec. Canadian J. Anim. Sci., 86: 325-336.

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

Ruiz-Sanchez R., R.W. Blake, H.M.A. Castro-Games, F. Sanchez, H.H. Montaldo and H. Castillo-Juarez (2007). Short Communication: Changes in the association between milk yield and age at first calving in Holstein cows with herd environment level for milk yield. J. Dairy Sci., 90:4830-4834.

Sehar Ö., D. Mundan and O. Karabulut (2011). Repeatability and producing ability of milk yield of Holstein cows in Koçaş State Farm. YYU J. The Faculty of Veterinary Medicine, 22: 35-38.

Soysal M.I. and Y.T. Tuna (2000). Genetic Principles of Animal Breeding. Publications of the Faculty of Agriculture, Trakya University: Publication No 78, Tekirdağ (Turkey).

Şahin A. and Z. Ulutaş (2010). Fertility and milk yield traits of Holstein cattle raised in Polatlı State Farm. Anadolu J. Agricultural Sciences, 25: 202-212.

Şeker I., H. Tasalh, M. Bayraktar, M. Saatçi and M. Tilki (2009). Environmental effects on milk yield traits in Brown Swiss herd raised at Muş Alparslan State Farm in Turkey. J. The Faculty of Veterinary Medicine, Kafkas University 15: 297-300.