Asian Australas. J. Biosci. Biotechnol. 2019, 4 (1), 67-73

Asian-Australasian Journal of Bioscience and Biotechnology
ISSN 2414-1283 (Print) 2414-6293 (Online)
www.ebupress.com/journal/aajbb

Article

Comparison of different models for estimation of standardized 300 day milk yield from 15 day test interval records of Red Chittagong Cattle in Bangladesh

Md. Ahsan Habib[1], A K Fazlul Haque Bhuiyan[2], Md. Ruhul Amin[2] and Md. Sajjad Khan[3]

[1]Bangladesh Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka 1341, Bangladesh
[2]Bangladesh Agricultural University (BAU), Mymensingh 2202, Bangladesh
[3]University Agriculture Faisalabad, Pakistan

*Corresponding author: Dr. Md. Ahsan Habib, Senior Scientific Officer (SSO), Fodder Research and Development Project, Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka 1341, Bangladesh. Phone: +8801712855030; E-mail: ahsan.rony@yahoo.com

Received: 06 April 2019/Accepted: 28 April 2019/ Published: 30 April 2019

Abstract: The present study was carried out with retrospective data collected from the nucleus herd of USDA funded Red Chittagong Cattle (RCC) project at Bangladesh Agricultural University (BAU) and community herd at Char Jailkhana, Mymensingh during 2005 to 2011. The 15 days test interval daily milk yield records of 141 lactations taken from 52 cows from two different herds were collected to estimate multiplicative ratio factors (RF), simple regression from last test day milk yield record (SRLTD) and last test day along with average daily milk yield from known lactation part at any duration (SRLTAD) for prediction of standard 300 days milk yield. The correlations among 300 day milk yields estimated by three different extension models were also investigated and were found no statistically significant differences ($P>0.05$) with significantly ($P<0.01$) highly correlated with each other. The results revealed the accuracy of prediction of ratio factors and regression coefficients for three different models and may be adopted any of those models to extend standardized milk production (300 day) for RCC in Bangladesh.

Keywords: RCC; ratio factors; regression coefficients; test interval records; standardized milk yield

1. Introduction

In animal breeding operation, selection of animal on the basis of their performance is the key role for further genetic improvement of the animal population. In dairy cattle breeding, milk production performance are evaluated rigorously for selection and culling of dam and sire. Actual breeding worth of a sire or a dam is subjected to get complete performance records of the individual. But it needs long time duration. Early estimates of a cow's and a sire's breeding value by extending lactations in progress can help to reduce the generation interval as well as increase the selection intensity. Projected records are also used to estimate what cow will produce in a lactation while her lactation is still in progress. This early information can facilitate the breeders to decide if one should be kept or discarded for producing the offspring. However, it helps in the allocation of resources such as feed supplies both for an individual cow and the herd in economic way. Various methods of extending partial records have been used in the past. The ratio method was used earlier (Lamb and McGillard, 1960, 1960a; Van Vleck and Henderson, 1961; Syrstad, 1964; Lamb and McGillard, 1967) to develop multiplicative adjustment factors. The ratio of 305-day milk yield and part-lactation yield at any stage of lactation were calculated and method was popular for its simplicity. The projection factors employed by USDA in 1965 were ratio factors by breed for two ages of freshening (McDaniel *et al.*, 1965). The season of calving was however ignored to make the adoption of these factors easier for the dairy record processing centers (Wiggans and Van Vleck, 1978). Multiple linear regression techniques have also been used (Madden *et al.*, 1959; Van Vleck and Henderson, 1961; Appleman *et al.,* 1969) to estimate 305-day yield from test-day yield. The prediction errors are generally smaller from this method as compared to ratio-method (Khan and Iqbal, 1999). Multiple regression factors may be developed from the regression of complete yield on all available monthly records (Van Vleck and Henderson, 1961). A better alternative adjustment procedure is the last test day adjustment procedure (Khan, 1996) which has been stated as more accurate and less biasness. The procedure predicts future daily milk yield at any lactation length. This predicted milk yields for the unknown part of the lactation is then added with known part of lactation to get complete milk yield of a standard lactation length. A modified last test day method have been developed in this connection in predicting future daily milk yield from not just last test day milk yield record but also from average daily milk yield of the known part of lactation is considered which not only reduces the bias and improves accuracy, but also accounts for the differences in high and low producers with similar last test day yield. The main objective of this study was to estimate ratio factors and regression coefficients to extend milk yield for 300 days from any partial test interval records of RCC and to estimate correlations between three different methods.

2. Materials and Methods

2.1. Study location and climates

The study was carried out from two different sites; the on-station nucleus herd located about 4.5 km apart from Mymensingh city in Bangladesh lies between $24^0$30´ and $25^0$10´ North latitude and $90^0$15´ and $91^0$15´ East longitude and on-farm community herd located about 2.0 km apart in the North side from Mymensingh city lies between $24^0$77´ and $24^0$78´ North latitude and $90^0$39´ and $90^0$41´ East longitudes. It has a pronounced tropical monsoon-type climate has warm temperatures throughout the year, with a hot and rainy summer and a dry winter with relatively little variation from month to month. January tends to be the coolest month with temperatures averaging near 26^0C (78^0F) and April/May the warmest with temperatures from 33 to 36^0C (91 to 96^0F). The climate is one of the wettest in the world. Most places in the plain land receive more than 1,525 mm of rain a year. Most rains occur during the monsoon (June-September) and little in winter (November-February). There are three prominent seasons: the dry summer/pre-monsoon/hot season from March to June, monsoon/wet summer/rainy season from July to October and winter/dry season from November to February.

2.2. Feeding and management of animals

The feeding and management of RCC on-station (nucleus herd) was solely intensive where animals were stall fed throughout the year. The animals were provided three different kinds of feeds such as concentrate, green grass and straw where straw was the basal diet added with urea and/molasses. Animals were grazed at seldom due to lack of facility. Urea-molasses-straw (UMRS) or some times only molasses-straw (MRS) were provided twice a day *ad libitum* throughout the year. Green forages and roadside grasses were provided with limited amount due to scarcity. Concentrate mixture (Corn, Wheat bran, Rice Police, Mustard Oil cake, Soybean meal) was supplied once a day in the morning at the rate of 600g/lactating cow, 500g/pregnant cow, 400g/dry cow and heifers. The feeding and management system of RCC on-farm (community farmer's house) were not similar as in nucleus herd. Farmers seldom used straw for their animals. Road side, land side or fellow land green grasses were the main sources of feed. During dry and cropping seasons cut and carry green grasses were used to feed their animals. Farmers used to escape their animals for grazing in an around 6 to 8 hrs a day. Farmers used to offer drink water for their animals with some bran (wheat or rice) and salt regularly according to their ability specially lactating cows.

After freshening, cows were hand milked once a day except test days when morning and evening milking were allowed to count total daily milk yield for recording exclusive of that drawn by the calves until production declined below 250g per day. The calves were allowed to suckle their dam for few hours after milking and again few hours before evening and it continued up to 3-4 months. Afterwards, calves were allowed to suckle once a day after milking until weaning. Due to low yields and short lactation duration, cows were actually milked until they spontaneously became dry; hence forced drying due to advanced pregnancy seldom occurred. In the farmer's house, calves were allowed to present with their dam after milking up to evening.

Heat detections were by the signs of estrous and observed daily for every cow. Breeding usually commenced by artificial insemination (AI) technique at the first estrous both for lactating cows and heifers (subject to conformation). Animals were dewormed and vaccinated at regular interval by the close monitoring of the project personnel. Regular vaccination (against FMD and Anthrax disease), deworming (according to incidence on fecal sample examination) and medicare were performed in both herds.

2.3. Recording data

Milk yield records (n = 141) of 52 RCC cows maintained at Bangladesh Agricultural University Dairy Farm and Community Herd at Char Jailkhana, Mymensingh from 2005 to 2011 were used for this study. The test day

(TD) records (15 days interval) were maintained in the herds of RCC data files containing cow identity number, lactation order, date and season of freshening, date and amount of milk yield on each test interval day and date of dry off. Editing was done on the basis of criteria that fulfilled the analysis process. The cows that completed their lactations normally or abnormally (culled, death of calf etc.) at any length before 300 days were estimated for their complete milk yield by test interval method (TIM) followed by ICAR (2002) guidelines using the formula given below:

$$LMY = L_0M_1 + L_1 \times \left(\frac{M_1+M_2}{2}\right) + L_2 \times \left(\frac{M_2+M_3}{2}\right) + L_{n-1} \times \left(\frac{M_{n-1}+M_n}{2}\right) + L_nM_n$$

Where, M_1, M_2, M_n are the test day milk yield, L_1, L_2, L_{n-1} are the intervals in days between recording dates, L_0 is the interval in days between the lactation period start date and first recording date and L_n is the interval in days between the last recording date and the end of the lactation period.

2.4. Models for estimation of standardized 300 day milk yield

After calculating the total milk yield from the known part of lactation length, the rest of the unknown lactation part up to 300 day lactation lengths were estimated by the prediction equations with the following three methods. For each of the method, a total of 38 out of 141 lactations that completed their lactations normally for more than 270 days were considered for calculation of prediction equations. As previous analysis showed a significant difference of lactation milk yield between primiparous and multiparous cows, prediction equations were developed separately. After calculating multiplicative ratio factors and regression coefficients for different test interval (15 days) days, sequentially from 15 days (1^{st} test day) to 285 days (19^{th} test day) a total of 113 lactations that completed their lactations spontaneously or dry off due to death of calf or disposed before 300 days (20^{th} test day) were then extended of milk yield up to 300 days for further analyses.

For calculating ratio factors, the average milk yields representing the first, second, third……… up to the twentieth TD were calculated. Afterwards, all the average milk yields calculated for each TD were added to obtain the sum of averages (total). Finally, the sum of averages for all test days milk yield was divided by each accumulated average to estimate the rate for each test day. These ratios were ratio factors to project 300 day milk yield respectively for 15, 30, 45, …………., 285^{th} day (1^{st} , 2^{nd} ………, 19^{th} test day) records (Table 1).

$$\frac{\text{Total}}{1^{st}\text{ TD}},\quad \frac{\text{Total}}{1^{st}+2^{nd}\text{ TD}},\ \ldots\ldots\ldots\ldots,\quad \frac{\text{Total}}{1^{st}+2^{nd}\text{ TD}+\ldots\ldots\ldots+20^{th}\text{ TD}}$$

Actual 300 day yield was then calculated by the formula of $\hat{Y}_{300} = X_iRF_i\,(\times 15)$; where, $\hat{Y}_{300}$ is expected lactation milk yield for 300 days; X_i is the milk yield of the i^{th} test day record; RF_i is the ratio factors for the ^{i}th test day record (Table 1).

In the procedure of simple regression from last test day record (SRLTD), the last test day milk yield information at any lactation length was applied to predict future daily milk yield for unrecorded lactation period. All typical lactations of ≥ 300 days duration were used to develop this equation and for all lactation lengths the 300 day milk yield was estimated by the formula of $\hat{Y}_{300} = Y_t + (\alpha + \beta_1X_i)$ (300-DIM), where, $\hat{Y}_{300}$ is expected lactation yield for 300 days; Y_t = Total milk yield produced at any lactation length; α = Intercept at any lactation length; β_1 = Regression coefficient for any lactation length; X_i = Last recorded milk yield and DIM = Days in milk.

While regression equations were developed to predict future daily yield, lactation behavior was studied to see if lactation were typical or atypical. Lactations were considered atypical if there was a decline instead of an increase in milk yield after calving, or if there was an increase after the peak instead of a decline (Khan and Gondal, 1996). Only typical lactations were used to develop regression equations for this study.

A modified regression equation could be used to predict future daily milk yield to account for variation in the behavior of lactation for low and high producing cows with a similar test day yield by simple regression from last test day and average daily yield (SRLTAD). In this prediction equation future daily milk yield can be predicted using last test day milk yield along with average daily milk yield of known part of lactation (Khan and Chudhry, 2001). The regression equation was as follows:

$\hat{Y}_{300} = Y_t + (\alpha + \beta_1X_1 + \beta_2X_2)$ (305-DIM), where, $\hat{Y}_{300}$ is expected lactation yield for 300 days; Y_t = Total milk yield produced at any lactation length; α = Intercept at any lactation length; β_1 and β_2 = Regression coefficients; X_i = Last recorded milk yield; X_2 = Average daily milk yield of known part of lactation at any lactation length and DIM = Days in milk.

2.5. Statistical analysis

All the necessary data were entered in a excel worksheet, arranged systematically and analyzed with SPSS 20.0 statistical packages for simple means with standard error of means, test of significance by analysis of variance (ANOVA) and Pearson's product moment correlations between methods.

3. Results and Discussion

Out of a total of 141 lactations, 27% lactations had a standard lactation length which fulfilled the criteria for the prediction equations development. Bajwa *et al.* (2004) in their study on Sahiwal cattle in Pakistan found 30% standard lactation length which closely agreed by this study. 80% lactations that did not persist up to 300 days were considered for estimation of extended 300 day milk yield from which 80% lactations were from first calver (primiparous cow) and rest 20% were from later calver (multiparous cow). Bajwa *et al.* (2004) reported 57% lactations below than standard duration which was higher than this study. 21% lactations lasted over 300 days. Lactation lengths below 100 days were 1.5%, from 100-150 days were 4.25%, from 150-200 days were 15.5%, from 200-250 days were 27% and from 250-300 were 28%. Actual milk yield of RCC for the period under study was 420.24±14.75 kg with an average length of 250.25±5.78 days. The result is closely in agreement for average lactation length (247.6±66.7 days) but much lower than 1475±651 kg reported by Bajwa *et al.* (2004) for Sahiwal cattle in Pakistan. Average milk yield varied with lactation length in a positive trend. Very short lactations (below 150 days) had an average yield of 203.80±13.19 kg, while those of 150-200 days, 200-250 days, 250-300 days and above 300 days were 304.52±22.80, 412.29±14.21, 553.13±25.49 and 660.66±42.34 kg, respectively.

For the estimation of ratio factors described in the materials and methods, the multiplicative ratio factors for every 15 days interval test day records are illustrated in Table 1. As expected, the multiplicative ratio factors were decreased as number of test day records increased. In this study ratio factors for lactation duration of 30, 60, 90,……, 270 days varied from 0.04 to 0.41 than that of Simmental cows reported by Cilek and Tekin (2006) and 0.02 to 0.39 than that of Holstein cows reported by DHIA (1965) and the variations tends to reduce as the number of test day increase. The variations of ratio factors among different reports might be due to different breeds, herds, environment, feeding, management system or different methods of estimation. According to these results, ratio factors to project in to a 305 day basis must be estimated independently for breed, herd, season and area. However, applying these factors to other data with different environment and possible genetic differences is not recommended.

The regression coefficients from last test record at different lactation duration of primaparous and multiparous cow are given in Table 2. Among the last test days records used for prediction of 300 days milk yield, the R^2 values for 45th to 90th and 225th to 240th test days yields were ranged between 80.70-95.20% for primiparous cow. So, those test day records are better last test day predictors for estimating 300 days milk yield. On the other hand, 30th to 60th or 225th to 240th test days are better predictor of last test day information of estimating 300 days milk yield for multiparous cow having R^2 values ranged between 70.6-80.1%. From the regression analyses using last test day information, R^2 values ranged from 26-95% for primiparous cows and 38-80% for multiparous cows. Bajwa *et al.* (2004) in their study on Sahiwal cattle in Pakistan reported the values from 30-65% for this method.

The regression coefficients from last test record along with average daily milk yield of known part of lactation yield at different lactation duration of primaparous and multiparous cow are given in Table 3. Among the last test days records as well as average daily milk yield used for prediction of 300 days milk yield, The R^2 values for 30th to 90th and 195th to 240th test day yields were ranged between 84.1-99.1% for primiparous cow. So, those test day records are better last test day with average daily yield predictors for estimating 300 days milk yield. On the other hand, 15th to 75th or 180th to 240th test days are better predictors of last test day with average daily yield information of estimating 300 days milk yield for multiparous cow having R^2 values ranged between 63.1-80.1%. From the regression analyses using last test day and average daily milk yield information, R^2 values ranged from 64-99% for primiparous cows and 54-80% for multiparous cows. Bajwa *et al.* (2004) in their study on Sahiwal cattle in Pakistan reported the values from 32-70% for this method.

The mean 300 day milk yields estimated from three different methods were 435.69±24.28, 414.03±27.16 and 417.69±14.54 kg, respectively for SRLTD, SRLTAD and RF in case of primaparous cows (Table 4). Table 4 also shows that there were no significant variations of milk yield among three methods. In case of multiparous cows those values were 515.85±14.41, 521.54±14.38 and 497.03±08.29 kg, respectively for SRLTD, SRLTAD and RF with insignificant variations among three methods (Table 4).

In the correlation study, there were highly significant (P<0.01) correlations (from 0.84** to 0.99**) of 300 day milk yields among three different methods (Table 5) indicating that estimation of 300 day milk yield from any of those three methods would be more accurate for the genetic evaluation of cows. A more objective way to compare the above three adjustment procedures is to calculate the standard deviation of bias and correlation between actual and predicted milk yield reported by Bajwa *et al.* (2004) to find out which method is more accurate to predict standard lactation yield. But in this study the sample size was too less regarding the test. However the correlations study among the three methods also indicated that any of those methods that best suited for the farm level could be used for the genetic evaluation of cows in Bangladesh.

Table 1. Ratio factors (RF) for extending milk yield for lactation terminated before 300 days.

Days in milk	Total milk yield (kg)		Cumulative milk yield (kg)		Ratio factors	
	Primiparous cow	Multiparous cow	Primiparous cow	Multiparous cow	Primiparous cow	Multiparous cow
15	34.80	35.85	-	-	16.66	17.75
30	37.95	44.40	072.75	080.25	07.97	07.93
45	39.45	44.25	112.20	124.50	05.17	05.11
60	39.60	42.60	151.80	167.10	03.82	03.81
75	35.70	39.00	187.50	206.10	03.09	03.09
90	34.20	37.35	221.70	243.45	02.61	02.61
105	33.60	36.90	255.30	280.35	02.27	02.27
120	30.45	34.20	285.75	314.55	02.03	02.02
135	32.85	34.20	318.60	348.75	01.92	01.82
150	33.00	33.90	351.60	382.65	01.65	01.66
165	30.60	31.95	382.20	414.60	01.52	01.53
180	30.00	32.10	412.20	446.70	01.41	01.42
195	28.65	30.45	440.85	477.15	01.31	01.33
210	24.45	28.65	465.30	505.80	01.25	01.26
225	24.15	27.00	489.45	532.80	01.18	01.19
240	20.55	24.30	510.00	557.10	01.14	01.14
255	19.65	23.55	529.65	580.65	01.09	01.09
270	18.75	21.75	548.40	602.40	01.06	01.06
285	17.70	19.80	566.10	622.20	01.02	01.02
300	13.50	14.10	579.60	636.30	01.00	01.00

Table 2. Regression coefficients for estimating 300 day milk yield from last test day information method.

Days in milk	Primiparous cow			Multiparous cow		
	α	β	R^2 (%)	α	β	R^2 (%)
15	0.84	0.49	39.50	0.70	0.62	37.50
30	-0.41	0.93	79.90	0.61	0.51	70.60
45	-0.09	0.77	82.20	0.42	0.56	80.10
60	-0.31	0.82	82.30	0.51	0.54	74.80
75	0.57	0.53	95.20	0.46	0.58	68.30
90	0.41	0.53	86.60	0.85	0.46	56.10
105	0.59	0.55	47.30	0.70	0.49	58.60
120	0.67	0.53	26.00	0.31	0.68	58.10
135	0.69	0.46	75.70	0.37	0.64	53.80
150	0.45	0.54	67.80	0.46	0.59	53.80
165	0.41	0.61	64.60	0.42	0.62	58.70
180	0.42	0.59	63.40	0.36	0.62	68.10
195	0.29	0.66	73.20	0.32	0.65	54.40
210	0.06	0.90	75.00	0.22	0.71	63.00
225	-0.05	0.98	84.20	0.07	0.81	71.20
240	-0.24	1.20	80.70	0.10	0.86	73.20
255	-0.31	1.51	71.30	-0.17	1.02	59.20
270	0.15	1.58	34.20	-0.44	1.33	54.20
285	-0.82	1.92	57.30	-0.55	1.52	53.60

* α = Intercept, β = Regression coefficient (slope) and R^2 = Coefficient of determination

Table 3. Regression coefficients for estimating 300 day milk yield from last test day and average daily milk yield of known recorded days.

Days in milk	Primiparous cow				Multiparous cow			
	α	**β_1**	**β_2**	**R^2 (%)**	**α**	**β_1**	**β_2**	**R^2 (%)**
15	1.91	8.21	-9.68	71.90	2.65	3.43	-4.40	75.90
30	-1.49	2.49	-1.55	90.20	0.70	0.70	-0.30	72.00
45	-0.19	1.22	-0.52	84.10	0.42	0.55	0.01	80.10
60	-0.52	1.47	-0.69	84.70	0.46	0.42	0.15	75.20
75	0.75	0.69	-0.25	96.10	0.28	0.25	0.41	75.50
90	0.39	0.50	0.03	86.60	0.39	0.02	0.60	69.70
105	0.22	-0.09	0.76	78.70	0.37	0.14	0.48	70.50
120	0.37	-0.45	1.01	78.70	0.21	0.19	0.49	68.70
135	0.39	0.27	0.32	79.60	0.12	0.19	0.51	68.60
150	0.31	0.25	0.35	69.80	0.16	0.16	0.52	64.90
165	0.41	0.63	-0.02	64.60	0.07	0.29	0.43	69.00
180	0.36	0.48	0.14	64.10	0.05	0.38	0.35	74.50
195	0.61	1.63	-0.97	87.70	0.02	0.24	0.48	63.30
210	0.17	1.96	-0.85	90.40	0.18	0.64	0.07	63.10
225	0.12	1.63	-0.58	96.20	0.09	0.84	-0.04	71.30
240	-0.08	2.23	-0.81	99.10	0.37	1.19	-0.36	76.50
255	-0.08	2.15	-0.52	79.20	-0.36	0.84	0.21	61.10
270	1.63	4.02	-2.32	64.90	-0.41	1.36	-0.04	54.20
285	-1.12	0.74	1.01	74.50	-0.45	1.59	-0.09	53.70

*α = Intercept, β_1 = Regression coefficient for last test day yield, β_2 = Regression coefficient for average daily yield of known part of lactation, and R^2 = Coefficient of determination.

Table 4. Extended 300 days milk yield estimated by three different methods.

Methods of estimation	Primiparous cow		Multiparous cow	
	Mean±SE (n=22)	**Significance**	**Mean±SE (n=91)**	**Significance**
Last test day yield (SRLTD)	435.69±24.28	NS(P>0.05)	515.85±14.41	NS(P>0.05)
Last test day and average daily yield (SRLTAD)	414.03±27.16		521.54±14.38	
Ratio factors (RF)	403.38±24.69		497.03±08.29	
Overall	417.69±14.54		511.47±08.29	

Table 5. Correlations of extended 300 days milk yield among different methods.

	SRLTD	**SRLTAD**	**RF**
SRLTD	1	0.95**	0.91**
SRLTAD	0.99**	1	0.84**
RF	0.96**	0.97**	1

4. Conclusions

In the summing up of this study, it should however be concluded that both ratio factors and regression coefficients estimated in this study could be used more accurately to estimate 300 day milk yield for the indigenous cattle available in Bangladesh as indicated by their correlations study.

Acknowledgements

The authors would like to acknowledge USDA for funding the project from which data were collected and those who were involved in this project for providing us the necessary information to complete this work.

Conflict of interest

None to declare.

References

Appleman RD, SD Musgrave and RD Morrison, 1969. Extending incomplete lactation records of Holstein cows with varying levels of production. J. Dairy Sci., 52: 360-368.

Bajwa IR, MS Khan, MA Khan and KZ Gondal, 2004. Comparison of different procedures for lactation length adjustment of milk yield in Sahiwal cattle. Pak. Vet. J., 24: 117-120.

Cilek S and ME Tekin, 2006. Calculation of Adjustment Factors for Standardizing Lactations to Mature Age and 305-Day and Estimation of Heritability and Repeatability of Standardized Milk Yield of Simmental Cattle Reared on Kazova State Farm. Turk. J. Vet, Anim. Sci., 30: 283-289.

Dairy Herd Improvement Associations (DHIA) Letter, 1965. USDA-ARS, 41: 44-164.

Khan MS, 1996. Adjustment of milk yield for lactation length in Nili-Ravi buffaloes. Pak. J. Agric. Sci., 33: 77-81.

Khan MS and J Iqbal, 1999. A review on lactation length adjustment of milk yield records. Int. J. Agric. Biol., 3: 179-183.

Khan MS and KZ Gondal, 1996. Factors affecting lactation curve of Nili-Ravi buffaloes. In: Proc. National Seminar on Statistical Application in Agriculture and Industry. University Agriculture Faisalabad. pp. 55-59.

Khan MS and HZ Chudhry, 2001. Prediction of lactation yield from last record day and average daily yield in Nili-Ravi buffaloes. Buffalo Newsletter, 15: 7-10.

Lamb RC and LD McGilliard, 1960. Variables affecting ratio factors for estimating 305-day production from part lactations. J. Dairy Sci., 43: 519-528.

Lamb RC and LD McGilliard, 1960a. Comparison of ratio factors for extending part time milk and fat records. J. Dairy Sci., 43: 879.

Lamb RC and LD McGilliard, 1967. Ratio factors to estimate 305-day production from lactation records in progress. J. Dairy Sci., 50: 1101-1108.

Madden DE, LD McGilliard and NP Ralston, 1959. Relations between test-day milk production of Holstein cows. J. Dairy Sci., 42: 319-326.

McDaniel BT, RH Miller and EL Corley, 1965. DHIA factors for projecting incomplete records to 305 days. Dairy Herd Improvement letter, USDA-ARS, 41: 1-21.

Syrstad O, 1964. Studies on dairy herd records. I. Evaluation of incomplete records. Acta Agric. Scand., 14: 129-149.

Van Vleck LD and CR Henderson, 1961. Ratio factors for adjusting monthly test-day data for age and season of calving and ratio factors for extending part lactation records. J. Dairy Sci., 44: 1093-1101.

Wiggans GR and LD Van Vleck, 1978. Effect of proportion of concentrates in herd ration on lactation curves. J. Dairy Sci., 61: 135-140.