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Research Article

EFFECTIVENESS OF ADDITIVE AND MULTIPLICATIVE AGE ADJUSTMENT FACTORS FOR MILK PRODUCTION IN MURRAH BUFFALOES

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ABSTRACT

A total of 1637 lactation records of Murrah buffaloes, progeny of 180 sires, maintained from 1993-2012 at Government Animal Farm at Hisar were analyzed for developing and evaluating the efficiency of additive and multiplicative age correction factors. Age at calving was classified into 24 classes with an interval of 120 days between classes. The model used for least squares analysis and deriving the age correction factors included sire as random effect, period of calving, season of calving and age groups as fixed effects and lactation length as covariate. Both the age correction factors were equally effective on the basis of F-value, phenotypic correlation and repeatability. Additive correction factor ranged from -121.592 (AG_1) to 504.49 (AG_{24}), whereas multiplicative correction factor ranged from 0.79 (AG_{17}) to 1.06 (AG_1). Additive correction factors (ACF) were found to be more effective when compared on the basis of means and R^2 values, while multiplicative correction factors (MCF) were more effective in retaining similar coefficient of variation in different age groups as that of uncorrected data. It may be concluded that both ACF and MCF are equally efficient for correcting milk yield for age at calving. Hence either of these methods may be preferred in sire evaluation programmes to obtain accurate estimates of sire breeding values and to increase efficiency of selection.

Key words: Additive age correction factor, Multiplicative age correction factor, Murrah buffaloes

The success of a dairy industry in India is much dependent on buffaloes and the level of production and reproduction traits. Age at calving is one of the major non-genetic factors which mask its genetic potential of the buffalo for milk production. Milk production reaches maximum level at maturity and then decreases with age. The percent of reduction in total variance due to age has been estimated to be around 5% to 14% for lactation milk yield (Sikka 1950; Gacula *et al*., 1968; Tajane, 1975; Everett *et al*., 1982).

The age differences of daughters are likely to cause biases in the evaluations of sires under progeny testing programme and also in comparison of mates. By applying proper correction factors the superior sires having production performance from youngest daughters may be ranked accurately in comparison to the sire having performance records from older daughters. In the absence of accurate phenotypic value of milk production traits, it becomes difficult to estimate genetic parameters of the traits which determine the optimum selection criteria for genetic improvement of the animals.

MATERIALS AND METHODS

The data on production and reproduction performance from the 1637 history cum pedigree sheets of Murrah buffaloes sired, by 180 sires maintained at Central Institute for Research on Buffaloes, Hisar for a period of 20 years (1993-2012) were collected and utilized for the present study.

Animal who had completed having minimum lactation length ≥100 days and having lactation record of at least one lactation and maximum up to fifth lactation were included in the analysis. Records on total lactation milk yield (TLMY), 305 days milk yield (305 DMY), lactation length (LL), peak yield (PY), dry period (DP), service period (SP) and calving interval (CI) were analyzed to estimate the effect of parity, period and season of calving by using mixed model technique of Harvey (1990). The duration of 20 years was divided into five periods viz. period 1 (1993-1996), period 2 (1997-2000), period 3 (2001-2004), period 4 (2005-2008) and period 5 (2009-2012). Year of calving was divided into four seasons viz. summer (April-June); rainy (July-September); autumn (October-November); winter (December-March).

The statistical model used in the study was:

$$Y_{ijkklm}=\mu+S_i+Hj+P_k+SE_l+b_l(L_{ijklm}-L)+e_{ijklm}$$

Where, Y_{ijklm}=Observation on m^{th} progeny of i^{th} sire, j^{th} age group calved in k^{th} period and l^{th}season; μ=Overall mean; S_i=Random effect of i^{th} sire; H_j=Fixed effect of j^{th} age group (j = 1, 2…..5); P_k=Fixed effect of k^{th} period of calving (k =

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1,2…5); SE_1=Fixed effect of l^{th} season of calving (k = 1,2…4); b_1=Linear regression coefficient of a trait on lactation length; L_{ijklm}=Lactation length in days pertaining to Y_{ijklm} th observation; L=Mean lactation length and e_{ijklm}=random error assumed to be normally and independently distributed with mean zero and variance σ_e^2 (N~ 0, σ_e^2).

The additive correction factor (ACF) was computed by using the equation: ACF for i^{th} class=Least squares constant for i^{th} class–Least squares constant for base class. The class with the largest number of observation in age groups was chosen as base class i.e. AG_4 (1376-1495).

Milk yield corrected by ACF = Uncorrected milk yield–Additive correction factor. The multiplicative correction factors (MCF) were derived from the least squares means using the following expression which was also used by Saxena *et al.* (1991). MCF for i^{th} class= Least squares mean for base class/Least squares mean for ith class

The base class for age at calving for this method was also be the same as ACF i.e. AG_4 (1395-1476). Milk yield corrected by MCF = Uncorrected milk yield ×Multiplicative Correction Factor

F-ratio, least squares means, coefficient of variation, phenotypic correlation, repeatability, reduction of variance between age groups (R^2) were used to test the efficiency of the age correction factors.

RESULTS AND DISCUSSION

Age Correction Factors: The correction of milk yield records for age at calving is necessary to measure accurate estimates of breeding value of dairy animals. Milk yield of dairy animals increases with age upto certain limit and thereafter it declines. Therefore, age corrected records should be used for the estimation of breeding values of dairy animals. The results of the present study also indicated that age at calving had significant ($p<0.01$) effect on milk yield. So, it is necessary to correct the milk yield records for age at calving. For the purpose of developing age correction factors, the data from first to fifth lactation was classified into 24 age groups with an interval of 120 days. The least squares constants and means along with their standard error for different classes of age at calving are shown in (Table 1). For the base class AG_4 (1376-1495 days), least squares constants and means were -249.98±35.28 kg and 1925.61±35.63 kg, respectively. The least squares constants and means of milk yield for different age groups did not show any definite trend and these findings corroborated with findings of Saxena *et al.* (1991), Gandhi and Gurnani (1997) and Kumar and Singh (2003).

Additive and multiplicative correction factors for age at calving are given in Table 1. The ACF was maximum (504.49) for the buffaloes calving in AG_{24}

Table 1
Least square constants (LSC), least square means (LSM) along with their standard errors (SE), additive (ACF) and multiplicative (MCF) correction factors for total lactation milk yield in different age groups

Age group	Duration (days)	N	LSC±SE(kg)	LSM±SE(kg)	ACF	MCF
AG_1	<1135	53	-371.57±23.02	1804.02±61.90	-121.592	1.06
AG_2	1136-1255	44	-248.68±58.13	1926.92±58.31	1.301	0.999
AG_3	1256-1375	128	-295.65±54.08	1879.94±40.04	-45.676	1.024
AG_4	1376-1495	204	-249.98±35.28	1925.61±35.63	0.000	1.000
AG_5	1496-1615	103	-249.30±30.24	1926.30±42.41	0.681	0.999
AG_6	1616-1735	101	-125.25±37.89	2050.34±41.25	124.72	0.939
AG_7	1736-1855	147	-46.42±36.63	2129.17±36.22	203.56	0.904
AG_8	1856-1975	94	-58.70±31.00	2116.90±42.32	191.28	0.909
AG_9	1976-2095	82	49.50±38.08	2225.10±43.94	299.48	0.86
AG_{10}	2096-2215	112	-1.48±39.42	2174.11±38.55	248.49	0.88
AG_{11}	2216-2335	63	58.88±33.49	2234.49±47.39	308.87	0.86
AG_{12}	2336-2455	58	112.76±42.44	2288.36±48.73	362.74	0.84
AG_{13}	2456-2575	82	109.26±44.31	2284.86±42.86	359.24	0.84
AG_{14}	2576-2695	58	139.06±37.82	2314.66±49.37	389.047	0.83
AG_{15}	2696-2815	40	117.17±44.34	2292.77±57.50	367.15	0.83
AG_{16}	2816-2935	80	35.92±53.11	2211.52±43.97	285.90	0.87
AG_{17}	2936-3055	32	232.10±38.75	2407.70±64.10	482.08	0.79
AG_{18}	3056-3175	33	57.77±59.50	2233.38±62.11	307.76	0.86
AG_{19}	3176-3295	43	-29.05±57.24	2146.54±56.95	220.93	0.89
AG_{20}	3296-3415	27	98.52±52.03	2274.12±70.45	348.51	0.84
AG_{21}	2416-3533	16	62.59±65.75	2238.19±87.91	312.57	0.86
AG_{22}	3536-3655	11	196.32±83.00	2371.92±106.01	446.30	0.81
AG_{23}	3656-3775	15	151.68±100.62	2327.28±91.95	401.66	0.82
AG_{24}	>3776	11	254.51±87.05	2430.11±105.97	504.49	0.79

Table 2
Analysis of variance for effects of age groups on uncorrected, additively and multiplicatively corrected total lactation milk yield

Type of data	Sum of squares	Mean squares	Variance ratio (F)
Uncorrected	21437061.26	932046.14	9.034**
Additively corrected	0.009710	0.000422	0.000
Multiplicatively corrected	40284.575	1751.503	0.020

**p<0.01

(>3776 days), while it was minimum (-121.592) in AG_1 (<1135 days). The multiplicative correction factor was the highest (1.06) in AG_1 (<1135 days) and the lowest (0.79) in the AG_{17} and AG_{24}. The ACF and MCF for age did not show any specific trend. The present results are comparable with those of Saxena *et al.* (1991), Kumar and Gandhi (1995), Gandhi and Gurnani (1997) and Kumar and Singh (2003) in different breeds of cattle. On the contrary, Malik *et al*. (2001) reported increasing trend of ACF with the increase in age at calving. However, Das and Balaine (1983), Wilmink (1987), Chauhan (1988) and Cilek and Tekin (2006) reported different results than the present investigation. However, their results are not comparable to the present study because of differences in methods and models used. Wilmink (1987) in Friesian cows suggested that a more accurate age adjustment could be obtained by updating the mean production of heifers at 24 months of age. Chauhan (1988) concluded that a model of sire evaluation was equally accurate using the data pre-corrected ACF and MCF.

Efficiency of Age Correction Factors: For testing the efficiency of multiplicative and additive adjustment factors for age, F-value, means, coefficient of variation, repeatability, phenotypic correlation and R^2 methods were used. The variance ratio F-value (Table 2) for age at calving in uncorrected total lactation milk yield was 9.034 (Table 2). The F-value for age at calving in corrected milk yield by ACF and MCF were 0.000 and 0.020, respectively. It indicated the maximum reduction in F-value by both the methods and both the methods were equally efficient. These findings were in agreement with those of Chauhan (1988), Saxena *et al*. (1991), Kumar and Gandhi (1995), Gandhi and Gurnani (1997), Gandhi (2000) and Kumar and Singh (2003).

The least squares means (Table 3) for uncorrected milk yield and milk yield corrected for age at calving by different methods indicated that least squares means for uncorrected milk yield was the highest (2430.11 kg) for the buffaloes calved in AG_{24} (>3776 days) and was lowest (1804.02 kg) in AG_1 (<1135 days). Total lactation milk yield corrected for age at calving by ACF were almost similar in all classes. However, age corrected by MCF were more or less comparable to each other with the difference of 33.75 kg between the maximum (1496-1615 days) and minimum (>3776 days) age class. Since, ACF retained almost constant least squares means, it could be regarded as more efficient method.

The overall coefficient of variation for uncorrected milk yield and corrected milk yield for age at calving by ACF and MCF were 42.81%, 48.37% and 44.86%, respectively (Table 4). The CV of additively corrected and multiplicatively corrected data was almost similar to the coefficient of variation of uncorrected data, so both correction factors were equally efficient. These findings were in agreement with those of Kumar (1982), Chauhan (1988), Saxena *et al*. (1991) and Gandhi and Gurnani (1997). The phenotypic correlation of age at calving with

Table 3
Least squares means (kg) of total lactation milk yield on uncorrected, additively corrected and multiplicatively corrected data in different age groups

Age groups	N	Uncorrected	Additively corrected	Multiplicatively corrected
AG_1	53	1804.02	1925.61	1926.18
AG_2	44	1926.92	1925.62	1935.41
AG_3	128	1879.94	1925.62	1931.29
AG_4	204	1925.61	1925.61	1931.37
AG_5	103	1926.30	1925.62	1937.43
AG_6	101	2050.34	1925.61	1924.85
AG_7	147	2129.17	1925.61	1925.21
AG_8	94	2116.90	1925.62	1922.51
AG_9	82	2225.10	1925.61	1924.42
AG_{10}	112	2174.11	1925.62	1923.74
AG_{11}	63	2234.49	1925.62	1920.71
AG_{12}	58	2288.36	1925.61	1929.13
AG_{13}	82	2284.86	1925.61	1933.49
AG_{14}	58	2314.66	1925.61	1929.63
AG_{15}	40	2292.77	1925.61	1932.94
AG_{16}	80	2211.52	1925.61	1926.94
AG_{17}	32	2407.70	1925.62	1926.55
AG_{18}	33	2233.38	1925.62	1924.48
AG_{19}	43	2146.54	1925.61	1925.49
AG_{20}	27	2274.12	1925.61	1928.33
AG_{21}	16	2238.19	1925.61	1910.99
AG_{22}	11	2371.92	1925.62	1904.56
AG_{23}	15	2327.28	1925.62	1929.84
AG_{24}	11	2430.11	1925.61	1903.68

Table 4
Least- square means (LSM), coefficient of variation (CV) and correlation between total lactation milk yield and age groups

Type of data	LSM (kg)	CV (0/0)	Correlation
Uncorrected	2182.82±20.19	42.81	0.15
Multiplicatively corrected	1925.38±21.35	44.86	-0.11

Table 5
Sum of squares and R^2 values for total lactation milk yield calculated before and after correction for age groups

Type of data	Sum of squares		
	Among age groups	Total	R^2
Uncorrected	21437061.260	369930689.791	5.79
Additively corrected	0.009710	348493628.540	0.00002
Multiplicatively corrected	40284.575	294335031.673	0.0136

milk yield corrected for age at calving by ACF and MCF were 0.95 and 0.94 (Table 4). The phenotypic correlation between milk yield corrected for age by ACF and MCF and age at calving did not differ indicating that both correction factors are equally efficient. Similar results were also reported by Saxena *et al*. (1991) and Malik (1995). The overall estimate of repeatability for uncorrected milk yield was 0.32. For TLMY corrected for age at calving by ACF and MCF, the repeatability estimates were 0.34 and 0.33, respectively. As the repeatability of TLMY corrected for age at calving by ACF was comparatively higher than MCF, so ACF could be regarded as more efficient method. Similar results were also reported by Das (1978) in Hariana cattle and Murrah buffaloes for correction factors developed by least squares method. Malik (1995) also reported similar results in crossbred cattle. The R^2 value (sum of squares of production records due to age expressed as fraction of the total sum of squares) for uncorrected milk yield was observed as 5.79% (Table 5). The R^2 value obtained by ACF and MCF were 0.00002% and 0.0136%, respectively. The result of the present investigation reveals that maximum reduction in variability due to age group was observed for milk yield corrected by ACF, which indicated that additive correction factor was more effective for correction of milk yield for age at calving than that of multiplicative correction factor.

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