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Seasonal Age Correction Factors for 305 Day Milk Yield in Holstein Cattle

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Abstract
Total of 3780 lactation records of Holstein Friesian cattle kept at a commercial farm (Dena Farm) in Egypt, during the period from 1988 to 1996 were used. Fixed effects of month and year of calving and age at calving as a regression and random effects of sire and cow within sire on 305 day milk yield were used. Least squares analysis of variance showed significant effects of month and year of calving, age at calving, sire and cow within sires. Including age at calving as a polynomial regression of the second degree in the model yielded significant regression coefficients. The partial linear and quadratic regression coefficients of age at calving on 305 day milk yield were 8.49 ± 1.76 kg/mo and -0.51 ± 0.05 kg/mo^2, respectively. A set of multiplicative age factors was derived for 305 day milk yield for each season of calving and for all data by fitting a second degree polynomial for production on age. It is suggested that there should be a separate set of age correction factors for each season of calving and for each region.

Introduction
Milk yield in dairy animals is affected by many genetic and non-genetic factors. Evaluation of the non-genetic effects on milk yield provides basic information for developing breeding and management programs for genetic improvement. The removal of the effects of the non-genetic factors permits accurate genetic evaluation for the breeding animal. Age at calving is one of the non-genetic factors affecting milk yield. It has been established that milk yield increased as age of the cows advances till the maximum production is obtained and then decline (Galal *et al*., 1974; Mourad *et al*., 1986; Weller *et al*., 1986; Khattab and Ashmawy, 1988, 1990; Sallam *et al*., 1990; Rege, 1991; Mourad and Khattab, 1992; Soliman *et al*., 1994; Abdel Glil, 1996; Kaya, 1996; Yener *et al*., 1998). Galal *et al*. (1974) and Soliman *et al*. (1994) working on Friesian cattle and Egyptian buffaloes respectively used three sets of age correction factors (gross comparison, fitting a second degree polynomial of prediction on age and paired comparison). The three methods were reported to succeed in removing the dependence of milk production on age and were not significant different from each other in that regard.
Miller and Henderson (1968) computed seasonal age correction factors from New York DHIA records by the maximum likelihood method in addition to the gross and paired comparison method. They found that the seasonal differences were large for factors of the gross comparison method, small for factors of both the paired comparison and maximum likelihood method.
Khattab and Ashmawy (1990) and Mourad *et al*. (1986) working on Friesian cattle and Egyptian buffaloes, reported that age correction factors different from season to another and at different region. Also, Cooper and Hargrove (1982) arrived at the same results in Holstein Friesian cattle in Pennsylvania Dairy Herd improvement plans. Mourad and Khattab (1992) working on 3738 lactation records Egyptian buffaloes, estimated age correction factors for each parity and for all parities, by fitting a second degree polynomial prediction on age, they suggested that there should be a separate set of age correction factors for each parity.
The purpose of this study were to estimate non-genetic factors affecting 305 day milk yield and constructing five sets of second degree polynomial regression of factors of production on age for correcting 305 days milk yield.

Materials and Methods
Data: Data used in this study were obtained from the milk production records of Holstein Friesian cattle raised in Dena Farm far from Cairo by 80 km. They comprised 3780 normal 305 day lactation records covering the period from 1988 to 1996. A total number of sires, cows per sire and average of daughters per sire were 345, 1297 and 10.70, respectively. Sires were chosen at random and artificial insemination were used.
Cows were grazing on Egyptian clover *(Trifolium alexandrinum),* Berseem, during December-May. During the rest of the year animals were fed on concentrate mixture along with rice straw and limited amount of clover hay when available. Requirements for each animals were calculated on the basis of its live weight and milk production. Cows giving more than 10 kg/day were provided with extra concentrate mixture proportional to their yield. Cows were machine milked twice daily and milk yield was recorded individually to the nearest 0.5 kg.

Analysis: Data were analysed using mixed model least squares and maximum likelihood computer program of Harvey (1987). Records of all available seasons were analysed according to the following model;

$$Y_{ijklm} = \mu + S_i + \alpha_{ij} + M_k + R_l + b_{1L}(X_1 - \bar{x}) + b_{2Q}(X_1 - \bar{x})^2 + e_{ijklm} \quad (1)$$

where
Y_{ijklm}: 305 day milk yield; μ: overall mean, Si :random effect

of the i[th] sire; α_{ij}: random effect of the j[th] cow nested within ith sire; M_k: fixed effect of the k[th] month of calving (k = 1,2,..., 12); R_l: fixed effect of the l[th] year of calving (l = 88,..., 96); b_{1L} and b_{2Q}: partial linear and quadratic regression coefficients of 305 day milk yield on age at calving; X_i: the age of cow in month that correspond, $\bar{x}$: the mean of age at calving; and e_{ijklm}: random error.

Records of lactation started in each season were analysed separately according to the following model;

$$Y_{ijklm} = \mu + S_i + a_{ij} + R_k + b_{lL}\left(X_i - \bar{x}\right) + b_{2Q}\left(X_i - \bar{x}\right)^2 + e_{ijklm} \quad (2)$$

where

Y_{ijklm} = 305 day milk yield of the Ijklm record, the other terms are defined as in model (1).

The prediction equations of 305 day milk yield from age at calving $(X)_i$ were used. Then the age at maximum production was located by setting the first derivative of

$$Y_i = \mu + b_{lL}\left(X_i - \bar{x}\right) + b_{2Q}\left(X_i - \bar{x}\right)^2 \quad (3)$$

with respect to Y equal to zero and solving for X.

The maximum production was obtained by substituting the value of X back into equation (3).

Age correction factors to mature equivalent basis were estimated as follows,

$$F^o = Y_m / Y_n$$

where

F_o: the multiplicative age correction factor for milk records, Y_m: the maximum milk yield and Y_n: yield milk at the n[th] age in months.

Results and Discussion

Least squares mean of 305 day milk yield was 4738 ± 76 kg (Table 1). The present mean was lower than those reported by Kaya (1996); Makuza and McDaniel (1996), Kelm *et al*. (1997) and Yener *et al*. (1998) working on Holstein Friesian cattle in different countries and ranged from 5040 to 8383 kg while, the present mean was higher than those estimated reported by Khattab and Sultan (1991) and Abdel Glil (1996), being (2954 kg and 2254 kg, respectively). The differences between our results and those of other workers could be due to differences in climatic and management conditions and/or genetic differences in herds.

Least squares analysis of variance of 305 day milk yield is presented in Table 2. Effects of, month of calving, year of calving, age at calving as a regression and sire and cow within sire as a random on 305 day milk yield were significant ($p<0.01$).

Results (Table 1) show that cows calving in winter and spring months had the highest 305 day milk yield, while summer and autumn calves had the lowest 305 day milk yield. These findings are in close agreement with those of Ashmawy (1991), Khattab and Sultan (1991) and Yener *et al*. (1998). Also, Kaya (1996), Makuza and McDaniel (1996) and Kelm *et al*. (1997) found significant effect of month of calving on milk yield, all working on Holstein Friesian. However, Eltawil *et al*. (1976) observed a consistent trend in season of calving effect on milk yield although not attaining statistical significance in most cases. Also, Khattab and Ashmawy (1990) and Abdel Glil (1996) working on Friesian cattle in Egypt, found no significant effect of season of calving on 305 day milk yield.

Table 1: Least squares constants of factors affecting 305 day milk yield

Classification		305 day milk yield	
Least squares means	N	constant	S.E.
	3780	4738	76
Month of calving			
1	266	384	76
2	277	336	78
3	304	224	72
4	240	-60	81
5	241	-43	82
6	232	-265	82
7	328	-313	67
8	401	-285	61
9	436	-114	57
10	375	-69	61
11	319	0.26	68
12	361	205	67
Year of calving			
1988	474	283	100
1989	498	558	88
1990	473	8	74
1991	506	-174	57
1992	649	-355	50
1993	528	-648	61
1994	379	39	71
1995	225	557	105
1996	48	-270	190
Regressions			
Age, linear	3780	8.49	1.76
Age, quadratic	3780	-0.51	0.05

The high yield in winter and spring calves could be attributed to the favorable climatic conditions for abundant growth and availability of good quality Egyptian clover (berseem) during the increasing stage of lactation.

Effects of year of calving on 305 day milk yield (Table 2) were highly significant ($p<0.01$) for each season of calving and for all data, but no specific trend was noticed the significant effect of year of calving on 305 day milk yield (Table 1). Mourad *et al.* (1986), Khattab and Ashmawy (1988, 1990), Khattab and Sultan (1991), Ashmawy (1991), Kaya (1996), Makuza and McDaniel (1996),

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Table 2: Least squares analysis of variance for factors affecting 305 day milk yield for different seasons of calving: Winter (W), Spring (S), Summer (Sr), Autumn (A) and for all seasons (All)

Source of	W.		S.		Sr.		A.		All	
variation	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.	d.f.	M.S.
Sire	220	2648305**	200	1767946**	249	2260781**	300	2794727**	344	4027038**
Cow Sire	346	1597739**	352	1316701**	325	1240713**	449	1854013**	952	1988965**
Month of calving									11	7081803**
Year of calving	8	2641385**	8	4492116**	7	11516605**	7	9401869**	8	34840547**
Regressions										
Age, linear	1	607653**	1	5469752**	1	111855**	1	3857673**	1	21645507**
Age, quadratic	1	11357908**	1	8120556**	1	14592939**	1	28927502**	1	76123543**
Remainder	327	845674	222	728340	377	9045572	777	979351	2462	940376

**$p<0.01$

Kelm *et al*. (1997) and Yener *et al*. (1998) with different herds of dairy cattle reported significant effect of year of calving on 305 day milk yield. They indicated that differences in this respect may be due to differences between years in feeding system and managerial practices. The linear and quadratic regression coefficients of 305 day milk yield in age at calving were highly significant ($p<0.01$, Table 2) for each season and for all data. Significant effect of age at calving on 305 day milk yield were reported by many workers in different countries (i.e., Mourad *et al*., 1986; Khattab and Ashmawy, 1990; Sallam *et al*., 1990; Khattab and Sultan, 1991; Mourad and Khattab, 1992; Soliman *et al*., 1994; Makuza and McDaniel, 1996). Abdel Glil (1996) working on Friesian cattle in Egypt, estimated partial linear and quadratic regression coefficients of age at first calving on 305 day milk yield were significant, being (21.58 ± 3.04 kg/mo and -0.18 ± 0.03 kg/mo2, respectively). The maximum milk yield (Ytn) was found to the 4980, 4580, 4701, 5033 and 4773kg for winter, spring, summer and autumn calves and for all data, respectively (Table 3).

Values of maximum milk yield were used as numerators for age the correction factors. The maximum age for each of the five equations for estimating the correction factors in the same order were 52, 64, 48, 52 and 56, respectively (Table 3).

Table 3: Prediction equations of 305 day milk yield (Y) of Holstein Friesian Cattle from age at calving *(X)*

N	Dependent variable $\mu + b_{IL}(X-\bar{x}) + b_{20}(X-\bar{x})^2$
904	$Y_{winter} = 4975 + 3.32(X-\bar{x}) - 0.52(X-\bar{x})^2$
785	$Y_{spring} = 4425 + 18.60(X-\bar{x}) - 0.56(X-\bar{x})^2$
961	$Y_{summer} = 4702 - 2.47(X-\bar{x}) - 0.90(X-\bar{x})^2$
1536	$Y_{autumn} = 5021 + 5.46(X-\bar{x}) - 0.60(X-\bar{x})^2$
3780	$Y_{all\ data} = 738 + 8.49(X-\bar{x}) - 0.51(X-\bar{x})^2$

The present results show that female cows calving in summer reach mature age earlier than those calving in other seasons of the year. Khattab and Ashmawy (1990) working on another set of Friesian cattle in Egypt, reported that the maximum milk production was reach at approximately 76.9, 78.8, 85.7, 96.8 and 80.1 month of age for winter, spring, summer, autumn and all seasons, respectively. Galal *et al.* (1974) showed that peak yield was reached at approximately 84 month of age. At such a time cows reached mature body weight and this is associated with complete development in size and function of digestive, circulatory, mammary gland the other body systems. Therefore, the amount of feed intake, feed utilization and efficiency of milk synthesis are greatly increased with advantage in age thereafter the physiological activity of all body system start to decrease and secretory tissue of other is partially degenerated leading to gradual decrease in the amount of milk yield.

Table 4: Age correction factors for 305-day milk production for different seasons of calving :Winter (W), Spring (5), Summer (Sr) and Autumn (A) and for all seasons (All)

Age no.	Factors W	S	Sr	A	All
24	1.08352	1.25236	1.07883	1.10750	1.12556
28	1.05937	1.19581	1.05151	1.07730	1.09366
32	1.03988	1.14929	1.03057	1.05292	1.06741
36	1.02459	1.11107	1.01533	1.03367	1.04611
40	1.01316	1.07985	1.00533	1.01907	1.02926
44	1.00534	1.05467	1.00027	1.00874	1.01646
48	1.00099	1.03482	1.00000	1.00243	1.00743
52	1.00000	1.01975	1.00452	1.00000	1.00198
56	1.00236	1.00908	1.01395	1.00139	1.00000
60	1.00811	1.00255	1.02857	1.00664	1.00144
64	1.01738	1.00000	1.04884	1.01587	1.00634
68	1.03036	1.00138	1.07540	1.02929	1.01480
72	1.04732	1.00670	1,10918	1.04724	1,02699
76	1.06865	1.01611	1.15142	1.07018	1.04318
80	1.09486	1.02983	1.20388	1.09873	1.06376
84	1.12662	1.04821	1.26897	1.13372	1.08919
88	1.16479	1.07174	1.35013	1.17627	1.12015
92	1.21051	1.10106	1.45236	1.22787	1.15749
96	1.26529	1.13708	1.58319	1.29052	1.20231
100	1.33116	1.18096	1.75447	1.36701	1.25613

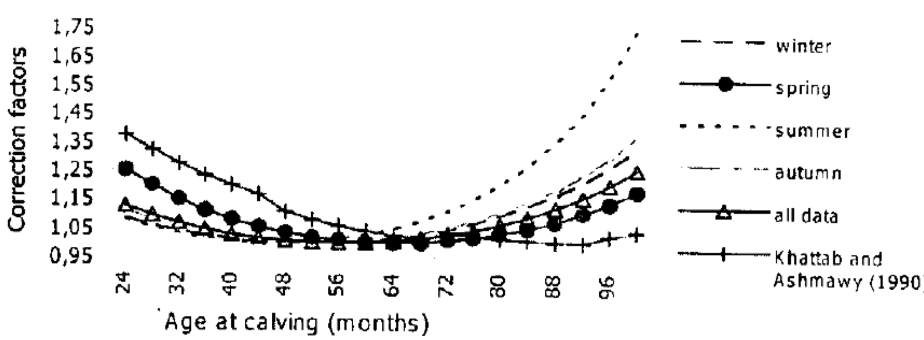

Fig. 1: Age correction factors of different seasons and other published factors

A set of multiplicative age correction factors for each season of calving and for all seasons by fitting the polynomial regression of second degree for 305 day milk yield for predicting on age was derived and presented (Table 4).

The numerical values of age correction factors of different seasons were larger in older ages than in younger ages. Mature equivalent factors from this study show a rapid decline for the younger cows relative to the gradual decline thereafter (Fig. 1).

For the comparisons between separate factors of different seasons, and absolute difference of at least 0.05 was considered large enough to warrant separate set of correction factors at any stage of the curve (Cooper and Hargrove, 1982). While there are differences between correction factors which are more than 0.05 (Fig. 1). Then change in the age correction with age different from season to another. It also, shows that the factors of different seasons are more similar at middle age (45-50 mo) than in either or older ages. However, more data are required to show the necessity of by separate sets of correction factors.

Comparisons of present factors of all seasons and those of Khattab and Ashmawy (1990) (Fig. 1). A high percentage of difference in correction factors (present minus Khattab and Ashmawy, 1990) is large and negative values and generally the factors of the present study were lower as compared to their.

The apparent difference between correction factors in different seasons and regions suggests that it is necessary to separate set of age correction factors for each deserves a serious consideration.

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