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THE GENETIC AND PHENOTYPIC EFFECTS OF DAYS OPEN AND DRY PERIOD ON 305-DAYS MILK, FAT AND PROTEIN YIELDS OF GERMAN FRIESIAN COWS

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ABSTRACT

Data relevant to 9092 Friesian cows from 21 herds located in Germany over a period of 18 years from 1979 to 1996 were used to estimate the genetic and phenotypic effects of days open and dry period on 305-days milk, fat and protein yields during the first three lactations. The effects of herd, season and year of calving and parity were investigated. Least squares analysis of variance showed a highly significant influence of all factors on 305-days milk, fat and protein yields. Partial linear and quadratic regression coefficients apparently showed an average increase of 3.28, 0.128 and 0.108, kg for 305-days milk, fat and protein yields, for each additional day open, and 1.72, 0.061 and 0.057, kg of 305-days milk, fat and protein yields, for each additional day dry. Multiple-trait maximum Likelihood was used to estimate variances and covariance. Heritabilities for first, second, third and all lactations were 0.34, 0.25, 0.24 and 0.24 for 305-days milk, 0.30, 0.24, 0.27 and 0.31 for fat yield, 0.29, 0.25, 0.22 and 0.33 for protein yield, respectively. Heritability for each of days open and dry period were low and ranged from 0.04 to 0.09. Genetic correlations between different traits in all lactations were positive and ranged from 0.32 to 0.87. Phenotypic correlations ranged from 0.19 to 0.92. A days open period of 60-90 and dry period of 60 days were suggested as optimum intervals for attaining maximum milk, fat and protein yields for Friesian cows in Germany.

INTRODUCTION

The integration of several traits such as age at first calving, days open, dry period, calving interval, herdlife besides milk performance and the knowledge of their relationships are important for effective control of the dairy production system for maximum economic return. Long calving interval imply long days open and probably long dry period too. The highest yielding cows have been reported to have the shortest subsequent dry period (Smith and Legates, 1962, and El-Awady and Tawfik., 2000). Therefore, previous milk yield should be included in the model when the effect of dry period is determined. A nonlactating period of 60-70 days between lactations is required for optimal milk production in the subsequent lactation. Either shorter or longer periods will reduce subsequent milk production (Smith and Legates, 1962; Wilton *et al.*,1967; Funk *et al.*, 1987 and El-Awady and tawfik.,2000). The range of heritability estimates for some fertility traits such as days open and calving interval is from 0 to 0.15. Days open from parturition to the subsequent conception affected milk yield and estimated breeding value

(EBV) of cows and sires (*Bar-Anan and Soller, 1979 and El-Awady and* Tawfik, 2000). With fewer current days open, nutrients consumed during late lactation are directed to gestation needs rather than to yield, and often cows are dried off prior to 305-days. With more days open, cows have more time to renew the body condition that is used for yield during the next lactation, and the converse may be expected. Relationships of these factors with milk traits are complex and are affected by management and environmental condition. The objective of our study were to estimate (1) the effects of *current days open and preceding* dry period on milk, fat and protein yields, (2) the effects of season and year of calving, parity, days open and dry period on milk, fat and protein yields and (3) genetic and phenotypic parameters for milk traits and both days open and dry period.

MATRIALS AND METHODS

Data for the present research were collected from 21 herds distributed *in a sub-region of* Osnbrück and were offered from VIT (Vereinigte Informationssysteme Tierhaltung, Verden). It was the original data which was used for the estimation of the breeding values for the German Friesian breed (Schwarzbunt). Number of lactation records, *sires, cows and daughters per* sire were 27654, 666, 9092, and 40.84, respectively. Data covered the period from 1979 to 1996. On the basis of prevailing climatic conditions, the year was classified into three season 1- winter (January-March), 2- spring and summer (April-August) and 3- autumn (September-December). Each lactation was identified by the parity of cow from 1 to 3 lactations. The data originated from different farms in one sub-region, so that the common variety farms are presented. The animals were fed in summer and autumn on concentrates *according to their performance* adding to the grassland. In the winter they get concentrates and conserved feed. The data were adjusted for herd-class before analysis. Lactations that began with an abortion or in which milking was interrupted by injury or sickness were excluded.

Records included number of days open for all lactations followed by a normal calving. This was computed as the interval between parturition and the date of successful mating, or by subtracting the mean of gestation period, estimated from the present data as 285 days, from the normal calving interval if the date of successful mating was not known. Length of dry period was computed by subtracting the date of last milking from the next calving date. Records with missing drying off date were rejected. However, these records *were included in the analysis of milk* traits (milk, fat and protein) when investigating the effect of the length of days open period.

Current lactation records were grouped into classes according to days open. Eleven classes for *days open were formed between* <60 days and ≥330 days and similarly eleven classes for dry period were between <30 days and ≥300 days.

Mixed model LSMLMW program (Harvey,1990) was used to estimate the relationship between 305 days milk, fat and protein yields, both current days open and dry period and parameters for milk performance in each lactation according to the following model:

$$Y_{ijklmnqyz} = \mu + s_i + +d_{ij} + h_k + r_l + a_m + p_n\ o_q + d_y + e_{ijklmnqyz} \quad (1)$$

Where: $Y_{ijklmnqyz}$ = observation $_{ijklmnqyz}$ of the trait, μ = the overall mean; s_i = the random effect due to sire groups; d_{ij} = the j^{th} cow mated with the i^{th} sire; h_k = the k^{th} herd effect; r_l = the effect of the l^{th} year of calving; a_m = the effect of the m^{th} season of calving; p_n = the effect of the n^{th} parity; o_q = the fixed effect of the q^{th} days open class; d_y = the fixed effect of y^{th} dry period class and $e_{ijklmnqyz}$ = the random error associated with the individual record of the $_{ijklmnqyz}$ observation.

The regression coefficient of each of 305-days milk, fat and protein yields on each of days open and dry period was calculated according to the following model:

$$Y_{ijklmno} = \mu + s_i + d_{ij} + h_k + r_l + a_m + p_n + b_1\,(DO)_{ijklmn} + b_2\,(DO)^2_{ijklmn} + b_3\,(DP)_{ijklmn} + b_4\,(DP)^2_{ijklmn} + e_{ijklmno} \quad (2)$$

Where: $Y_{ijklmno}$ = the observation $_{ijklmno}$ of the trait, (DO) and $(DO)^2$ = days open, and days open squared, respectively; (DP) and $(DP)^2$ = dry period and dry period squared, respectively; b_1 and b_2 are the linear and quadratic regression coefficients of Y_{ijklmn} in kgs on (DO) and $(DO)^2$, respectively in days; b_3 and b_4 are the linear and quadratic regression coefficients of Y_{ijklmn} in kgs on (DP) and $(DP)^2$, respectively in days and $e_{ijklmno}$ is the random error associated with the individual record of the $_{ijklmn}$ observation. The other symbols are defined as in model (1). All effects in the models (1) and (2) were treated as fixed except sire and cow within sire were random.

RESULTS AND DISCUSSION

Means and standard deviations of the different traits are presented in Table 1. The analysis of variance for the effects of sire, herd, year and season of calving and parity on milk yield traits is in Table 2. All effects on all traits were highly significant. No specific trends for the effect of year of calving on milk yield traits were indicated. However, autumn calvers had the highest milk performance, winter's were intermediate and summer's produced the lowest. The high yields in autumn could be attributed to better climatic conditions, grazing out on natural grass and the increase in the amount of feed intake specially concentrates. However, the decreased milk production in Summer may be attributed to the increased temperature and the low concentrates feed. The present results agree with those reported by Amin *et al.*, (1996) on Holstein cows in Hungary. Milk yield increased with increase of lactation order. This is logically due to the increase in body weight combined with advancing age and to the full development of the secretory tissue of the udder. The same results were depicted by Zahed (1994), Aly (1995), Amin *et al.*, (1996), El-Nady (1996) and Alemam (2002).

The herd influence reflected variability among herds in feeding, management policies for breeding and management expertise. Climatic differences among herds can be eliminated as all herds were from the same region. These results agree with those reported by Amin *et al.*, (1996) and Alemam (2002). Variations from one herd to another in days open have been attributed to differences in the expertise of detection of oestrus. Therefore, an intensive program of heat detection and practice of insemination may significantly shorten open periods.

Effects of DO on milk, fat and protein yields were highly significant (Table 2). These results agree with those reported by Bar-Anan and Soller (1979); Khattab and Ashmawy (1988); Campos *et al.*, (1994) and El-Awady and Tawfik (2000).

Least squares analysis of variance indicated that the effect of previous dry period on the following 305-days milk, fat and protein yields was highly significant (Table 2). Schaeffer and Henderson (1972) and El-Awady and Tawfik (2000) reported that the short dry period had significantly diminished milk yield in the subsequent lactation. In contrast, Smith and Legates (1962) found that the length of dry period had very little influence on production, accounting for less than 0.1% of the total variation in 305-DMY.

Table (1): Phenotypic means and standard deviations (SD) of milk traits, days open and dry period for lactations.

Trait	Lactations			
	First	Second	Third	All
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
305-DMY (kg)	6147 ± 1101	6763 ±1133	7470 ± 1234	6651±1485
Fat yield (kg)	257 ± 43	286 ± 44	314 ± 54	280 ± 66
Protein (kg)	204 ± 32	229 ± 33	248 ± 43	222 ± 49
DO (day)	91 ± 30	90 ± 29	103 ± 32	95 ± 55
DP (day)	108 ± 34	105 ± 33	119 ± 37	111 ± 57

* Number of records were 9240, 9211, 9203 and 27654 for first, second, third and all lactations, respectively.

Table (2): The F values and tests of significance for factors affecting milk traits in all lactations.

Factors	df	F-Value		
		305-DMY	Fat	Protein
Sire	665	7.00**	8.58**	6.99**
Cow:sire	8426	4.73**	5.24**	6.07**
Herd	20	308.64**	350.27**	436.27**
Year of calving	17	15.43**	27.83**	25.70**
Season of calving	2	176.26**	190.28**	137.50**
Parity	2	30.80**	31.32**	29.60**
Days open	10	7.98**	7.30**	6.65**
Dry period	10	6.01**	5.43**	4.82**

* Residual mean squares of 305-DMY, fat and protein were 643092, 1241 and 587 kg, respectively, with 18501 df.
** significant at ($P<0.01$).

Increasing the length of DO from two to eleven months resulted in an increase of only 668, 30 and 28 kg of milk, fat and protein yields, respectively (Table 3). Meantime , the present results show that a yearly calving interval requires DO of no more than 90 day. Schaeffer and Henderson(1972) and El-

Awady and Tawfik (2000) suggested the same period of days open to be ideal for management practices in terms of reproductive efficiency. In addition, Gill and Allaire (1976) and El-Awady and Tawfik (2000) recommended 12-13 months as an optimum calving interval. Bar-Anan and Soller (1979) indicated that for maximum production cows should be mated as early as 30-50 days after calving and heifers as early as 70-100 days after calving. The yields increased with increasing DO. However, each additional day open up to 90 days may add an extra day of lactation to yields, and each additional day open above 90 days may also add an extra day only to the low production part of lactation if considering a fixed length of gestation period.

Table (3) : Least squares means and standard errors (S.E) of milk traits for different classes of days open.

Days open (day)	Number	305-DMY (kg)	Fat (kg)	Protein (kg)
		Mean ± S.E	Mean ± S.E	Mean ± S.E
<60	4395	6004 ± 26	252 ± 1.14	203 ± 0.86
60-89	8430	6850 ± 16	286 ± 0.72	226 ± 0.55
90-119	6745	6880 ± 19	288 ± 0.81	229 ± 0.61
120-149	4419	7020 ± 23	294 ± 1.03	233 ± 0.77
150-179	2889	7153 ± 29	300 ± 1.26	237 ± 0.95
180-209	1749	7317 ± 38	305 ± 1.69	241 ± 1.27
210-239	1122	7422 ± 47	312 ± 2.03	246 ± 1.54
240-269	712	7469 ± 64	315 ± 2.81	246 ± 2.13
270-299	417	7472 ± 90	316 ± 3.81	246 ± 2.90
300-329	195	7501 ± 149	314 ± 6.24	247 ± 4.91
≥330	129	7518 ± 173	315 ± 7.07	248 ± 5.49

Previous dry period of 60 days gave the optimal average milk production in the following lactation than shorter or longer dry periods (Table 4). These results agree with the accepted management recommendation of a 60-days dry period.

Table (4) : Least squares means and standard errors (S.E) of milk traits for different classes of preceding dry period.

Dry period (day)	Number	305-DMY (kg)	Fat (kg)	Protein (kg)
		Mean ± S.E	Mean ± S.E	Mean ± S.E
<30	789	6008 ± 47	253 ± 2.11	217 ± 1.56
30-59	7976	6680 ± 17	281 ± 0.74	234 ± 0.56
60-89	8744	6712 ± 16	296 ± 0.71	235 ± 0.54
90-119	3010	6866 ± 29	291 ± 1.26	234 ± 0.95
120-149	1749	7906 ± 38	299 ± 1.89	241 ± 1.27
150-179	1876	7020 ± 65	290 ± 2.92	237 ± 2.19
180-209	1342	7041 ± 43	293 ± 1.87	243 ± 1.39
210-239	866	7003 ± 55	304 ± 4.48	245 ± 1.88
240-269	527	7109 ± 78	300 ± 3.33	239 ± 2.55
270-299	194	7162 ± 136	301 ± 6.02	244 ± 4.30
≥300	142	7114 ± 167	286 ± 6.71	240 ± 5.16

Beyond 60 days this data suggested that additional length of dry period probably will not result in enough extra milk yield to compensate for the extra costs of feeding cows with longer dry periods. Similarly, more days dry probably do not maximize milk yield per day of herdlife. The same conclusion was reported by Makuza and McDaniel (1996) on Holstein cows. In addition, an optimal range of 50-90 days dry period was given by Schaeffer and Henderson (1972) and El-Awady and Tawfik (2000).

The results in Table (5) indicated a curvilinear relationship between current days open and milk yield traits. A highly significant average increase of 3.278±0.0133, 0.128±0.005 and 0.108±0.004 kg in 305-DMY, fat and protein yields, respectively, was found for each additional day open. Khattab and Ashmawy (1988) obtained a highly significant average increase of 2.20±0.30 kg in 305-DMY for each additional day open. Makuza and McDaniel (1996) arrived at the same conclusion with Holstein Friesian cows.

The present results illustrated a curvilinear relationship between previous dry period and milk yield traits (Table 5). A highly significant average increase of 1.716±0.144, 0.061±0.006 and 0.057±0.004 kg in 305-DMY, fat and protein yields, respectively, was obtained for each additional day of dry period. The same relationship between preceding dry period and both milk and fat yields was documented by El-Awady and Tawfik (2000).

Table (5) : Partial linear(b_1 and b_3) and quadratic (b_2 and b_4) regression coefficients of 305- days milk yield, fat and protein yields on each of days open (DO) and dry period (DP).

Trait		305-DMY (kg)	Fat (kg)	Protein (kg)
DO	b_1	3.278**±0.133	0.128**±0.005	0.108**±0.004
(day)	b_2	-0.0129**±0.0012	-0.0005**±0.0001	-0.0004**±0.0001
DP	b_3	1.716**±0.1439	0.061**±0.0060	0.057**±0.0044
(day)	b_4	-0.0011±0.0013	-0.0000±0.0001	-0.0001**±0.0000

** significant at (P<0.01)

Heritabilities:

Estimates of heritability for milk yield traits in the first three and all lactations are presented in (Table 6), ranging from 0.22 to 0.34. The highest estimates of 0.34 for 305-DMY, 0.30 for fat yield and 0.29 for protein yield during the first lactation were as high as those reported by Zahed (1994), being 0.29, 0.31 and 0.27 for first lactation milk, fat and protein yields, respectively.. In addition, high estimates of heritability for first lactation milk yield of Friesian cows were reported by Aly (1995), El-Nady (1996) and Hammoud (1997) ranging from 0.34 to 0.52.

Estimates of h^2 for fat and protein yields (Table 6) were in agreement with those estimated by Zahed (1994),being in the range of 0.22 to 0.31 for fat and 0.22 to 0.27 for protein. However, low h^2 estimate of 0.14 and 0.18 for milk yield, was reported by El-Barabry *et al.*, (1999) and Alemam (2002),respectively. It was concluded that the heritability estimate could be a function of number of records. Amin *et al.*, (1996) obtained low heritability estimate of 0.14 for fat yield. Moreover, estimates by Gill and Allaire (1976) and Schutz *et al.*, (1990) were 0.14 and 0.17, respectively. Heritability estimates for protein yield were 0.13 and 0.20 (Schutz *et al.*, 1990 and Zahed, 1994).

Heritability estimates for DO and DP were small, ranging from 0.04 to 0.09 (Table 6). Low heritability estimates ranging from 0 to 0.09 for days open were reported by Everett *et al.*, (1966); Schaeffer and Henderson (1972); Moore *et al.*, (1992); Campos *et al.*, (1994); Makuza and McDaniel (1996) and El-Awady and Tawfik (2000). Therefore, selection for improved fertility defined as number of days open had little to offer to breeders. Results in the present study show that the effects on days open were almost all environmental. Therefore, improvement of environmental factors could reduce number of days open and thereafter may improve milk yield traits. Low heritability estimates ranging from zero to 0.20 were depicted by Amin *et al.*, (1996), El-Nady (1996) and El-Awady and Tawfik (2000).

Table (6) : Estimates of heritabilities (h^2) for 305-DMY, fat, protein, days open and dry period in different lactations .

Traits	Lactations			
	First	Second	Third	All
	$h^2 \pm$ S.E	$h^2 \pm$ S.E	$h^2 \pm$ S.E	$h^2 \pm$ S.E
305-DMY	0.34 ± 0.03	0.25 ± 0.03	0.24 ± 0.03	0.24 ± 0.02
Fat	0.30 ± 0.03	0.24 ± 0.03	0.28 ± 0.02	0.31 ± 0.02
Protein	0.29 ± 0.03	0.25 ± 0.03	0.22 ± 0.03	0.33 ± 0.02
Days open	0.08 ± 0.02	0.09 ± 0.02	0.05 ± 0.02	0.09 ± 0.01
Dry period	0.07 ± 0.02	0.09 ± 0.02	0.05 ± 0.02	0.09 ± 0.01

Correlations:

Genetic and phenotypic correlations between different traits were positive and highly significant (Table 7). The present genetic correlations between milk yield traits agree with those obtained by Zahed (1994) and Campos *et al.*, (1994) being in the range from 0.66 to 0.90. Low genetic correlation of 0.23 between milk and fat yield was reported by Schutz *et al.*, (1990) on Holstein Friesian. Genetic correlation between milk yield traits and DO and DP were in agreement with those given by Everett *et al.*, (1966); Moore *et al.*, (1992) and Campos *et al.*, (1994), ranging from 0.25 to 0.83. The genetic correlation between DO and DP was 0.39. Moore *et al.*, (1990) found a genetic correlation of 0.48 and 0.44 between DO and DP for Friesian and Ayrshire cows, respectively.

Phenotypic correlations between different traits ranged from 0.19 to 0.92 (Table 7). Phenotypic correlation between milk yield traits, given by Schutz *et al.*, (1990) and Zahed (1994) were from 0.68 to 0.97, between milk yield and days open were from 0.05 to 0.75 (Everett *et al.*,1966; Moore *et al.*, 1992; Campos *et al.*, 1994; Amin *et al.*, 1996; El-Nady 1996; Hammoud 1997 and Tag El-Dien 1997, between milk yield and DP, ranged from 0.06 to 0.51 (Afifi *et al.*, 1992 and Tag El-Dien 1997) and between DO and DP, ranged from 0.32 to 0.60 (Moore *et al.*, 1990; Afifi *et al.*, 1992 and Hammoud 1997).

Table (7) : Estimates of genetic (above diagonal) and phenotypic (below diagonal) correlations between different traits in all lactations.

Traits	305-DMY	Fat	Protein	DO	DP
305-DMY		0.661**	0.877**	0.615**	0.604**
Fat	0.785**		0.737**	0.436**	0.333**
Protein	0.924**	0.838**		0.335**	0.321**
DO	0.256**	0.239**	0.240**		0.392**
DP	0.214**	0.196**	0.194**	0.286**	

** significant at (P<0.01)

Conclusions:

As current days open increased, milk yield traits increased independently of previous yield and previous days open. Milk yield during the subsequent lactation increased rapidly after dry periods up to 60 days, but showed only a small additional increase after longer dry periods. The most profitable number of days open is 60 to 90 days which match with 12 to 13 month calving interval. The practical application of our results is that yield data should be adjusted at least for current days open from 60 to 90 days and preceding dry periods 60 days. A word of caution is that dry period and days open effects are mostly, but not totally, environmental. Selection against cows with short days open leads to selection against good fertility. Therefore, selection with emphasis only on lactational milk yields is likely to decrease fertility if genetic covariance exists between them. Perhaps a selection index is needed to incorporate the genetic, residual, and phenotypic correlations between these traits to increase accuracy and precision of estimates.

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التأثيرات الوراثية والمظهرية لفترة التلقيح والجفاف علي محصول اللبن في ٣٠٥ يوم والدهن والبروتين لأبقارالفريزيان الألمانية

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أجرى هذا البحث علي البيانات الخاصة بعدد ٩٠٩٢ بقرة فريزيان من ٢١ قطيع في المانيا وذلك لمدة ١٨ عام إبتداء من عام ١٩٧٩ لتقديرالتأثيرات الوراثية والمظهرية لفترتى التلقيح والجفاف علي محصول اللبن والدهن والبروتين خلال مواسم الحليب الثلاثة الأولي. هذا بالإضافة إلي دراسة تأثيرات القطيع ،فصل وسنة الولادة ، ترتيب موسم الحليب ، والتداخلات المحتملة. ولقد أظهرت نتائج التحليل للبيانات وجود تأثيرات عالية المعنوية لكل العوامل والتداخلات علي كل من إنتاج اللبن في ٣٠٥ يوم ومحصول الدهن والبروتين. معاملات الأرتداد الخطي أظهرت متوسط زيادة قدرة ٣,٢٨ كجم ، ٠,١٢٨ كجم ، ٠,١٠٨ كجم لإنتاج اللبن في ٣٠٥ يوم ومحصول الدهن والبروتين علي التوالي ، لكل يوم زيادة في فترة التلقيح. وكانت معاملات الأرتداد ١,٧٢ كجم ، ٠,٠٦١ كجم ، ٠,٠٥٧كجم بالنسبة لإنتاج اللبن في ٣٠٥ يوم ومحصول الدهن والبروتين علي التوالي ، لكل يوم زيادة في فترة الجفاف. كما كانت قيمة المكافئ الوراثي لموسم الحليب الأول والثانى والثالث ولكل المواسم ٠,٣٤ ، ٠,٢٥ ، ٠,٢٤ ، ٠,٢٤ بالنسبة لإنتاج اللبن في ٣٠٥ يوم علي التوالي ، وكانت ٠,٣٠ ، ٠,٢٤ ، ٠,٢٧ ، ٠,٣١ بالنسبة لمحصول الدهن علي التوالي ، بينما كانت ٠,٢٩ ، ٠,٢٥ ، ٠,٢٢ ، ٠,٣٣ بالنسبة لمحصول البروتين علي التوالي. وقيمة المكافئ الوراثي لفترتي الجفاف والتلقيح كانت منخفضة وتراوحت من ٠,٠٤إلي ٠,٠٩ وبالنسبة لمعاملات الأرتباط الوراثي بين كل من الصفات الثلاثة موضع الدراسة وطول فترتي التلقيح والجفاف في كل المواسم فكانت موجبة وتراوحت بين ٠,٣٢إلي ٠,٨٧ وأيضا كانت معاملات الأرتباط المظهري موجبة وتراوحت بين ٠,١٩إلي ٠,٩٢ ولقد أتضح أن طول فترة تلقيح مقدارها من ٦٠– ٩٠ يوم وطول فترة جفاف مقدارها ٦٠ يوم مناسبة للحصول علي أقصي محصول من اللبن والدهن والبروتين لأبقار الفريزيان في المانيا.