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PREDICTION OF 305 DAY MILK YIELD FROM SINGLE AND CUMULATIVE RECORDS OF HOLSTEIN COWS, USING REGRESSION PROCEDURES

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SUMMARY

Simple, multiple linear and stepwise regression procedures were used to predict 305 day milk yield (305MY) of 833 first lactation records of Holstein Friesian cows from single and cumulative monthly milk records. The milk yield of the seventh month (M7) gave the highest correlation with 305 day milk yield of the first lactation ($r = 0.863$) which was the highest among all months. Simple linear regression equations, 305MY = 2453.59 + 6.59M7 explained 75.9 percent of variation in 305 day milk yield. The accuracy (R^2) for predicting 305 day milk yield on the basis of cumulative monthly milk yield increased from a minimum of 54.7 percent for first 60-day milk yield to a maximum of 97.9 percent for 270-day milk yield. Among the various multiple linear regression equations, the best equation included the first seven months. This equation explained 94.2 percent of the variation in 305 MY. The equation of choice for stepwise regression was 305MY = 1199.84 + 4.75M7 + 3.25M3, which explained 87.5 percent of variation in 305MY. The increase in R^2 with adding extra months was negligible.

Keywords: Holstein Friesian, milk yield, prediction, single and cumulative records and regression equations

INTERODUCTION

The prediction of total milk yield of a cow from its part records is necessary to perform early selection, genetic evaluation of both cows and sires (Lamb and McGilliard, 1967 ; Murthy *et al*,1986 and Mathew and George,1989). The accuracy of estimating 305 day milk yield from part records depends upon the magnitude of the relationship between part records and 305 day milk yield and the method of estimation (Rao and Sundaresan,1980 ; Murthy *et al*, 1986).

The most cited reasons for using part records are 1) saving time, cost and effort of recording, 2) identifying the high producing cows for selection, 3) avoid cost of maintaining low producing cows, 4) early sire evaluation, 5) reducing generation interval and 6) increasing the rate of genetic gain (Chillar *et al*.,1980; Agyemang *et al*.,1985; Katoch and Yadav,1990; Parmar *et al*.,1990; Shobha and Khan,1990; Godra *et al*., 1991; Jain *et al*.,1991 ; Ahunu and Danbaro,1992 and Zahed *et al*. 1997).

Part records could be converted to complete records of a standard duration to reduce variation resulting from the influence of the length and the stage of lactation and to predict month-by-month and total milk yield of a dairy animal (Abdel-Aziz *et al*., 1973).

The purpose of this study was to investigate the possibilities of predicting 305 day first lactation milk yield from single or cumulative monthly records using three regression methods: simple regression, multiple linear regression and stepwise regression.

DATA AND ANALYSIS

First lactation records of 833 Holstein cows were collected by the Cattle Information System/Egypt (CISE) from El-Tobgy farm, Fayoum Governorate over a period of seven years from 1992 to 1998. Phenotypic correlation coefficients between 305 day milk yield and single months (1-10 months) were estimated using SAS (1996) program. For predicting 305 day milk yield from single and cumulative milk records, simple linear regression analysis with only one independent variable (single or cumulative milk record) in the model; multiple linear regression analysis where number of independent variables (single or cumulative milk records) increased with the availability of additional progressive records and stepwise regression for selecting best combination of two or more single months, were used.

The model used for simple linear regression was:

$$Y_j = a_i + b_i X_{ij} + e_{ij}$$

Where:

Y_j = estimated 305 MY of j^{th} animal,

a_i = the constant for i^{th} single or cumulative milk record,

b_i = the regression coefficient of Y on the i^{th} single or cumulative milk record,

X_{ij} = the i[th] single or cumulative milk record of j[th] animal, and
e_{ij} = the residual random error associated with the i[th] single or cumulative milk record of j[th] animal.

The model used for progressive multiple linear regression was:

$$Y_j = a_k + \sum_{i=1}^{k} b_i X_{ij} + e_{ij}$$

Where:
Y_j = estimated 305 MY of j[th] animal,
a_k = the specific intercept when there are k independent variables in the equation,
b_i = the partial regression coefficient of Y on the i[th] cumulative milk record,
X_{ij} = observed value of the i[th] cumulative milk record of j[th] animal, and
e_{ij} = the residual random error associated with the i[th] cumulative milk record of j[th] animal.

Stepwise regression analysis was followed, where relative contribution of each additional single month in the prediction equation was tested before it was selected for the next step. All regression equations were calculated using SAS (1996) procedure.

RESULTS AND DISCUSSION

Phenotypic correlations

The phenotypic correlations between 305 day milk yield (305MY) and single monthly milk yield were positive and highly significant (Table 1). The estimates of phenotypic correlations were higher in the middle months of lactation (M4-M8) than the first and late months of lactation. This observation is in agreement with many published papers (Van Vleck and Henderson, 1961; Lamb and McGilliard, 1967; Kang *et al.*, 1990 and Shelke *et al.*, 1992).

Table 1. Phenotypic correlation coefficients between single monthly milk yield records (M1-M10) and 305 day milk yield (305MY) of Holstein cows

	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
305MY	0.57	0.73	0.77	0.80	0.82	0.84	0.86	0.83	0.75	0.64
M1		0.67	0.50	0.48	0.44	0.39	0.45	0.35	0.26	0.25
M2			0.72	0.66	0.66	0.57	0.55	0.52	0.36	0.32
M3				0.76	0.67	0.66	0.60	0.52	0.46	0.34
M4					0.77	0.68	0.67	0.58	0.42	0.37
M5						0.82	0.72	0.67	0.46	0.35
M6							0.82	0.69	0.53	0.45
M7								0.82	0.59	0.52
M8									0.71	0.53
M9										0.67

Results revealed that the single months from the 4[th] to the 8[th] month can be used to predict 305MY.

Predicting 305MY on the basis of single months milk yield

Regression equations for predicting 305MY from single months milk yield are given in table 2. The tabulated equations revealed that M7 accounted for a maximum R^2 (75.9%) in predicting 305MY, followed by M6 (72.9%), M8 (70.2%), M5 (69.9%) and M4 (67.3%). The equation based on the seventh month (M7) was 305MY= 2453.6 + 6.59 M7. The prediction equation derived from monthly milk yield showed a trend similar to that reported by Bhadauria *et al.* (1986) for Jersey cows; Do-Ch *et al.* (1986 a) for Holstein-Friesian and Mandal and Mehla (1997) for Murrah buffaloes.

Van Vleck and Henderson (1961); Do-Ch *et al.* (1986b); Kang *et al.* (1990) and Roy and Pyrbot (1994), found that the best single months for predicting total milk yield were the 4[th], 5[th] and 6[th] months of lactation.

In other breeds, Gaur *et al.* (1996) reported that the equation containing the 4 [th] month milk yield of Sahiwal cows was the best of all the equations which were based on yield of single months. The same conclusion was reported by Ray and Katpatal (1989) in Jersey cows.

Table 2. Simple linear regression equations for predicting 305 day milk yield (305MY) of Holstein cows on the basis of single month's milk yield

Y	X	a	B	SE(b)	R^2 (%)
305MY	M1	3492.57	4.88	0.26	33.2
	M2	2076.28	6.32	0.20	58.5
	M3	2237.80	6.10	0.18	61.5
	M4	2227.50	6.25	0.17	67.3
	M5	2184.09	6.50	0.16	69.9
	M6	2346.00	6.50	0.15	72.9
	M7	2453.59	6.59	0.14	75.9
	M8	2697.34	6.50	0.16	70.2
	M9	3018.58	6.40	0.18	63.5

All 'b' values were significant at $p < 0.01$

Predicting 305MY from cumulative milk yield

Regression equations for predicting 305MY from cumulative milk yield are presented in Table 3. The accuracy of estimation (R^2) increased from a minimum of 54.7 % for the first two months (CY60) to a maximum of 97.9 % for cumulative yield of 270 days. The increase in R^2 values with additional months records was not linear. The increase in R^2 values was 14.0, 8.4, 6.5, 5.2, 3.9, 3.0 and 2.2 percent with each additional month.

Table 3. Simple linear regression equations for predicting 305day milk yield (305MY) from cumulative monthly yields of Holstein cows

Y	X	a	b	SE(b)	R^2 (%)
305MY	CY60	1905.54	3.41	0.12	54.7
	CY90	1025.77	2.63	0.07	68.8
	CY120	666.58	2.09	0.04	77.1
	CY150	392.61	1.75	0.03	83.6
	CY180	244.01	1.51	0.02	88.8
	CY210	198.95	1.32	0.01	92.7
	CY240	137.02	1.18	0.01	95.7
	CY270	79.74	1.07	0.01	97.9

All 'b' values were significant at $p < 0.01$; CY= Cumulative milk yield.

R^2 values of Table 3 showed that increasing the length of cumulative record beyond 210 days (CY210) contributed at a decreasing rate in the accuracy of prediction. The same conclusion was also drawn by Bhadauria *et al.* (1986) for Jersey cows and Kang *et al.* (1990) for Holstein cows. Ashmawy *et al.* (1985) also concluded that the first seven months of lactation were considered sufficient for predicting 305-day milk yield of Egyptian buffaloes.

Predicting 305MY from combinations of single monthly records using multiple linear regression:

Multiple linear regression equations for predicting 305MY are given in Table 4. The accuracy of estimation (R^2) increased gradually with increasing the number of monthly milk records included in the equation. The accuracy was 59.6 percent when M1 and M2 were used in the prediction equation and reached 98.4 percent when the first nine months milk yield were included. The increase in R^2 values with each additional monthly yield was 12.00, 7.52, 6.42, 5.06, 3.59, 2.45 and 1.66 percent, respectively. The best equation for Practical use was that which include of the first seven months. This equation explained 94.2 percent of the variation in 305 MY with very small increase in accuracy with adding more single monthly records.

Predicting 305MY from combinations of single monthly records using stepwise regression procedure

Prediction equations derived through stepwise procedure for predicting 305MY from monthly milk yields are shown in Table 5. The M7 alone was the best predictor of 305MY with an accuracy of 75.9 percent. This result was the same as obtained by using a simple regression equation (Table 2). The second best monthly yield was M3 where R^2 reached 87.5 percent. The increase in R^2 values with additional monthly milk records after each step was 11.56, 4.11, 3.45, 1.74, 1.30, 0.55, 0.35, 0.34 and 0.36, respectively. For practical purposes, the best equation for predicting 305MY was: 305MY = 1199.84 + 4.75M7 + 3.23 M3, with accuracy of 87.45. After this step, the rate of increment of R^2 values was low.

Table 4. Multiple linear regression equations for predicting 305day milk yield from progressive monthly milk yield of Holstein cows

Variable	a	b1	b2	b3	b4	b5	b6	b7	B8	b9	R^2(%)
M1-M2	1815.23	1.19 (±0.27)	5.57 (±0.26)								59.6
M1-M3	1072.46	1.18 (±0.23)	2.74 (±0.28)	3.79 (±0.22)							71.6
M1-M4	797.49	1.09 (±0.19)	1.90 (±0.24)	1.83 (±0.23)	3.31 (±0.21)						79.1
M1-M5	489.82	1.28 (±0.16)	1.03 (±0.21)	1.64 (±0.19)	1.55 (±0.20)	3.17 (±0.18)					85.5
M1-M6	374.66	1.19 (±0.13)	1.22 (±0.17)	0.93 (±0.16)	1.53 (±0.16)	1.04 (±0.18)	3.04 (±0.16)				90.6
M1-M7	389.15	0.82 (±0.10)	1.21 (±0.13)	1.13 (±0.12)	0.98 (±0.13)	0.10 (±0.14)	1.28 (±0.15)	2.64 (±0.13)			94.2
M1-M8	239.49	1.04 (±0.08)	0.79 (±0.10)	1.23 (±0.09)	1.09 (±0.10)	0.61 (±0.11)	1.33 (±0.11)	1.12 (±0.12)	2.21 (±0.10)		96.7
M1-M9	133.53	0.96 (±0.06)	1.09 (±0.07)	0.83 (±0.07)	1.06 (±0.07)	0.82 (±0.08)	1.10 (±0.08)	1.17 (±0.08)	0.82 (±0.09)	1.87 (±0.07)	98.4

All 'b' values were significant at $p < 0.01$

Table 5. Regression equations for predicting 305 day milk yield (305MY) from monthly milk yields of Holstein cows using stepwise procedure

Step	Variable	a	B	SE(b)	R^2 (%)
I	M7	2453.59	6.59	0.141	75.9
II	M7	1199.84	4.75	0.126	87.5
	M3		3.25	0.129	
III	M7	970.93	3.49	0.124	91.6
	M3		2.83	0.109	
	M9		2.30	0.126	
IV	M7	482.58	3.01	0.098	95.0
	M3		1.61	0.101	
	M9		2.37	0.097	
	M2		2.23	0.102	
V	M7	373.83	2.81	0.087	96.8
	M3		1.27	0.083	
	M9		2.28	0.078	
	M2		1.82	0.085	
	M5		1.66	0.087	
VI	M7	343.16	2.09	0.068	98.1
	M3		1.35	0.065	
	M9		1.50	0.071	
	M2		1.71	0.066	
	M5		1.83	0.068	
	M10		1.07	0.050	

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Table 5.Cont.

Step	Variable	a	b	SE(b)	R^2 (%)
VII	M7	160.24	1.93	0.059	98.6
	M3		1.35	0.055	
	M9		1.55	0.060	
	M2		1.18	0.065	
	M5		1.95	0.058	
	M10		1.06	0.043	
	M1		0.84	0.051	
VIII	M7	145.10	1.81	0.052	98.9
	M3		1.02	0.052	
	M9		1.59	0.052	
	M2		1.12	0.056	
	M5		1.63	0.054	
	M10		1.03	0.037	
	M1		0.82	0.044	
	M4		0.84	0.056	
IX	M7	124.90	1.38	0.049	99.3
	M3		0.84	0.044	
	M9		1.56	0.043	
	M2		1.17	0.046	
	M5		1.19	0.051	
	M10		0.10	0.031	
	M1		0.86	0.037	
	M4		0.93	0.046	
	M6		0.95	0.053	
X	M7	109.27	0.90	0.039	99.7
	M3		0.99	0.032	
	M9		0.96	0.038	
	M2		0.95	0.034	
	M5		1.03	0.060	
	M10		1.07	0.020	
	M1		0.95	0.030	
	M4		0.97	0.030	
	M6		1.03	0.040	
	M8		1.07	0.040	

All 'b' values were significant at $p < 0.01$

CONCLUSION

The results obtained from the present study indicated that 305MY could be predicted from the milk yield of the seventh month (R^2 =76%) and from the cumulative milk yield of the first seven months (R^2=93%). The stepwise regression was the best procedure to predict 305MY compared with the multiple linear regression.

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