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Genetic Evaluation of the Egyptian Buffalo Population for Production Traits

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Abstract: Test-day records were collected monthly over the period between 1999 and 2010 to propose the early routine genetic evaluation for milk yield traits in Egyptian buffalo. The available data set contained 5785 test-day records of milk, fat and protein yield from 1189 lactations of 775 buffalo cows raised at experimental herds were analysed to estimate genetic, permanent environmental and phenotypic changes using restricted maximum likelihood (REML) procedure, fitting multi-trait repeatability animal model. All fixed effects contributed significantly ($P<0.01$) to varition in milk yield traits. Estimates of genetic change for milk yield were -0.05 ±0.04 kg/yr, while permanent environmental and phenotypic changes were 0.01 ±0.04 and -0.01 ±0.00 kg/yr, respectively. The genetic trends of fat and protein yield were -0.43 ±0.50 and -0.88 ±0.81 kg/yr, respectively. The corresponding estimates of permanent environmental change were 0.21 ±0.47 and 0.18 ±1.00 kg/yr, respectively, while phenotypic change were -0.14 ±0.02 and -0.30 ±0.03 kg/yr, respectively. Based on the correlation between the estimated breeding values from the test-day and lactation yield traits, early routine genetic evaluation can be proposed based on test-day records to improve milk yield traits.

Key words: Test-Day Records · Egyptian Buffalo · Genetic Change

INTRODUCTION

Routine genetic evaluation for economically important traits is the main determinants of incomes to dairy farmers and breeding objectives [1]. Thus, the precise information used from individual animals can help in early decisions of management practices and culling when selection is made based on the ranking of their animals in herds by breeding values. Traditionally, aggregated 305-d milk yield of estimating breeding values provide dairy breeders with a tool for identifying the best bull and females for breeding. The main goal of breeding schemes is the early prediction of genetic merit to reduce the generation interval which result in increasing the amount of genetic gain [2, 3, 4]. In the last decades, test-day (TD) models have already implemented early routine genetic evaluation of large commercial dairy cattle populations for economical important traits. One reason for this is to reduce costs and effort of recording schemes. Information of TD milk yield records along the trajectory of the lactation provide longitudinal data could assist in determining biological and management purposes of dairy animals [5]. Compared with the traditional models for accumulated 305-d yields, TD models are more accurate with increasing the volume of data [6,7].

Meyer *et al.* [4] and Ptak and Schaeffer [8] suggested animal model with repeated TD records along the trajectory of the lactation of the same trait (with permanent environmental factor). They fitted herd-TD as a fixed effect of accounting for time-dependent temporary environmental effects that affect the whole herd at a particular TD, such as feed requirements. In Egypt, estimating breeding values focused mostly on aggregated 305-d milk yield. Therefore, much attention should be paid to perform routine test-day records evaluation for economical traits of buffalo populations. First lactation yield is the most commonly used trait as a selection criterion for dairy animals. In experimental stations, most buffaloes have low milk yield and short lactation length during their first lactation [9]. Consequently, the genetic evaluation based on breeding value estimates of milk yield in most cases, is delayed to next lactations. It seems appropriate to maintain animals according to high breeding value estimates through the first three lactations

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or more. Information on the pattern of genetic variation and the relationship between estimated breeding values from the test-day and lactation traits is very limited.

The objectives of this study were to estimate the genetic change, permanent environmental and phenotypic trends for lactation yield traits of milk (LMY) fat (LFY) and protein (LPY) including lactations 1 to 5 in buffalo population under Egypt conditions and to compute the correlation between estimated breeding values from the test-day yield traits of milk (DMY), fat, (DFY) and protein (DPY) and lactation yield traits.

MATERIALS AND METHODS

The study was carried out from buffalo experimental herds belonging to the Animal Production Research Institute (APRI) of the Agricultural Research Center, Egypt.

Description of the Dataset: Test-day records of milk yield, fat and protein percentages were measured following an alternative am-pm monthly recording scheme. Records pertained to 1989-2005 years of the birth, 1999-2010 years of the calving and from the first five lactations between 5 and 285 days in milk (DIM) were considered in this study. In addition, the first class included test days between 5 and 15 DIM and all the subsequent tests were of 30-d interval up to 285 DIM. Buffalo cows had at least 4 TD records/lactation. TD data before 5 day and after 285 days were discarded as well from dataset. TD records/lactation were classified according to days in milk into ten test-days (TD1 to TD10). Data file were classified according to the month of calving into two seasons: hot (April through September) and mild for the rest of months. In the editing process, abnormal records affected by diseases or by missing birth dates, calving dates or dry off dates and yields were excluded. All buffalo cows had actual lactation and lactation milk, fat and protein yield was computed from test-day records. In total, there are 5785 TD records from 1189 lactations of 775 buffalo cows progeny of 119 sires and 516 dams. All pedigree information available were considered in data file between 1989 to 2005. More detalied consideration of dataset and management of the experimental population were presented by El-Bramony *et al.* [10].

Statistical Analysis: Fixed effects of herd-year-season of calving and age at calving on lactation traits were evaluated with the model:

$$Y_{ij} = \mu + hys_i + b\,(X_{ij} - \overline{X}) + e_{ij} \qquad (1)$$

Where, Y_{ij} is a record of lactation yield traits (LMY, LFY and LPY); μ is the overall mean; hys_i is the effect of $_i^{th}$ herd-year-seson of calving, coded as i=1, 2...,88; b is the regression coefficient of lactation traits on age at calving; X_{ij} is the age at calving of buffalo cow in the $_i^{th}$ herd-year-season of calving; $\overline{X}$ is average the age at calving and e_{ij} is the effect of random residual normally and independently distributed $(0,I\sigma^2_e)$. The following model was used to analyse fixed effects of herd-test-day, year-season of calving and days in milk. The effects of both age at calving and DIM at TD1 were taken into account by fitting them as covarites on test-day traits:

$$Y_{ijkl} = \mu + htd_i + ys_j + dim_k + b_1(X_{ijkl} - \overline{X}) + b_2(X_{ijkl} - \overline{X}) + e_{ijkl} \qquad (2)$$

where, Y_{ijkl} is a record of test-day yield traits (DMY, DFY and DPY); μ is the overall mean; htd_i is the effect of $_i^{th}$ herd-test-day coded as i=1, 2..., 393; ys_j is the effect of $_j^{th}$ year-season of calving, coded as i=1, 2..., 24; dim_k is the effect of $_k^{th}$ days in milk, $_k$= 1, 2,…, 10 starting with TD1 between 5-15d and increased by 1 every 30 days up to 285-d (TD10); b_1 is the regression coefficient of test-day traits on age at calving; X_{ijkl} is the age at calving of buffalo cow in the $_i^{th}$ herd-test-day, $_j^{th}$ year-season of calving, $_k^{th}$ days in milk; $\overline{X}$ is average age at calving; b_2 is the regression coefficient of test-day traits on DIM at TD1; $\overline{X}$ is the aveage at TD1; X_{ijkl} DIM at TD1 in the $_i^{th}$ herd-test-day, $_j^{th}$ year-season of calving and $_k^{th}$ days in milk and e_{ijkl} is previously defined. The annual breeding values for lactation and test-day traits were predicted of buffalo cows and sires considering all available pedigree information generated from their ancestors by restricted maximum likelihood (REML) procedure, using the software PEST 4.0, as described by Groeneveld and García Cortés [11] fitting multivarite repeatability animal model. In matrix notation, the model and its respective assumptions can be described as follows:

$$y = X\beta + Z\alpha + Wc + e \qquad (3)$$

Where, y is the vector of lactation traits; β is the vector of an overall mean and fixed effects of herd-year-season of calving and age at calving; α is the vector of animals' random additive genetic effects; c is the vector of animals' random permanent environmental effects; *X, Z and W* are incidence matrices for fixed and random effects and e is the vector of random residual effects normally and independently distributed as $(0,I\sigma^2_e)$. The assumed multivarite repeatability animal model, in matrix notation, were considered to analyse test-day yield traits:

$$y= X\beta + Z\alpha + Wc + e \quad (4)$$

Where, y is the a vector of test-day traits; β is the vector of an overall mean and fixed effects of herd-test-day, year-season of calving, days in milk, age at calving and DIM at TD1; α, c, X, Z and e are defined as in model (3). Annual genetic change for lactation traits were estimated as the regression of the average estimated breeding vaules on their birth dates of buffalo cows born between 1989 and 2005. Similary, the permanent environmental change were estimated as the regressed coefficient of permanent environmental vaules on year of birth. The phenotypic change were estimated as the regression of overall least squares means estimated from model (1) on year of calving. Correlation coefficients between the estimated breeding values from the test-day and lactation traits were obtained using SAS.

RESULTS AND DISCUSSIONS

Table (1) presents the overall mean (standard deviation, SD) of lactation traits. These averages tended to increase from the first lactation being 1192.9 (525.4), 80.2 (37.1) and 44.8 (18.4) kg to the top at the fifth lactation being 1585.0 (651.6), 108.3 (43.8) and 68.4 (25.9) kg for LMY, LFY and LPY, respectively.

The general pattern of the estimates were naturally of this population. The overall mean was 1439.7(454.0) kg for LMY. This estimate is comprable to the value (1495 - 617) stated by Tonhati *et al*. [12]. It's clear from Table (1) that overall mean of both LFY and LPY were much lower than their corresponding estimates given by Rosati and VanVleck [13] for the Italian buffalo (197 and 105 kg, respectively). Therefore, shifting management applications can improve the performance of the herd. The fixed effects of herd-year-season of calving and age at calving contributed highly significant (P<0.01) to varition in lactation traits (Table 2). Similar results were confirmed by Ashmawy [14] and Mourad and Mohamed [15].

Table 1: Description of edited data for lactation yield traits

		Milk, kg		Fat, kg		Protein, kg	
Lactation	Number of TD record	Mean	SD[1]	Mean	SD	Mean	SD
1	970	1192.9	525.4	80.2	37.1	44.8	18.4
2	1471	1407.7	595.4	93.4	41.4	53.2	22.1
3	1215	1462.9	553.9	99.4	39.2	55.5	20.6
4	1114	1567.0	641.8	104.2	47.1	58.5	23.9
5	1015	1585.0	651.6	108.3	43.8	68.4	25.9
Overal mean		1439.7	454.0	96.1	41.9	53.8	22.2

[1]SD: standard deviation

Table 2: Analysis of covariance for lactation yield traits.

		Mean Sqaure		
Source of variation	d.f	Milk	Fat	Protein
Herd-year- season of calving	87	2038642	9496	2674
Age at calving	1	16893984	85125	22295
Residual	1101	198224	1021	284

All the effects on lactation yield traits are significant (P<0.01).

Table 3: Analysis of covariance for test-day yield traits

		Mean Sqaure		
Source of variation	d.f	Milk	Fat	Protein
Herd-test-day	393	19.01	0.12	0.04
Year-season of calving	23	12.88	0.09	0.03
Days in milk	9	346.80	1.28	0.42
TD1[t]	1	79.38	0.41	0.11
Age at calving	1	1567.83	7.88	2.26
Residual	5357	4.17	0.03	0.01

[t]TD1: days in milk at TD1; all the effects on test-day yield traits are significant (P<0.01).

They were working on another data of the same population. Tonhati *et al*. [12]and Flores *et al.* [16] worked on another buffalo populations and found also similar results. Table 3 shows that herd-test-day, year-season of calving, age at calving and DIM at TD1 influenced highly (P<0.01) on test-day traits. Similar findings are reported by Tonhati *et al*. [12] and Flores *et al*. [16].

Estimated breeding values of buffalo cows by birth year for lactation traits are plotted in Figure 1. LFY and LPY increase over the entire range of birth years from 1992 to 1998, while LMY increase until 1996. Then, the trend has been decreased rapidly for all lactation traits. Similarly, the average values of permanent environmental due to random buffalo cows along years of birth increased at nearly the same rate as given in Figure 2. The highest estimated breeding values of buffalo cows with records over the entire range of birth years were +31 kg for LMY, +3 kg for LFY and +2 kg for LPY. The lowest values were -77, -5 and -3 kg, for these three traits, respectively. Thus, unfavorable genetic change for lactation traits during studied period except for the buffalo cows breeding values had born over the range of birth years 1992 to 1998 (economically positive). The increases and decreases in the graph are apparently due to the effect of specific widely used bulls that either strongly positive or negative for this trait [17].

Similarly, permanent environmental values were +51 for LMY, +4 for LFY, +2 for LPY kg, while the negative values were -70, -4 and -3 kg, respectively. However, the negative trend of permanent environmental values by birth years in lactation traits is due to many defects in management applications. This is in agreement with the results of Ulutas *et al.* [18], they suggested that the negative trend of permanent environment on milk yield due to the non-stability in the management system. Least squares mean values of buffalo cows by calving years are plotted in Figure 3 for lactation yield traits. The phenotypic values along the studied years decreased rapidly until 2005 for LMY and then irregular fluctuation was observed. The trends of both LFY and LPY decreased slightly with years of calving advanced. Table 4 shows that the insignificant annual genetic change were -0.05±0.04, -0.43±0.50 and -0.88±0.81 kg/yr for LMY, LFY and LPY, respectively. Also, their insignificant annual permanent environmental trend was 0.01 ±0.04 and 0.21 ±0.47 and 0.18 ±1.00 kg/yr. Mourad [19] stated that genetic response about 2.8 kg in 305-d milk yield per generation working on another data from 1959 to 1980 for the same population. In general, annual genetic change of the lactation traits was economically favorable from 1992 to 1998 and since then it has not been favorable. In Italian buffalo, Catillo *et al*. [20] stated that the genetic trend for LMY along 15 years of birth was 2.1 kg milk/yr of bulls and 1.0 kg milk/ yr for all population. The regression coefficients on year reflects annual phenotypic trend for LMY, LFY and LPY were -0.01 ±0.00, -0.14 ±0.04 and -0.30 ±0.03 kg/yr, respectively as shown in Table 4. It should be noted that no genetic variability among buffalo cows in lactation traits during studied period and in most cases, animals do not adapt to disturbances in management conditions.

Estimated daily breeding values of buffalo cows over the entire range of birth years from 1989 to 2005 at selected DIM for test-day traits are plotted in Figure 4. Pattern of genetic change tend to positive estimates toward mid-lactation of buffalo cows born during the years 1992 to 1995 and since then the trend has been negative for DMY. Moreover, genetic level tends to negative with fluctuated estimates over the entire range of the rest birth years. Clearly, estimates of both DFY and DPY tend to positive toward the end of the trajectory of the lactation. In general, estimates were low ranging between -0.73 to 0.31 kg, for DMY, while were close to zero (-0.13 to 0.08) and (-0.07 to 0.06) kg for DFY and DPY, respectively. The results in Table 5 shows that correlation between estimated breeding values from the test-day and lactation traits of buffalo cows (with records) were in the range similar to correlation for sires. Estimates were high to moderate ranging from 0.89 to 0.97 and from 0.45 to 0.57 and 0.61 to 0.69%, of yield traits (milk, fat and protein), respectively. Correlation estimates for yield traits stated by Swalve [21] ranged from 89 to 90 and from 90 to 92%. Within sires, (Table 5) the correlation were low to moderate ranging from 0.41 to 0.69%. Results reported by

Table 4: Annual genetic, environmental and phenotypic changes for lactation yield traits of buffalo cows born between 1989 and 2005

	Milk			Fat			Protein		
Parameter	b[2]	SE[3]	*P*	b	SE	*P*	b	SE	*P*
Genetic	-0.05	0.04	0.22	-0.43	0.50	0.41	-0.88	0.81	0.29
Environmental[1]	0.01	0.04	0.94	0.21	0.47	0.67	0.18	1.00	0.86
Phenotypic	-0.01	0.00	0.01*	-0.14	0.02	0.01*	-0.30	0.03	0.01*

[1]: Permanent environmental; [2]b: regression coefficient; [3]SE: standard error; * p<0.05

Table 5: Pearson correlations between breeding values from test-day and lactation yield traits

		Trait		
	Number of animals	Milk	Fat	Protein
Buffalo cows with records	775	0.97	0.57	0.61
All sires Sires with	119	0.89	0.45	0.69
1 ≤ 5 daughters	66	0.48	0.50	0.46
6,…, ≤ 10 daughters	33	0.61	0.69	0.61
11,…, ≤ 20 daughters	13	0.54	0.67	0.52
21,…, ≤ 50 daughters	7	0.41	0.60	0.49

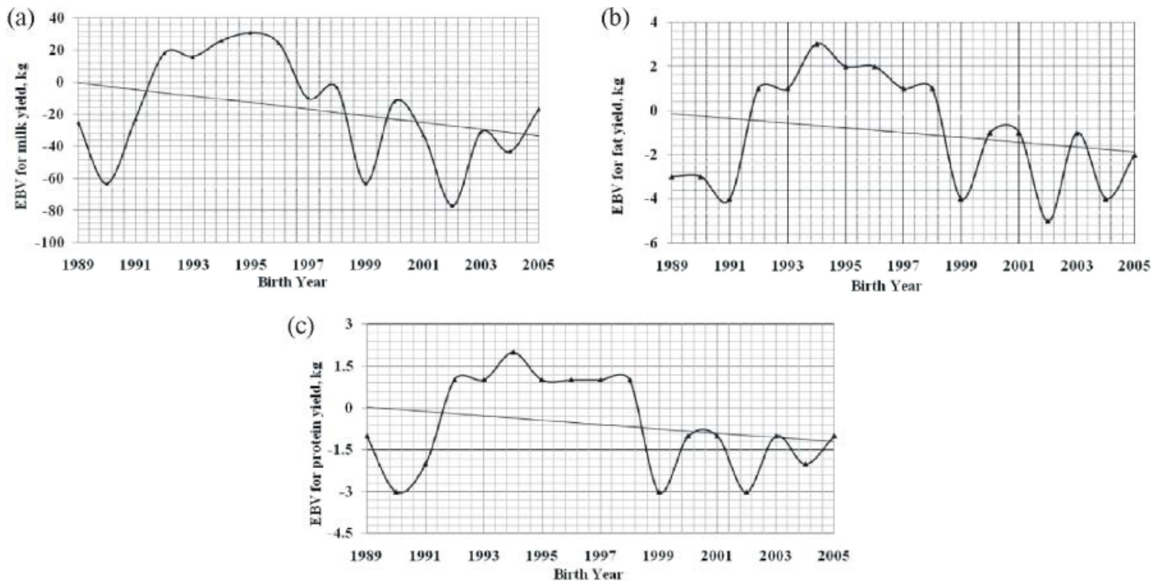

Fig. 1: Estimated breeding values (EBV) by year in lactation yield traits sorted as: (a): milk; (b): fat and (c): protein in buffalo cows.

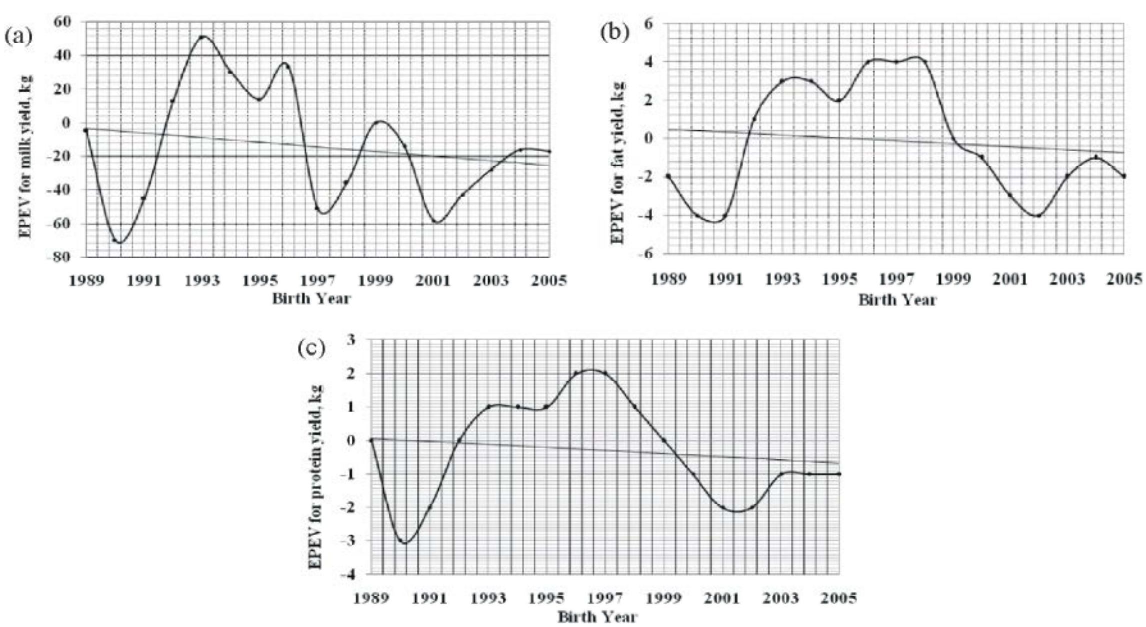

Fig. 2: Estimated permanent environmental values (EPEV) by year in lactation yield traits sorted as: (a): milk; (b): fat and (c): protein in buffalo cows.

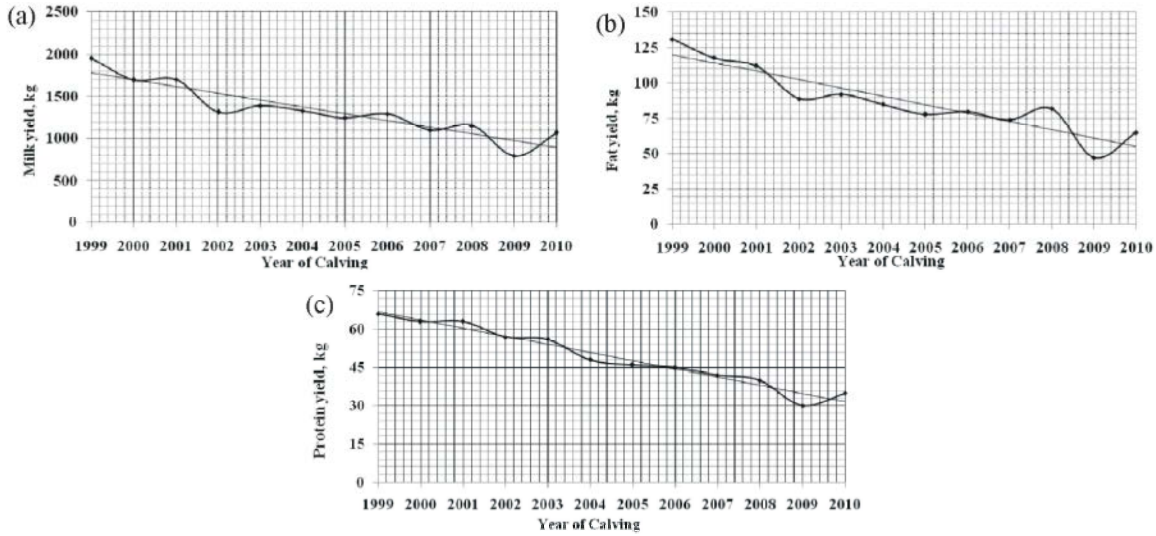

Fig. 3: Estimated phenotypic values by year in lactation yield traits sorted as: (a): milk; (b): fat and (c): protein in buffalo cows.

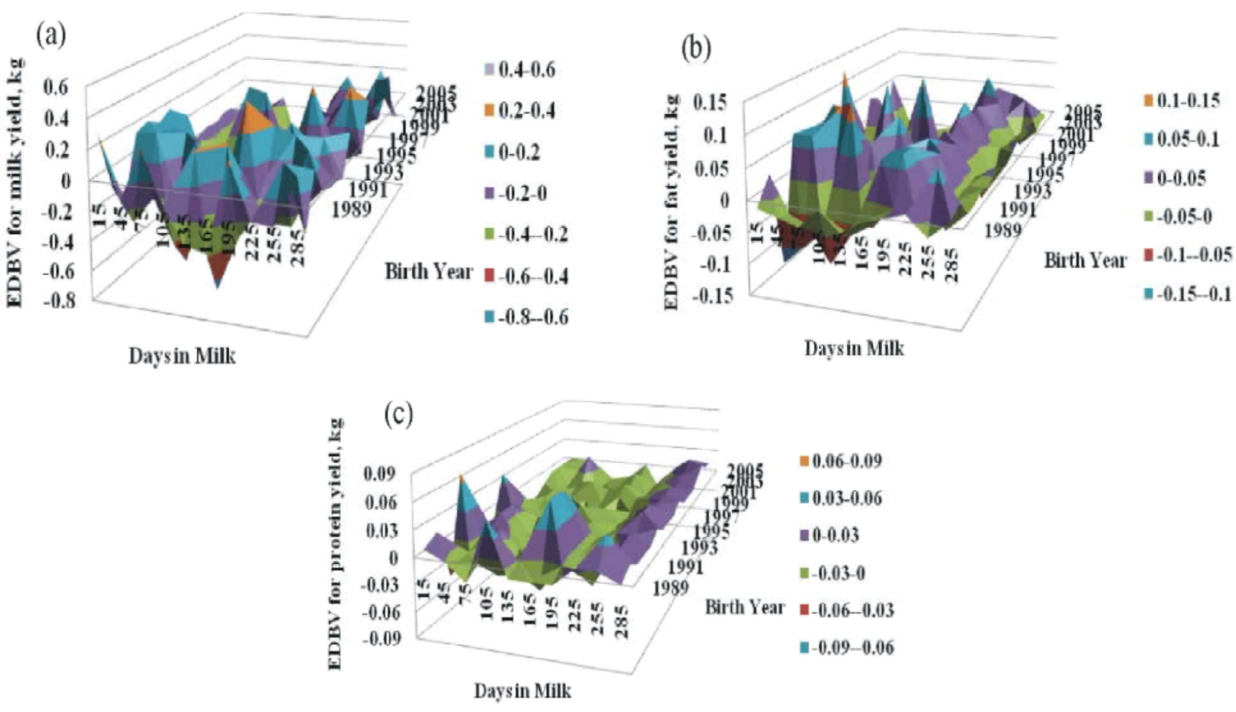

Fig. 4: Estimated daily breeding values (EDBV) by year in lactation yield traits sorted as: (a): milk; (b): fat and (c): protein in buffalo cows.

Swalve [21] were in contradiction to the current findings as who indicated that within sires, the correlations increased as number of aughters per sire increased for increasing accuracy. As expected, widely used bulls for a long time, result in a large number of daughters per sire increased generation interval. The present findings Agree with Chadha *et al*. [22]. They found that within sires, the highest breeding values were obtained when number of daughters per sire increased up to 24 in Murrah buffaloes.

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CONCLUSION

Compared with the traditional models used for aggregated production traits, TD models are more accurate with increased dataset volume per lactation. The available information per lactation on lactating buffalo cows over the range of birth year can be explained by the fact that the most buffalo cows making early dry off. Also, the size of the contemporary group for herd-test-day is minimized. Unfavorable genetic change was observed for lactation traits during the studied period, except breeding values of buffalo cows born during the years 1992 to 1998. Based on the correlation between the estimated breeding values from the test-day and lactation yield traits, early routine genetic evaluation can be proposed based on test-day records to improve milk production. In general, artificial insemination should be used for breeding with proven sires and intense genetic selection for increasing selection differential. Also, a prospective study should be conducted on the use of a large amount of data.

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