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Estimation of adjustment factors for standardizing age and season corrected 305 day milk yield and estimation of heritability and repeatability of stadardized milk yield of Red Chittagong cattle

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ABSTRACT

Adjustment factors for lactation milk yield to mature age and season corrected 305–day were calculated and heritability and repeatability of 305-day and test day (TD) milk yields were estimated from the nucleus herd of Red Chittagong Cattle (RCC) reared during 2005 to 2009. Lactation records (116) of 50 lactating cows were used for estimation. The factors for standardizing incomplete lactations to projected 305-day were estimated by taking 4 calving age groups (<4, 4–5, 5–6, and 6+ years of age) and 3 seasons (mid Feb to mid June, summer; mid June to mid Oct, rainy and mid October to mid Feb, winter) with the ratio factors. The heritability estimates for TD and 305-day milk yield were found as 0.41±0.08 and 0.35±0.08, respectively. Heritability estimates of individual TDs ranged from 0.24±0.33 to 0.64±0.06. Heritability of individual TD milk yield was highest in the first three months (TD2 to TD6) whereas, lowest in first few days and later after 3 months. The repeatability of 305-day and TDs milk yield were estimated as 0.28±0.12 and 0.49±0.04, respectively using intra-class correlation.

Key words: Adjustment factor, Heritability, Repeatability, RCC, Test day model

The most important environmental factors identified by the animal breeders in selection for milk yield are breed, region of country, herd management and management group within a herd (Everett *et al.* 1994, Reents *et al*. 1995, Jamrozik *et al*. 1997), day of the year (including weather conditions), lactation number (Jamrozik *et al*. 1997, Swalve and Gengler 1998, De Roos *et al.* 2001), age at calving (Kaya *et al.* 2003), days in milk (Hamed 1995, Kaya *et al.* 2003), pregnancy status (Amin 2003) and frequency of milking per day (Wiggans 1986). Now-a-days, test-day model is used instead of 305-day model for the genetic evaluation of dairy cattle. Test-day model considers all genetic and environmental effects directly on a test-day basis (Ptak and Schaeffer 1993). It improves the accuracy of genetic evaluation and provides better modeling. Moreover, it avoids the use of factors to extend partial lactation records (Wiggans and Goddard 1996) and is a possible solution for the problem of differences in the amount of information contributing to the 305-day prediction. Early selection can reduce the management cost of the herd. Several test day models (TDM) were developed for genetic evaluation of dairy breeds (Vargas *et al*. 1998). In developing countries, breeding programmes are characterized by inefficient recording systems and poor data collection, storage and processing procedures (Syrstad and Ruane 1998, Kahi *et al*. 2004). Selection based on daily yield records would result in reduced cost of recording and maintaining cows and bulls with low breeding values (Schaeffer *et al*. 2000, Swalve 2000). Genetic merit of animals can be predicted based on daily milk yield records from early lactations at reduced cost (Pander *et al*. 1992). However, use of TD data in genetic evaluation programmes requires accurate estimates of genetic and phenotypic parameters of specific daily milk yield records. In this study, an attempt was made to calculate the adjustment factors for standardizing lactations to mature age and season corrected 305-day milk yield and to calculate heritability and repeatability of standardized milk yield for the Red Chittagong Cattle at BAU nucleus herd.

MATERIALS AND METHODS

Fortnightly milk yield records (1790) of 116 lactations of 50 Red Chittagong cows calving between 2005 to 2009 at University RCC nucleus herd were used for this study. The test day (TD) records were maintained in the nucleus herd

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of RCC data files containing cow identity number, date, season of calving, and milk yield. Editing was done on the basis of missing identification, birth and calving or test date. Age at test-day was defined as number of months from birth. In the TD analysis, only first 20 test-day yields were used for each cow's lactation beginning with the first month of lactation and ending with the 10^{th} month. The sum of the 20 test day records which made up a cow's record was defined to be a complete lactation record. The fortnightly records were corrected for age at calving and season, with the ratio factors (Van Vleck and Henderson 1961). Ratio factors for adjusting fortnightly test day records to a common base were obtained by dividing the means of a base lactation (6+ years of age at calving and calving in season 3) by the other lactation means with the following formula given below:

$$\frac{X_{4,3,1}}{X_{1,1,1}}, \frac{X_{4,3,2}}{X_{1,1,2}}, \ldots\ldots, \frac{X_{4,3,20}}{X_{1,1,20}}$$

where $X_{4,3,1}, \ldots\ldots, X_{4,3,20}$ are the twenty fortnightly test day means of the base lactation (6+ years of age at calving in season 3) and $X_{1,1,1}, \ldots\ldots, X_{1,1,20}$ are the means of twenty fortnightly test day records of cows calving at <4 years of age (age group 1) in season 1.

Similarly, ratio factors were constructed for estimating a 10-month cumulative test day record from cumulative test day data of 1, 2, ………20 records as per following formula

$$\frac{T_{4,3}}{\sum_{i=1}^{1} X_{4,3,i}}, \frac{T_{4,3}}{\sum_{i=1}^{2} X_{4,3,i}}, \ldots\ldots, \frac{T_{4,3}}{\sum_{i=1}^{2} X_{4,3,i}}$$

are the cumulative ratio factors for age class 4 and season 3.

For the calculation of ratio factors to mature age, 4 age groups viz. <4 years, 4–5 years, 5–6 years and >6 years and 3 seasons, viz. summer (mid February to mid June), rainy (mid June to mid October) and winter (mid October to mid February) were formed. So total of 12 classes (4×3) were constructed to calculate ratio factors for mature age and season correction.

After construction of ratio factors for age and season correction, the incomplete TD records (due to culled, death of calf or not allowed for milking for long day etc.) and records more than 305-day yield of animals in the nucleus herd were also projected to a 305-day yield (Van Vleck and Henderson 1961). In that case, for each group the average values representing the first, second, third……… up to the 20^{th} TD were calculated. Then the average of each group was accumulated subsequently as given below. Afterwards, all the average values calculated for each TD were added to obtain the sum of averages (total).

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

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 adjustment factors to 305-day milk yield respectively for 15, 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180, 195, 210, 225, 240, 255, 270, 285, 290 and 305-day milk yields (Tables 1 and 2).

The final data file contained 116 different lactation records of RCC cows. In this study, only a combination of age and season of calving with 12 levels was used. The 305-day milk yield was defined as milk yield up to 305-days of lactation. The 305-day lactation yield was calculated by multiplying the sum of fortnightly test day yield with 15.25 (20×15.25=305 day).

After records were standardized for mature age and season to a 305-day basis, heritability was estimated. Heritability of 305-day milk yield was estimated from 116 standardized lactation records of 50 cows. Heritability of individual TDs milk yield was also estimated from 1568 TDs of 93 lactations. In the calculation of repeatability for 305 day milk yield, 1573 TDs of 95 lactations record of 32 cows that had at least 2 lactations were used. For the estimation of TDs repeatability 1776 TDs of 107 lactations of 46 cows were considered. Repeatability was estimated by intra-class correlation with standardized milk yields.

Simple means along with standard errors of mean were estimated by using statistical packages for social science (SPSS 2002 Version-11.5) program. For the estimation of heritability REML using VCE-4.2.5 (Groeneveld 1998) computer software was also used considering lactation number, season of calving and year of calving as fixed effects and animal's additive genetic variances as random effect. For the estimation of repeatability, variance analysis was also done by the application of SPSS program.

The statistical model was as follows:

$$Y_{ijkl} = m_i + L_{ij} + S_{ik} + C_{il} + A_{im} + e_{ijklm}$$

where, $Y_{ijklm,}$ observed milk yield at j^{th} lactation number, k^{th} season of calving, l^{th} calving year and m^{th} age at calving of i^{th} individual, m_i, population mean of individual I; $L_{ij,}$ effects of lactation number for individual i (j, 1, 2, 3, 4, 5, 6); S_{ik}, effects of season of calving for individual i (k, summer, rainy and winter); $C_{il,}$ effects of calving year for individual i (l, 2005, 2006, 2007, 2008 and 2009); $A_{im,}$ effects of age at calving for individual i (l, <4, 4–5, 5–6 and 6+ years); $e_{ijklm,}$ random residual effects.

RESULTS AND DISCUSSION

The highest milk yield (668.5 kg) was in cows at 6+ years of age at calving and calving in season 3 (age-season class 12) (Table 1) and this yield was regarded as mature age yield. This yield was divided by milk yield of the other age-season classes to obtain multiplying factors (MF) (Table 2) for adjusting to a common age-season class. For lactations less than 305 day milk yield, the ratio factors (RF) for 15^{th} day to 305^{th} day are presented in Table 3. Similarly, for lactations

Table 1. Means of fortnightly test day records for cows of different classes for age and season of calving

	Age-season classes											
TD	1	2	3	4	5	6	7	8	9	10	11	12
1	1.93	1.99	2.35	1.81	2.39	2.35	2.50	1.73	2.16	2.35	2.35	2.40
2	2.23	2.71	2.59	1.98	2.71	2.49	3.28	2.86	2.33	2.71	2.40	2.97
3	2.40	2.74	2.61	1.81	2.59	2.31	3.05	2.72	2.33	2.70	2.80	2.81
4	2.68	2.57	2.13	1.58	2.35	2.32	2.96	2.88	2.13	2.78	2.15	2.79
5	3.00	2.26	1.89	1.73	2.19	2.16	2.99	2.36	2.09	2.61	2.35	2.66
6	2.62	2.37	1.99	1.80	2.13	1.82	2.79	2.01	2.07	2.58	2.23	2.53
7	2.30	2.12	1.81	1.61	1.93	2.03	2.57	2.12	2.09	2.61	2.03	2.52
8	1.93	1.99	1.71	1.97	1.78	1.86	2.38	2.19	1.93	2.44	1.95	2.41
9	2.62	1.70	1.71	1.39	1.62	2.00	2.24	2.08	1.98	2.23	1.95	2.20
10	2.40	1.84	1.62	1.47	1.56	1.99	2.16	2.20	1.94	2.08	1.70	2.11
11	2.10	1.76	1.62	1.61	1.41	1.85	1.94	2.01	1.72	1.88	1.73	2.03
12	1.83	1.69	1.40	1.39	1.39	1.60	1.89	2.38	1.61	1.70	1.49	2.06
13	1.75	1.48	1.41	1.33	1.42	1.64	1.82	1.77	1.46	1.57	1.50	1.89
14	1.58	1.36	1.47	1.25	1.20	1.38	1.74	2.08	1.37	1.44	1.87	1.78
15	1.33	1.33	1.38	1.18	1.43	1.60	1.49	1.83	1.31	1.19	1.43	1.86
16	1.20	1.22	1.24	1.03	1.30	1.64	1.54	1.60	1.24	1.14	1.37	1.76
17	0.88	1.43	1.18	1.35	1.07	1.55	1.43	1.95	1.18	1.09	1.33	1.74
18	1.40	1.30	1.08	1.35	1.10	1.28	1.35	1.73	1.04	0.96	1.25	1.72
19	1.10	1.35	1.27	1.70	0.85	1.40	1.45	1.24	1.23	0.73	1.15	1.82
20	2.30	1.20	1.30	1.50	0.00	1.13	0.70	0.97	1.00	0.68	0.80	1.80
Total	39.58	36.41	33.76	30.84	32.42	36.40	42.27	40.71	34.22	37.47	35.83	43.84

Table 2. Multiplying factors (MF) for converting to base age-season class (72+ month of age at calving and calving in season 3)

	Age-season classes											
	1	2	3	4	5	6	7	8	9	10	11	12
MF	1.10	1.20	1.29	1.42	1.35	1.20	1.03	1.07	1.28	1.17	1.22	1.00

more than 305 days, RF to 305 day milk yield are presented in Table 4. Mean ratio factor for the 30th day was found as 8.16 and for the 305th day as 1.00 as expected which coincided with the reports of others (Suleyman *et al*. 2006, DHIA 1965). But the ratio factors for other test days are not exactly same within different studies and obviously this might be due to different breed, sample size, environment, feeding etc. According to these results, adjustment factors to mature equivalent and 305-day basis must be estimated independently for breed, herd and area.

The heritability estimates for individual test-days (TD1-TD20) and 305 day milk yield are presented in Table 5. The heritability estimate for 305-day milk yields was found as 0.35±0.08. The value is higher than the study of Suleyman *et al*. (2006) who found heritability as 0.24±0.08 for Simmental cattle in Turkey. Bilal *et al.* (2008) found heritability of 305 days milk yield for Sahiwal cattle in Pakistan as 0.082±0.077 which is very lower value than this study. The value of heritability for 305 days milk yields of all lactation in this study is at medium level which is in agreement with Swalve (2000). The variations between different studies might be due to different breed, environment, feeding and management, sample size, using different model etc. Random regression models generally give higher heritability estimates compared to ordinary test-day models (Jamrozik and Schaeffer 1997). Kettunen *et al.* (1998) observed that random regression models gave higher estimates of heritability than that of multiple trait models.

Heritability estimates in the beginning and end of lactation were lower. The heritability estimates of individual TDs ranged between 0.24±0.33 and 0.64±0.06. Heritability of individual TD milk yield was highest in the first three months (TD2 to TD6) whereas, lowest in first few days and later after 3 months. It was reported that estimates of heritability are higher in mid lactation than at the beginning and end of lactation (Ptak and Schaeffer 1993, Rekaya *et al*. 1999, Lidauer *et al*. 2003, Shadparvar and Yazdanshenas 2005, Bilal *et al*. 2008) which partially agreed to this study. The first test-day yield is comparatively less reliable than the subsequent yields. It usually takes few days after calving and many environmental factors like feeding before calving affect the trait (Shadparvar and Yazdanshenas 2005).

The heritability of all TDs (pooled) found in this study is 0.41±0.08 which is much higher than the study of Bilal *et al*.

Table 3. Age and season corrected adjustment factors to 305-day milk yield for lactation less than 305 days

Available TDs																				RF
1st																				18.27
1st	2nd																			8.16
1st	2nd	3rd																		5.36
1st	2nd	3rd	4th																	3.40
1st	2nd	3rd	4th	5th																3.22
1st	2nd	3rd	4th	5th	6th															2.71
1st	2nd	3rd	4th	5th	6th	7th														2.35
1st	2nd	3rd	4th	5th	6th	7th	8th													2.10
1st	2nd	3rd	4th	5th	6th	7th	8th	9th												1.88
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th											1.73
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th										1.60
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th									1.49
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th								1.40
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th							1.32
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th						1.25
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th					1.19
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th				1.14
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th			1.10
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th		1.04
1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	18th	19th	20th	1.00

Table 4. Age and season corrected adjustment factors to 305-day milk yield for lactation more than 305 days

Available TDs						RF
21st						1.08
21st	22nd					1.19
21st	22nd	23rd				1.17
21st	22nd	23rd	24th			0.71
21st	22nd	23rd	24th	25th		1.43
21st	22nd	23rd	24th	25th	26th	0.93

(2008) found as 0.02±0.05 for Sahiwal cattle in Pakistan. In our study, the heritability of TD milk yield was higher than that of 305 days milk yield. This result is contrary to other results (Swalve 1995, Kaya *et al*. 2003, Shadparvar and Yazdanshenas 2005 and Bilal *et al*. 2008). The variability of different works might be due to different breed, area, sample size, length of TDs, feeding and management, environment, use of different model for analysis etc.

The total variance ($\sigma^2_B + \sigma^2_w$) and variance between cows (σ^2_B) were found as 45525.57 and 12610.50, respectively. Then repeatability (r) was calculated as 0.28 by dividing $\sigma^2_B / \sigma^2_B + \sigma^2_w$. The standard error of repeatability was estimated at 0.12. The repeatability and standard error of repeatability of TDs milk yield were also estimated as 0.49 and 0.04, respectively using same procedure as before. When first lactation milk yield is standardized according to environmental effects, it may be an accurate measurement in selection for milk yield in dairy cattle.

Adjustment factors were estimated in this study for the first time in RCC cattle reared at BAU, Mymensingh, Bangladesh. As a small range of lactation records (116) were used, estimated adjustment factors may not be used reliably in the selection and culling of RCC. Furthermore, as there are no available adjustment factors for RCC in Bangladesh,

Table 5. Heritability of 305-day and individual test day milk yield

Test days (TDs)	No. of observation (N)	Heritability (h^2)	Standard errors of mean (SE)
TD1	116	0.247	0.084
TD2	113	0.622	0.058
TD3	111	0.638	0.058
TD4	109	0.537	0.069
TD5	109	0.430	0.081
TD6	107	0.511	0.076
TD7	104	0.343	0.083
TD8	102	0.285	0.085
TD9	100	0.376	0.086
TD10	97	0.342	0.096
TD11	93	0.308	0.094
TD12	92	0.418	0.093
TD13	87	0.392	0.097
TD14	79	0.303	0.104
TD15	68	0.247	0.164
TD16	60	0.535	0.121
TD17	47	0.514	0.137
TD18	40	0.282	0.210
TD19	31	0.354	0.277
TD20	23	0.240	0.326
305-day yield	116	0.349	0.082
TD	110	0.414	0.077

adjustment factors estimated in this study might be a route of further study with large volume of data. As heritability for TD and 305 days milk yield in this study were at medium level selection on the basis of heritability on this trait may not be accurate enough if environmental factors are not considered. Therefore, both individual and relative yield at this farm ought to be taken into consideration when selecting cows for milk yield. As repeatability of TD and 305 days milk yield were at lower to medium level, cows may not be evaluated according to first milk yield or any TD records in culling.

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