Department of Animal Production, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt

ASHRAF A. AMIN

Test-day model of daily milk yield prediction across stages of lactation in Egyptian buffaloes

Summary
Test-day records of 10515 daily milk yield (TDY) observations of Egyptian buffaloes were collected from four farms in Ismailia region, which exist east of Cairo. Two data sets were considered for analysis of variance according to lactation length. The first data set is TDY of the short lactation (5-10 months: LP_S). The 2nd data set is the TDY of the long lactation ($LP_L > 305$ days). Daily milk yield prediction equations were investigated using multiple lactations, separate lactations, and three groups of age at first calving. Polynomial regression functions were fitted to study the effect of stage of lactation on variation in test-day milk yield observations (TDY). Results of the present study showed that the effect of herd (farm, season and year of calving) on variation of TDY were significant and accounted for 35.22% of the total variance for the data set of LP_L. Variations in TDY due to the effect of either order of lactation or age at first calving groups were significant and accounted for 8.25% and 13.50%, respectively of the total variance. The overall least-square means of TDY were 5.5 and 7.8 Kg for LP_S and LP_L, respectively. The highest frequencies of similar TDY observations appeared in the early months across stage of lactation. The peak of the measured TDY obtained among the 4th and the 6th month of lactation of the pooled parity data set. Prediction equation of TDY across days of lactation (Days in Milk:DIM) using pooled parities was as the following:

$$Y = 3.4103 + .0466X - .0004X^2 + .00001X^3 - 1.03E\text{-}8X^4$$

Prediction equation of TDY across months of lactation (Months in Milk:MIM) using pooled parity data set was as the following:

$$Y = 1.9634 + 2.7927X - .8931X^2 + .1602X^3 - .0138X^4.$$

Prediction equations for TDY per parity and for each age at first calving group were computed.

Key Words: Egyptian buffaloes, daily milk yield, prediction equations, stage of lactation, test-day model

Zusammenfassung
Titel der Arbeit: **Testtagsmodell zur Vorhersage der täglichen Milchleistung nach unterschiedlichen Laktationsabschnitten bei ägyptischen Büffelkühen**

Erfasst wurden 10515 tägliche Milchleistungsdaten (TDY) von 429 ägyptischen Büffelkühen mit 5 Laktationen in vier Betrieben der Ismailia Region, östlich von Kairo gelegen. Für die Varianzanalyse wurden zwei Datensätze, die durch eine unterschiedliche Laktationslänge gekennzeichnet waren, betrachtet. Der erste Datensatz beinhaltet TDY bei einem kürzeren Laktationsabschnitt von 5-10 Monaten (LP_S) und der zweite den längeren Abschnitt von >305 Tagen (LP_L). Für die Voraussageschätzung der TDY wurden die Gesamtlaktationen sowie die Einzellaktationen bei drei Gruppen in Abhängigkeit vom Erstkalbealter betrachtet. Die multiple Regressionsfunktion wurde an die Prüfung des Effektes unterschiedlicher Laktationsstadien auf die Vorhersage der TDY angepasst. Die Ergebnisse der Studie zeigten, dass der Herdeneffekt (Betrieb, Saison und Kalbejahr) auf die Variation der TDY signifikant war und 35,22 % der Gesamtvarianz des Datensatzes LP_L betrug. Die Variation der TDY in Abhängigkeit von Laktationen oder Erstkalbealter war signifikant und betrug 8,25 % bzw. 13,50 % der Gesamtvarianz. Der Gesamtmittelwert der TDY betrug 5,5 bzw. 7,8 Milch-Kg. Eine hohe Übereinstimmung zu den erfassten TDY Daten scheint in den frühen Laktationsstadien zu bestehen. So lag die größte Übereinstimmung des Datensatzes zwischen dem 4. und 6. Laktationsmonat. Für die Vorhersage der TDY mittels Laktationstagen wurde folgende Gleichung genutzt:

$$Y = 3.4103 + .0466X - .0004X^2 + .00001X^3 - 1.03E\text{-}8X^4$$

Für die Vorhersage der TDY mittels Laktationsmonat wurde folgende Gleichung genutzt:

$$Y = 1.9634 + 2.7927X - .8931X^2 + .1602X^3 - .0138X^4.$$

Die Vorhersagegleichung für TDY je Kalbung und die unterschiedlichen Erstkalbeltersgruppen wurde berechnet.

Introduction

Genetic and phenotypic evaluation models in dairy cattle use test-day records instead of 305 days lactation records are of great interest in the field of genetic improvement and breeding programs for production traits (SCHAEFFER and DEKKERS, 1994; KETTUNEN et al., 1998). Prediction of daily milk yield is very essential as a basis for decisions to cull or to retain a dairy animal at an earlier stage of lactation (HANAA et al., 1998). The models for production traits are known as test-day model and can account for the effect of test date, number, order and intervals between test-day records and provide information about persistency (SCHAEFFER and DEKKERS, 1994; REENTS and DOPP, 1996). A common approach to investigate genetic associations between traits varying over time is to consider every trait at each time period as a separate trait and then to estimate the genetic correlations between these traits (VEERKAMP and THOMPSON, 1999). Therefore the present study will try to explain variations in TDY of Egyptian buffaloes using test-day model.

Buffaloes are the first native dairy animal in Egypt. Intensive buffalo farms in Egypt are very little. The small farmer is raising the most Egyptian Buffaloes individuals. Therefore applying results of the recent research for improving milk production of Egyptian Buffalo are very difficult. Determine and analysis the most important factors influencing milk yield of Egyptian buffalo are very important to characterize strategy of genetic improvement. Several factors are known to influence the shape of lactation curve of Egyptian buffalo (RAGAB et al., 1973). Variation in milk yield either total or daily yield due to variation in age at calving were very significant (KHALIL, 1993; RASHAD, 1989; MOURAD, 1984; REDDY and TANEJA, 1984). KAWTHER and KHATTAB (1992) found that estimates of linear and quadratic regression coefficients of 305 MY on age at first calving and age at calving in the fourth parity were not significant, while the corresponding estimates of linear regression was only significant in the 2nd and the 3rd parity. METRY et al. (1994) found significant negative correlation among persistency and season of calving. Also they found a significant linear and quadratic regression of TDY persistency on age at calving. Maximum daily yield in the 1st lactation appeared at the 48 month of age (KAWTHAR and KHATTAB, 1992). Overall mean of daily milk yield of Murrah buffaloes were 5.13$\pm$0.312, 5.27$\pm$0.36, and 5.14$\pm$0.29 in the 1st, 2nd and 3rd parity, respectively (SINGH and YADAV, 1987).

This study was carried out to investigate the effect of stage of lactation (days and months in milk) on variations in the observed values of test-day milk yield. Another objective of the present study was to suggest appropriate polynomial regression function for prediction of TDY using data sets of pooled parities, separate parities, and four ages at first calving groups.

Materials and Methods

Data collection and structure: Data of test-day milk yield of 429 Egyptian buffaloes distributed over a period of 6 years (from January 1995 until December 2000) were obtained from four different farms located in Ismailia region. All available records of identified or non-identified animals were collected. Total number for test-day yields

(TDY) observations were 10515 records. The present study was concerned with the first 5 successive parities. The current study involved two data sets according to length of lactation period. The first data set involved animals with 5-10 months of lactation (short lactation: LP_S). While the second data set involved animals with lactation longer than 10 months (long lactation: LP_L). Three age at first calving groups were classified as shown in Table 1. Prediction equations of daily milk yield using days in milk or months in milk were computed. Prediction of daily milk yield was applied in the categories of i) multiple lactation, ii) the first five parities separately, and iii) age at first calving groups. The intervals between the calving date and the TDY observation date were computed by subtraction. The present data included TDY observations for most days of milking across 390 days of lactation. In sequences, for each computed 30-days across stages of lactation was presented as one month of lactation. The present data set involved computed 13 months of lactation and their average of TDY (Fig. 1).

Table 1
Age at first calving groups (AFC)

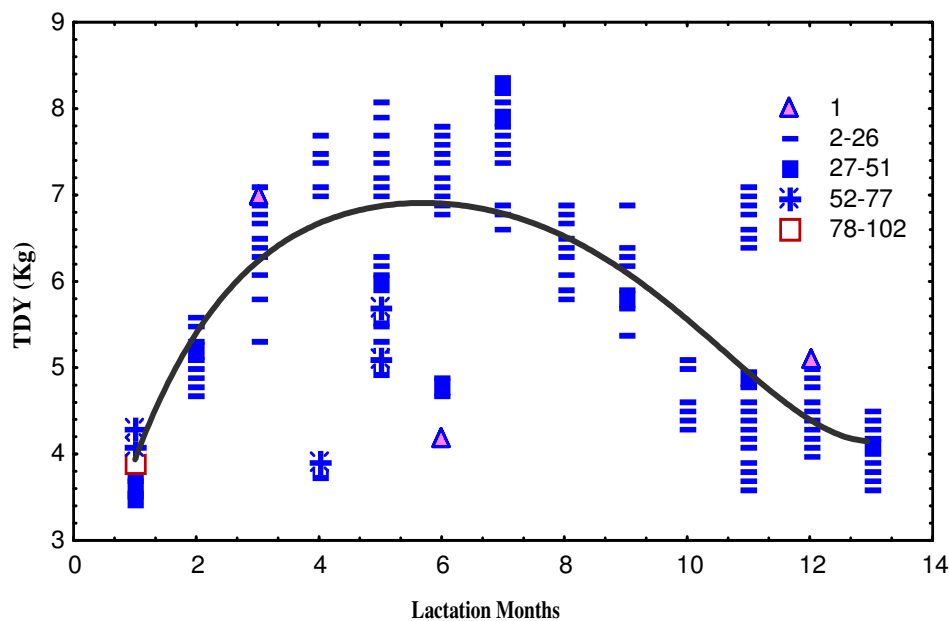| AFC (months)	Average age	Individual Numbers	Obs. No.	TDY$\pm$SE Kg		Min-Max Kg	
Overall	39.7	748	1209	5.72	0.91	2.31	9.17
$\leq$32	29.7	127	237	4.50	0.72	2.31	6.78
>32-$\leq$40	34.4	311	461	5.89	0.98	3.18	7.19
>40	42.6	310	511	6.76	1.03	5.27	9.17

Obs.No.: Observation Numbers

Fig. 1: Frequencies of similar test-day milk yield (TDY) observations across months of lactation of the pooled parities

Multi-trait animal models (multi-traits derivative free restricted maximum likelihood procedure MT-DF-REML, (BOLDMAN, 1997) was used to explore variations in test-day yield due to non-genetic effects. Sire half-sib sisters covariances were estimated applying Proc IML and Proc Plot and TRANSREG (SAS-6.12 1998) which was used for fitting solutions of polynomial regressions functions. Prediction equations for TDY

across days (DIM: 390 days) and months (MIM: 13 months) of lactation were created using the pooled parities, separate parities and age at first calving groups.

The general mathematical models used were:

$$Y_{ijklm} = u + H_i + A_j + S_k + P_l + \beta_{Stg}{}^N + e_{ijklm} \quad ....(model\ 1)$$
$$Y_{ijklm} = u + H_i + A_j + S_k + Age_l + \beta_{Stg}{}^N + e_{ijklm} \quad ......(model\ 2)$$

Where:

Y_{ijklm}: is the test-day milk yield

μ: Population mean, H_i: fixed effect of ith herd (that involved effect of farm, season and year of calving), A_j: is the effect of jth animal, S_k is the effect of kth sire assumed to be randomly distributed around zero with variance $A\sigma^2s$, (A is the numerator relationship matrix between sires), P_l: fixed effect of lth order of lactation (l=1 to 5 parity): model 1, **or** Age_l: is the effect of lth group of age at first calving : model 2. $\beta_{Stg}{}^N$: is the partial linear and nonlinear regression (N : is the power of regression function) of test-day yield on stage of lactation, e_{ijklm} : is the residual randomly distributed around 0 with variance $I\sigma^2e$, where I is the identity matrix.

Separate analyses of variance were also applied either for separate parities or for age at first calving groups.

Results and Discussion

Results in Table 2 show the influence of stage of lactation on variation of TDY (fitted in the mathematical model as a covariant) was significant for LP_L in data set of the pooled parities. On the other hand changes in the level of TDY across stages of lactation were significant in the data set of the 1st parity (Table 2 and Figure 2). Influence of stage of lactation as a covariant on variation in TDY was higher using LP_L than using LP_S in both data sets. This result indicates the clear influence of stage of lactation on variation in TDY its progressive nature with increasing length of lactation period.

Table 2
Sum of squares ratio for test-day milk yield in the studied data sets.

SOV	MS % - all parities		SOV	MS % - 1st parity	
	LP_S	LP_L		LP_S	LP_L
Random	23.03[s]	27.18[s]	Random	21.30[s]	21.11[s]
Herd	26.91[s]	25.25[s]	Herd	35.22[s]	33.15[s]
Parity	13.30[s]	10.08	Age	8.25	13.50[s]
Covariant	14.11[s]	18.05[s]	Covariant	16.50[s]	20.19[s]
Residual	22.65	19.44	Residual	18.73	12.05

MS%: Mean-squares ratio, S: significant, LP_S: short lactation, LP_L: long lactation

Variations in TDY due to effects of age at first calving groups and order of lactation were significant (Table 2) and accounted 8.25% and 13.30%, respectively. The lowest contribution for the effect of age at first calving groups on variation in TDY was occurred for data set of LP_S in the 1st parity.

Variations in TDY due to herd effect (farm-year-season of calving) was significant for all data sets. Herd effect was accounted for the highest proportion of variance compared to the other effects (Table 2). These results were in agreement with results reported by Metry et al. (1994) and Salem (1983). The highest contribution for herd effect was computed with analysis the data set of LP_S of the 1st parity.
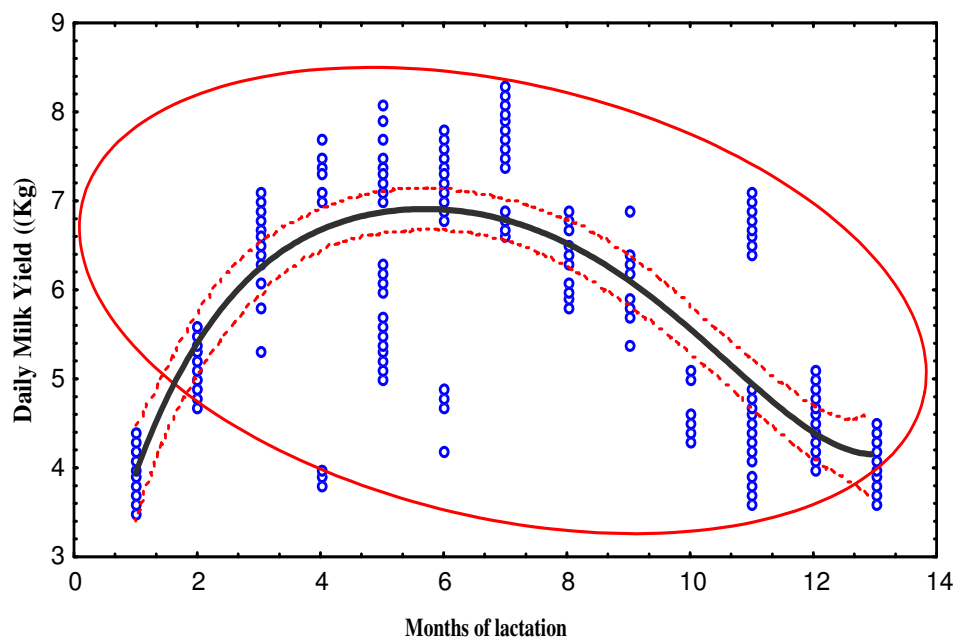
Fig. 2: Confidence band for the polynomial test-day milk yield across months of lactation of the pooled parities

Least-square means of TDY of different season of calving are presented in Table 3. The highest TDY appeared in winter and autumn calving and followed by spring and summer calving. Variation in TDY between winter and autumn *vs.* spring and summer may be attributed to changes of climate conditions among different seasons of calving also due to changes in feeding regimes. These results are in agreement with MOURAD et al. (1990) and MADALENA et al. (1979). Significant effects of calving season on variation in TDY were reported in several studies (ASHMAWY, 1991; KOTBY et al., 1988; KHATTAB et al., 1985).

Table 3
Least square means (LSM) and coefficient of variability (CV) for milk yield in different season of calving

Season	Short lactation				Long lactation			
	Obs. No.	TDY Kg	LP days	CV %	Obs. No.	TDY Kg	LP days	CV %
Winter	984	6.49	298	44.1	2342	8.47	330	33.7
Spring	642	5.77	219	28.7	1351	4.58	370	29.4
Summer	551	5.41	198	32.4	1194	5.04	390	27.9
Autumn	942	7.70	254	45.9	2509	8.49	340	31.4

Obs. No. Observation numbers, TDY: Test-day yield, LP: Lactation Length

Overall means of test-day yield per parity are presented in Table 4. The least-square means for TDY of LP_S and LP_L ranged from 3.6 to 7.2 Kg/day and from 5.8 to 9.5 Kg/day, respectively. These results were in agreement with RAGAB et al. (1973) and SALEM (1983). The highest numbers of TDY observations were present in the 2nd parity of the LP_L data set. Level of TDY increased with advancing order of lactation in all analyzed data sets till the 4th parity. The rate of increasing TDY from the 1st to the 2nd parity was higher than among the other parities for both data sets. On the other hand, the rate of reduction in the level of TDY from the 4th parity to the 5th parity was higher for LP_L than for LP_S data set (Table 4).

Table 4
Least-squares means (LSM) and coefficient of variability (CV) for daily milk yield (Kg) in the first five parities

Parity	Short Lactation			Long Lactation		
	Obs.No.	Mean	CV%	Obs.No.	Mean	CV%
1	785	3.6	28.4	1582	5.8	24.7
2	513	5.2	32.9	1833	7.4	24.9
3	728	6.9	31.4	1457	8.7	22.7
4	436	7.2	26.7	1367	9.5	25.1
5	657	6.2	29.4	1157	7.3	29.3
Overall	3119	5.5	28.7	7396	7.8	32.7

Figure 1 shows frequencies of the similar TDY observations on the same point across months of lactation of the pooled parities. Five categories of the similar TDY observations according to the rate of their frequencies were created and presented in Figure 1. Categories of repeated TDY observations were 1, 2-26, 27-51, 52-77, and 78-102 times. In general the highest TDY values were presented through the 4th and 6th months of lactation of the pooled parities. Also the most categories frequencies of the similar TDY observations were presented across months of middle lactation. These results may indicate great amount of variation among TDY values will be presented across days and months of middle lactation. The highest distributions of similar TDY observations were obtained for the 2nd category and for the 3rd category. The highest category of the similar TDY observation was the 5th category and it was obtained once time in the first month of lactation. Also TDY observations which repeated once time were little and presented in the early months of lactation.

Lactational polynomial curve of TDY across months of lactation was explored in Figure 2. Also level of confidence band at 95% for TDY observations was presented in Figure 2. The results of confidence interval indicate the differences around mean across stage of lactation were similar except in the later months of lactation.
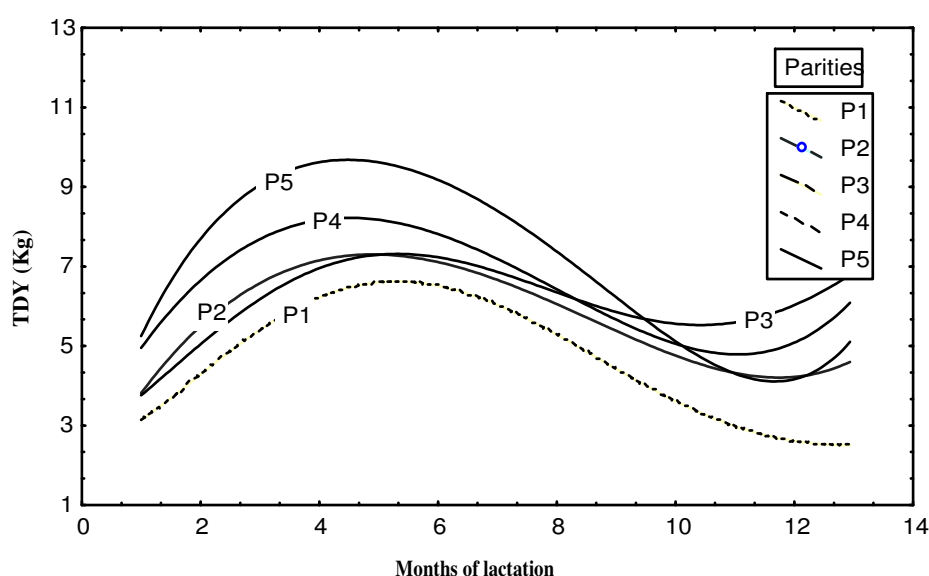

Fig. 3: Polynomial curve of test-day milk yield in the first five parities across months of lactation

Figure 3 shows estimates of TDY across months of lactation in the first five parities. The highest estimates for TDY were obtained across the 4th to the 6th month of lactation for all parities. Variations in TDY among months of lactation are much more

for the 1st parity *vs.* both the 4th and the 5th parities. On the other hand the corresponding variation in TDY among the 2nd *vs.* the 3rd parities were very little. Lactational curve of the 3rd parity was crossed in 4 points with the lactational curve of the other parities. The starting and finishing points of TDY on lactational curve were similar for the 2nd parity with the 3rd parity and for the 2nd parity with the 5th parity, respectively. The highest TDY observation obtained for the 5th parity in the 4th month of lactation. On the other hand, estimates of TDY in later months of the 5th parity were less than the corresponding estimates of the 3rd and the 4th parity.
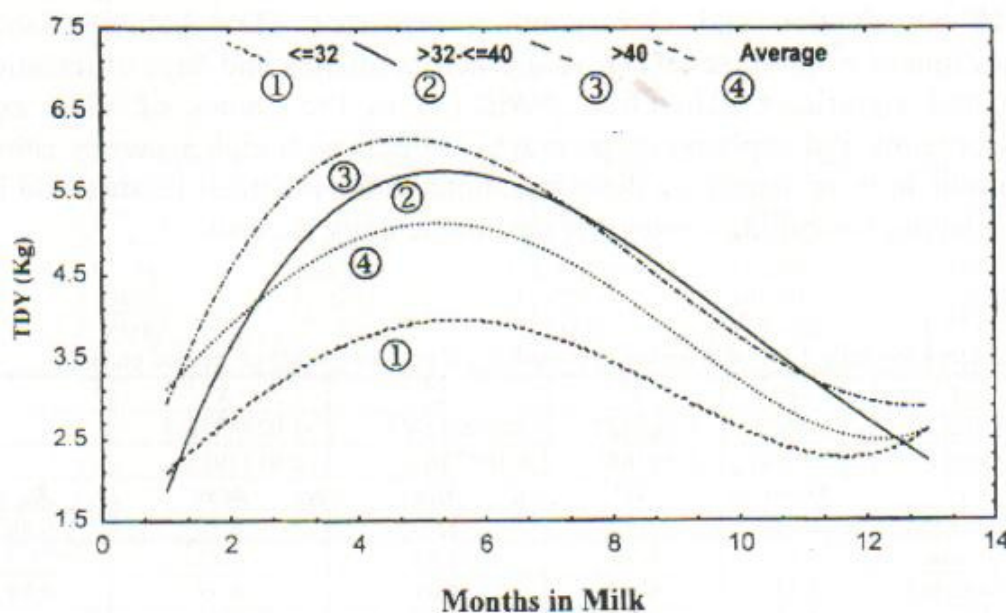

Fig. 4: Polynomial prediction curve for test-day milk yield across stage of lactation for age at first calving groups

Variations in TDY across months of lactation among four age at first calving groups were explained and plotted in Figure 4. The highest TDY occurred for the highest age at first calving group (>40 months) across 4th to 6th months of lactation. Lactational curve of TDY for the age group of >40 months was declined rapidly to the end of lactation than the others. While the endpoint of TDY on the lactational curve of age group >40 months was higher than the other age groups. Differences in TDY measures among overall mean and age group of >40 months were very little across the 7th to the 11th months of lactation. Also across the 7th to the 11th months of lactation occurred a great deference in observed values of TDY of age group ≤32 months than the age group >40 months. The lowest level in TDY obtained for age group of >32-≤40 as at the 1st and 13th months of lactation. Starting levels of TDY lactation curve were approximately similar for age groups of >32-≤40 with ≤32 months and for overall mean with age group of >40 months. On the other hand starting level of TDY lactational curve >40 and overall mean were higher than the others. Differences in TDY among age at first calving groups at the end points of their lactation curves were very smaller.

Test-day milk yield prediction
Daily (DIM) and monthly (MIM) test-day yield (TDY) prediction equations are presented in Table 5-a. Polynomial functions of the 4th degree was the optimal model for estimating predicted TDY values across months and days of lactation using pooled

parities data set. All partial regression coefficients were significant at p<0.01. Across 390 days of lactation, it could estimate the predicted TDY values by substituting X = 1 to 390 days in milk in DIM equation. Across 13 months of lactation, it could estimate predicted TDY/month by substituting X = 1 to 13 months in milk in MIM equation. Standard deviations, minimum and maximum actual and predicted TDY observations across days and months of lactation of pooled parities are presented in Table 5-a. Range of predicted TDY values was higher than the corresponding estimates for actual DIM-TDY, while the opposite results were obtained for MIM-TDY. Accuracy estimates (R_{ap}) of TDY predicted values were the correlation coefficients between actual TDY observation and corresponding predicted TDY values (Table 5-a). Accuracy estimates of predicted TDY values across months and days of lactation were very high and significant. Therefore prediction of the values of TDY could be suggested for using and applying in the practical fields with high accuracy either using days or months in milk. Applying these equations in the practical fields could help the farmer for planing his culling strategy of unsuitable dairy animals.

Table 5-a
Prediction equations for daily milk yield across days (DIM) and months (MIM) of pooled parities

	A	*X*	*X²*	*X³*	*X⁴*	
DIM	3.410263	0.046596	-0.000427	0.000002969	-1.029895E-8	
MIM	1.963401	2.792702	-0.893085	0.160228	-0.013793	
	Mean	*SD*	*Min*	*Max*	*R_{pa} ± SE*	
DIM	Predicted	5.71	1.12	3.70	8.10	0.86^s±.19
	Actual	5.62	0.96	3.68	6.83	
MIM	Predicted	5.58	0.99	4.01	6.79	0.89^s±.11
	Actual	5.61	1.22	3.97	7.61	

S: significant at P<0.01

Lactational daily and monthly predicted TDY equations of separate parities are presented in Table 5-b. Polynomial functions of the 4th degree represent the optimal model for estimating predicted TDY values across days (DIM) and months (MIM) of lactation for the first successive five parities, separately. All partial regression coefficient of DIM and MIM were significant. In DIM equations, estimates of intercept increased gradually with advancing order of lactation. The same trend was observed with estimates of MIM equations except that for the 5th parity although they were generally lower than those estimates for DIM equations. Accuracy estimates of the TDY predicted values were ranged from 0.79 to 0.94 and from 0.75 to 0.92 for DIM and MIM, respectively. In addition, accuracy estimates of DIM-TDY were higher than the corresponding estimates MIM-TDY across all parities except for the 3rd and the 4th parity. In the first three parities, the highest positive partial regression coefficients were obtained for the linear degree of the polynomial function of DIM and MIM. Changing estimates of partial regression coefficients of the 3rd degree among parities were greater for DIM than for MIM. In addition, rate of changing partial regression coefficient of X^2 of both models was low compared with other positive polynomial degrees.

Daily (DIM) and monthly (MIM) test-day yield prediction equations per age at first calving groups are presented in Table 5-c. Polynomial functions of the 4th degree were the optimal regression model for predicted TDY across days and months of lactation for age at first calving groups.

Table 5-b
Prediction equations for daily milk yield across days (DIM) and months (MIM) of lactation per parity

DIM	1st Parity		2nd Parity		3rd Parity		4th Parity		5th Parity	
A	0.020691		0.091537		0.291534		1.987654		1.998354	
X	3.015341		4.015347		4.112541		3.809603		4.783147	
X^2	-0.918378		-0.932571		-0.614782		-0.500731		-1.008939	
X^3	0.005743		0.021376		0.009937		0.009974		0.085967	
X^4	1.971538		3.112570		3.113478		4.844677		6.283415	

	1st Parity		2nd Parity		3rd Parity		4th Parity		5th Parity	
	Pre[1]	Act[2]	Pre	Act	Pre	Act	Pre	Act	Pre	Act
Mean	3.65	3.80	4.21	4.54	5.54	6.07	6.01	6.45	6.56	7.02
SD	0.11	1.03	0.91	1.43	1.22	1.03	0.97	1.16	1.11	1.81
Min	3.45	2.00	3.91	2.19	4.61	3.38	5.43	3.50	4.21	3.97
Max	3.97	5.50	4.95	7.10	6.18	7.80	7.18	8.71	8.02	10.5
R_{ap}	0.94		0.88		0.84		0.79		0.81	
SE	0.13		0.19		0.23		0.18		0.22	

MIM	1st Parity		2nd Parity		3rd Parity		4th Parity		5th Parity	
A	0.008615		0.057245		0.35772		2.058112		1.533364	
X	2.416172		3.106287		3.48823		3.292306		4.294076	
X^2	-0.33958		-0.44879		-0.54155		-0.52875		-0.66999	
X^3	0.012992		0.017289		0.024193		0.023009		0.027684	
X^4	2.098203		2.73203		3.328593		4.844677		5.185134	

	1st Parity		2nd Parity		3rd Parity		4th Parity		5th Parity	
	Pre	Act	Pre	Act	Pre	Act	Pre	Act	Pre	Act
Mean	3.61	3.92	3.73	4.54	5.59	6.07	6.11	6.18	5.18	6.72
SD	0.08	1.13	0.90	1.17	1.02	0.83	1.03	1.12	0.97	0.91
Min	3.42	2.80	4.01	3.07	4.78	4.98	5.11	4.08	5.28	4.97
Max	3.62	4.32	4.93	6.11	7.03	8.11	7.10	8.11	8.28	9.68
R_{ap}	0.91		0.82		0.87		0.92		0.75	
SE	0.17		0.23		0.25		0.22		0.24	

1: predicted; 2: actual

Table 5-c
Prediction equations for daily milk yield across days (DIM) and months (MIM) of lactation for age at first calving groups

DIM	All		≤32 mon		32-40 mon		>40 mon	
A	0.020691		0.0815253		1.82143661		0.9326264	
X	3.015341		2.1152476		2.18242436		4.11526344	
X^2	-0.918378		-0.9901476		-0.99133681		-0.15243987	
X^3	0.005743		3.2543693		0.08123698		0.77412365	
X^4	1.971538		2.18324758		2.00874521		2.10042415	

	All		≤32 mon		32-40 mon		>40 mon	
	Pre	Act	Pre	Act	Pre	Act	Pre	Act
Mean	3.61	3.92	2.85	3.01	3.73	3.65	4.25	4.18
SD	0.08	1.13	0.11	0.10	0.98	1.10	0.54	0.93
Min	3.42	2.80	2.19	2.54	3.17	3.01	3.71	3.48
Max	3.62	4.32	3.25	3.77	3.59	4.82	4.25	5.76
R_{an}	0.94		0.93		0.82		0.76	
SE	0.17		0..24		0.22		0.11	
MIM	All		≤32 mon		32-40 mon		>40 mon	
A	0.008615		0.0152436		0.00915241		0.08152471	
X	2.416172		2.9300214		1.08222411		3.15236942	
X^2	-0.339580		-0.9125774		-0.64001225		-0.41522361	
X^3	0.012992		0.0088325		0.02033141		0.00152332	
X^4	2.098203		3.0003369		2.05503143		1.40036523	

	All		≤32 mon		32-40 mon		>40 mon	
	Pre	Act	Pre	Act	Pre	Act	Pre	Act
Mean	3.97	3.90	3.01	3.07	3.96	4.17	4.11	4.53
SD	1.11	0.87	0.93	0.58	0.96	1.07	1.03	1.11
Min	2.32	2.27	1.78	1.90	2.01	1.99	2.59	2.55
Max	6.01	5.55	4.01	3.98	5.83	5.91	6.89	6.75
R_{an}	0.91		0.97		0.84		0.86	
SE	0.17		0.24		0.22		0.11	

The highest intercept value for DIM-TDY obtained at age at first calving group of >32-≤40 months. On the other hand, all intercept values of MIM-TDY were lower than the corresponding estimates of DIM-TDY. The 4th degree of the polynomial

function of DIM were similar for all age at calving groups, while the corresponding estimates of MIM-TDY decreased with advancing age at first calving.

The accuracy estimates of predicted TDY values were very high for analyzing the data set of the first age group than the other age groups. Partial regression coefficient of the 2nd degree of the polynomial function for age at first calving group of ≤ 32 and >32-≤ 40 for DIM were approximate similar in magnitude to that of MIM. While the rate of increasing TDY predicted values (coefficient of X) becomes low with advancing order of days in milk for > 40 months of age at first calving compared to the other age groups.

The highest increasing rate of the predicted both DIM and MIM-TDY values was obtained at the linear component of the polynomial function (coefficient of X) for age at first calving group of >40 months. In addition, the highest reduction rate in the 2nd polynomial degree was attained for the age groups of ≤ 32 and >32-≤ 40 months.

Conclusion

Two data sets of Egyptian buffaloes were considered for analysis of variance according to lactation length. The first data set is TDY of the short lactation and the 2nd for long lactation. Daily milk yield prediction equations (polynomial regression functions) were investigated using multiple lactations, separate lactations, and three groups of age at first calving.

Influence of stage of lactation on variation of TDY was significant for LP_L of the pooled data set and 1st parity. Influence of stage of lactation on variation in TDY its progressive nature with increasing length of lactation period. Increasing TDY from the 1st to the 2nd parity was higher than among the other parities. Reduction in TDY from the 4th parity to the 5th parity was higher for LP_L than for LP_S.

The highest contribution for herd effect was computed with analysis the data set of LP_S of the 1st parity.

Polynomial function of the 4th degree was created for estimating predicted TDY across months and days of lactation (multiple lactations, separate parities and age at 1st calving groups). Across 390 days of lactation, it could estimate the predicted TDY values by substituting $X = 1$ to 390 days in milk in DIM equation. Across 13 months of lactation, it could estimate predicted TDY/month by substituting $X = 1$ to 13 months in milk in MIM equation.

Accuracy estimates of predicted TDY values across months and days of lactation were very high and significant. Therefore, applying these equations in the practical fields could help the farmer for planing his culling strategy of unsuitable dairy animals.

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Authors address
Dr. ASHRAF A. AMIN
Department of Animal Production, Faculty of Agriculture,
Suez Canal University
41522-Ismailia / Egypt

E-Mail: aashraf20@hotmail.com