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Effect of dry period length on the subsequent production and reproduction in Holstein cows

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Abstract

Calving records of Holstein cows from January 1983 to December 2006 comprising 1,190 herds with 384,717 calving events were used to evaluate factors affecting the dry period length and effect of current dry days on the next productive and reproductive performances of Holstein cows. Statistical analyses of dry days, productive and reproductive traits in this study were performed as linear mixed models. Dry period length (DD) of cows was grouped into 14 classes from < 10 days through > 130 days. Average DD was 100.46 days in Holstein cows. Primiparous cows had the lowest DD and the mean of DD decreased over the years from 1983 to 2006 and summer calvers had the shortest DD ($p < 0.001$). Cows within the DD classes of 51-60 and 61-70 had the greatest actual milk yield, mature equivalent milk yield, adjusted milk yield, adjusted fat yield, mature equivalent milk yield, adjusted protein yield and mature equivalent protein yield ($p < 0.05$). Also, cows within the DD class of 0-10 had the greatest adjusted fat percentage, mature equivalent fat percentage and adjusted protein percentage ($p < 0.05$). Our current results showed a reduction in calving interval and age at calving after cows had shorter dry days than with other longer dry period lengths ($p < 0.05$). Given the recent advocacy for shortened dry periods, it is worthwhile to emphasize that 51 to 70 DD does provide maximal performance in Holstein cows.

Additional key words: dairy cow; dry days; productive performance; reproductive performance.

Introduction

Optimum length of the dry period has been a topic of interest for many years, with recorded debate beginning as early as 1805 (Grummer & Rastani, 2004). During recent years there has been a renewed interest in dry period length, perhaps partly because of an ever increasing need for dairy farmers to maximize their income on investment. During the production cycle before the expected calving a period of rest is needed and in that time milking is ceased and thus the production of milk in the udder stops. The dry period is required for the regeneration of the mammary gland and its preparation for lactation, during that time papillae of the rumen and the small intestine are regenerated, and the organism of the cow prepares for an increased nutrient requirement of the mammary gland during lactogenesis (Capuco *et al.*, 1997; Annen *et al.*, 2004). We also need to take into consideration the intensive growth of the fetus during that period.

Cows reach increasingly higher milk yields and this suggests the need to investigate the length of the dry period, since it is considerably connected with the profitability of production. The 60-day dry period, used to date, was adopted in the early 1900s and since then the principle "one calf a year" has been applied, which for a 305-day lactation gives 60 days of rest. It was found that its elimination or reduction may have an effect on reduced yield while improving fat and protein contents (Rémond *et al.*, 1997; Andersen *et al.*, 2005).

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Abbreviations used: AAC (age at calving); AFP (305-d adjusted fat percentage of milk); AFY (305-d adjusted fat yield); AMY (305-d adjusted milk yield); APP (305-d adjusted protein percentage of milk); APY (305-d adjusted protein yield); bST (bovine somatotropin); CI (calving interval); DD (dry period length); DIM (days in milk); ME (mature equivalent); MEFP (mature equivalent fat percentage); MEFY (mature equivalent protein yield); MEMY (mature equivalent milk yield); MEPY (mature equivalent protein yield); REML (restricted maximum likelihood); RMY (unadjusted milk yield).

According to Stockdale (2006), shortening or eliminating the dry period may result in a lower incidence of metabolic problems postpartum, and a reduced negative energy balance in early lactation due to the maintenance of dietary intake while milk yields and body condition loss are reduced (Pytlewski *et al.*, 2009).

Since 1936 many observational and experimental data have been generated to establish an optimal drying off time for cows (Şükrü Gülay, 2005). Observational studies (such as Dias & Allaire, 1982; Kuhn *et al.*, 2006) have much greater statistical power and accuracy of estimates but lack control over some unknown variables; designed trials generally lack power and accuracy but have more control over some extraneous variables and thereby provide confirmation for results found in observational studies (Kuhn *et al.*, 2006). Observational data will be affected by many factors, in addition to dry period length, that are highly related to subsequent milk production. For example, data from existing records often will not include the reason why a specific cow was dried off earlier than other cows or why cows were dried off late (< 60 d). Some cows cease lactation spontaneously or the dairy producer will dry off cows early because of insufficient milk production. Thus, the reason why cows had shorter dry periods most often cannot be learned from the milk yield records. Cows with short dry periods also may include those cows that calved early due to physiological problems, sickness or exposure to heat stress, among others. This would bias the estimated effect of dry days on milk yield in the subsequent lactation because of potential or actual problems during early lactation associated with early calving; this would affect the lactational performance. As a result, flaws in record analysis may produce a bias in the milk production records and this may result in insufficient information to estimate the true effects of dry period length adequately (Gulay *et al.*, 2003). Some experimental studies with randomized assignment of cows to different dry period length have been conducted (Gulay *et al.,* 2003, 2005; Annen *et al.,* 2004; Andersen *et al.,* 2005; Rastani *et al.,* 2005; Pezeshki *et al.,* 2007).

Increased potential for milk yield may have made cows more tolerant of shorter dry periods. Conversely, higher production may also result in a demand for a longer rest period in order to maintain production, health and fertility in the subsequent lactation. Considerable research has been done regarding the effect of dry days on subsequent lactation milk yield but far less research is available on the effects for other economically important traits such as milk components or fertility. Several recent studies (*e.g.,* Gulay *et al.*, 2003; Annen *et al.*, 2004; Rastani *et al.*, 2005) considered effects of dry days on fat, protein and somatic cell score. However, all of these studies were based on small numbers of cows and, although collectively such studies can be informative if enough of them are conducted, individually they lack adequate power to be conclusive (Kuhn & Hutchison, 2005). Furthermore, of the studies that have examined dry days effects on fat and protein yield, all have reported results in terms of either yield for partial lactations or in terms of 305-d, mature-equivalent lactational yield. Recent research has shown, however, that dry days has larger effects on actual lactational milk yield than on records standardized to a 305-d basis; the very standardization of records to a common lactation length (305 d) and mature-equivalent basis, in effect conceals variation in production caused by dry days partly because of its effects on days in milk (DIM) and culling in the subsequent lactation (Kuhn *et al.*, 2005b). If a short dry period, for example, caused problems in the subsequent lactation that resulted in early culling or earlier dry off, then extending records to a 305 d basis would tend to reduce or eliminate that effect. If short subsequent lactations are unrelated to dry days, then they will occur randomly across dry periods and cause no bias in the analyses (Kuhn *et al.*, 2005b). Given the high phenotypic correlation of milk yield with both fat and protein yield (Welper & Freeman, 1992), it is likely that actual lactational records would be more informative for fat and protein yield as well. Since dairy producers are paid for actual yield rather than standardized yields, effects of dry days on actual yields should be ascertained (Kuhn *et al.*, 2006). The effect of variation in dry period length on subsequent lactation production and reproduction, for modern day dairy cattle, is largely unknown and warrants re-evaluation. Therefore, the aim of this study was to evaluate the effect of different lengths of dry period on the subsequent productive and reproductive performances of Holstein cows.

Material and methods

Calving records from the Animal Breeding Center (Karaj, Iran), collected from January 1983 to December 2006 and comprising 384,717 calving events of Holsteins from 1190 dairy herds were included in the data set. The characteristics of dairy herds used in this study were described in previous studies (Ghavi Hossein-Zadeh *et al.*, 2009; Ghavi Hossein-Zadeh & Ardalan, 2011). The data included animal registration number, herd, calving date, parity, calving age, raw or unadjusted milk yield (RMY), 305-d adjusted milk yield (AMY), mature equivalent milk yield (MEMY), 305-d adjusted fat yield (AFY), 305-d adjusted fat percentage of milk (AFP), mature equivalent fat yield (MEFY), mature equivalent fat percentage (MEFP), 305-d adjusted protein yield (APY), 305-d adjusted protein percentage of milk (APP), mature equivalent protein yield (MEPY), calving interval (CI) and age at calving (AAC). Adjusted 305-d yields were actual yields of dairy cows which were corrected based on days in milk and twice daily milking. RMY was actual lactation milk yield, not standardized to 305 d. Mature equivalent (ME) yields/percentages were milk, fat or protein yields/percentages which standardized for age at calving. Records were eliminated if no registration number was present for a given cow. Records were also deleted from the analyses if there was no information on the productive and or reproductive performances. Months of calving were grouped into four seasons: April through June (season 1 = spring), July through September (season 2 = summer), October through December (season 3 = fall), and January through March (season 4 = winter). In addition, calving years were grouped into four classes: 1983 through 1988, 1989 through 1994, 1995 through 2000 and 2001 through 2006. Also, dry period length (DD) of cows was grouped into 14 classes: 0-10 (class 1), 11-20 (class 2), 21-30 (class 3), 31-40 (class 4), 41-50 (class 5), 51-60 (class 6), 61-70 (class 7), 71-80 (class 8), 81-90 (class 9), 91-100 (class 10), 101-110 (class 11), 111-120 (class 12), 121-130 (class 13) and > 130 (class 14). DD was calculated as calving interval minus total DIM in the previous lactation. As an example, if a cow initiated her first lactation on 1 January 2005 and calved the second time on 1 January 2006 (a 365-d calving interval) and her total DIM in first lactation was 320, then she had DD = 365 – 320 = 45. The distribution of observations over different dry period length classes in Holstein cows is shown in Fig. 1 and the greatest number of observations was within the DD class of 61-70.

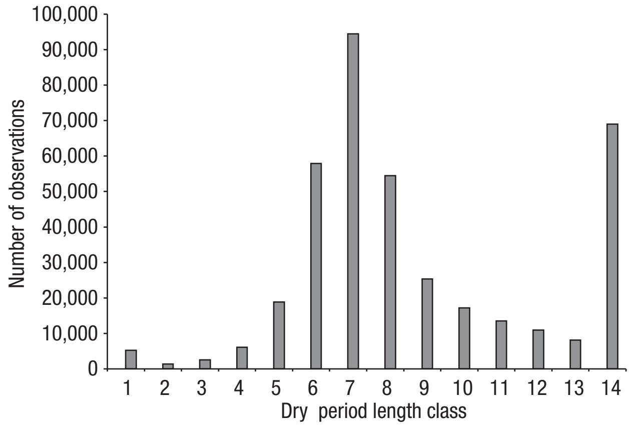

Figure 1. Distribution of observations over different dry period length classes in Holstein cows. Dry period length classes are: 0-10 (class 1), 11-20 (class 2), 21-30 (class 3), 31-40 (class 4), 41-50 (class 5), 51-60 (class 6), 61-70 (class 7), 71-80 (class 8), 81-90 (class 9), 91-100 (class 10), 101-110 (class 11), 111-120 (class 12), 121-130 (class 13) and > 130 (class 14).

Statistical analyses of dry period length, productive and reproductive traits in this study were performed as linear mixed models (Proc Mixed) with the best fitted covariance structure of SAS (SAS Inst., 2002). The least square means were estimated by Restricted Maximum Likelihood (REML) method. The models used to analyze RMY, AMY, MEMY, APY, MEPY, APP, AFY, MEFY and AAC included the fixed class effects of herd, calving year, calving season, parity of dam, dry period length, interaction effects of year by parity, year by season, year by dry period length, season by parity, season by dry period length and parity by dry period length and linear and quadratic covariate effects of age. Linear covariate effect of days in milk was included in the model of analysis for RMY. In addition, AFP was analyzed in a model in which the following variables were included: herd, calving year, calving season, dry period length, interaction effects of year by parity, year by season, year by dry period length, and parity by dry period length and linear covariate effect of age. MEFP was analyzed in a model in which the following variables were included: herd, calving year, dry period length, interaction effects of year by parity, year by season, year by dry period length, season by dry period length and parity by dry period length and linear and quadratic covariate effects of age. The model used to analyze CI included the fixed class effects of herd, calving year, parity of dam, dry period length, interaction effects of year by parity, year by season, year by dry period length, season by parity, season by dry period length and parity by dry period length and linear and quadratic covariate effects of age. The model used to analyze dry period length included the class effects of herd, calving year, calving season and parity and interaction effects of year by season, year by parity and season by parity and linear and quadratic covariate effects of age at calving and covariate effect of milk. Animal effect was consi-

Table 1. Milk yield, fat yield and percentage at different dry period lengths in Holstein cows

Dry period length	Trait[1]						
	RMY	AMY	AFY	AFP	MEMY	MEFY	MEFP
0-10	5,669.3 (42.9)^{l}	5,472.4 (25.0)^{k}	191.4 (0.8)^{i}	3.58 (0.01)^{a}	5,686.1 (26.1)^{j}	198.9 (0.9)^{j}	3.58 (0.01)^{a}
11-20	5,913.2 (75.9)^{k}	5,586.7 (46.9)^{j}	186.6 (1.6)^{j}	3.41 (0.02)^{b}	5,777.5 (48.2)^{i}	192.9 (1.6)^{k}	3.41 (0.02)^{b}
21-30	6,763.9 (59.7)^{j}	6,160.0 (36.1)^{i}	203.4 (1.2)^{h}	3.35 (0.01)^{c}	6,373.6 (37.2)^{h}	210.5 (1.3)^{i}	3.35 (0.01)^{c}
31-40	7,505.0 (39.5)^{fg}	6,750.7 (23.6)^{h}	219.9 (0.8)^{e}	3.30 (0.01)^{d}	6,984.7 (24.4)^{g}	227.5 (0.9)^{e}	3.30 (0.01)^{d}
41-50	8,212.5 (22.3)^{c}	7,275.3 (13.0)^{c}	233.1 (0.5)^{b}	3.24 (0.00)^{e}	7,525.7 (13.4)^{c}	241.1 (0.5)^{c}	3.24 (0.00)^{e}
51-60	8,539.4 (12.7)^{a}	7,467.7 (7.2)^{ab}	236.3 (0.3)^{a}	3.19 (0.00)^{hi}	7,720.5 (7.4)^{a}	244.3 (0.3)^{a}	3.19 (0.00)^{hi}
61-70	8,581.8 (9.9)^{a}	7,518.9 (5.7)^{a}	236.5 (0.2)^{a}	3.17 (0.00)^{j}	7,760.3 (5.8)^{a}	244.1 (0.2)^{ab}	3.17 (0.00)^{j}
71-80	8,387.3 (13.2)^{b}	7,436.2 (7.4)^{b}	234.9 (0.3)^{ab}	3.18 (0.00)^{ij}	7,658.4 (7.6)^{b}	241.9 (0.3)^{bc}	3.18 (0.00)^{ij}
81-90	7,915.6 (18.9)^{d}	7,168.1 (10.9)^{d}	227.4 (0.4)^{c}	3.20 (0.00)^{gh}	7,359.8 (11.1)^{d}	233.5 (0.4)^{d}	3.20 (0.00)^{gh}
91-100	7,689.1 (22.8)^{e}	7,028.6 (13.3)^{e}	222.7 (0.5)^{d}	3.20 (0.00)^{gh}	7,208.4 (13.6)^{e}	228.4 (0.5)^{e}	3.20 (0.00)^{gh}
101-110	7,603.1 (26.0)^{ef}	6,979.2 (15.2)^{e}	221.1 (0.5)^{de}	3.20 (0.00)^{gh}	7,159.0 (15.5)^{e}	226.8 (0.6)^{ef}	3.20 (0.00)^{gh}
111-120	7,460.1 (28.7)^{gh}	6,911.6 (16.9)^{f}	219.1 (0.6)^{ef}	3.21 (0.01)^{gh}	7,084.1 (17.2)^{f}	224.6 (0.6)^{fg}	3.21 (0.01)^{gh}
121-130	7,318.6 (33.2)^{i}	6,791.9 (19.9)^{gh}	215.8 (0.7)^{g}	3.21 (0.01)^{fg}	6,957.6 (20.2)^{g}	221.1 (0.7)^{h}	3.21 (0.01)^{fg}
>130	7,360.9(12.1)^{hi}	6,846.4 (7.1)^{g}	217.3 (0.2)^{fg}	3.23 (0.00)^{ef}	7,015.6 (7.2)^{g}	222.6 (0.3)^{gh}	3.23 (0.00)^{ef}

[1] RMY: raw milk yield (kg); AMY: adjusted milk yield (kg); AFY: adjusted fat yield (kg); AFP: adjusted fat percentage; MEMY: mature equivalent milk yield (kg); MEFY: mature equivalent fat yield (kg); MEFP: mature equivalent fat percentage. Standard errors are within the parenthesis. $^{a\text{-}l}$ Means within a column that do not have a common superscript are significantly different ($p < 0.05$).

dered as a random variable in all models of analysis for productive and reproductive traits. Phenotypic correlations between DD and productive and reproductive traits were calculated by Corr procedure of SAS (SAS Inst., 2002), and regression coefficients of productive and reproductive traits per one day change in DD were estimated using Reg procedure of SAS (SAS Inst., 2002).

Results

The average dry period length was 100.46 days in this study. The productive and reproductive performances at different dry period length groups in Holstein cows are shown in Tables 1 and 2. Cows within the DD classes of 51-60 and 61-70 had the greatest RMY, MEMY, AMY, AFY, MEFY, APY and MEPY, and cows

Table 2. Protein yield and percentage and reproductive performances at different dry period lengths in Holstein cows

Dry period length	Trait[1]				
	APY	APP	MEPY	CI	AAC
0-10	185.2 (0.9)^{j}	3.45 (0.01)^{a}	192.7 (1.0)^{h}	401.8 (2.6)^{e}	54.9 (0.3)^{g}
11-20	196.4 (2.3)^{i}	3.35 (0.02)^{b}	203.4 (2.3)^{g}	407.8 (3.8)^{d}	56.4 (0.6)^{f}
21-30	213.9 (1.7)^{h}	3.28 (0.01)^{c}	221.9 (1.8)^{f}	410.2 (2.6)^{cd}	57.0 (0.4)^{f}
31-40	229.8 (1.0)^{f}	3.20 (0.01)^{d}	238.3 (1.0)^{d}	412.4 (1.9)^{bcd}	55.5 (0.3)^{g}
41-50	241.3 (0.5)^{c}	3.15 (0.00)^{e}	249.8 (0.5)^{b}	410.8 (1.0)^{bcd}	55.1 (0.1)^{g}
51-60	245.6 (0.3)^{ab}	3.12 (0.00)^{fg}	254.0 (0.3)^{a}	411.6 (0.5)^{bcd}	55.6 (0.1)^{g}
61-70	247.5 (0.2)^{a}	3.10 (0.00)^{h}	255.6 (0.2)^{a}	412.8 (0.4)^{bcd}	56.8 (0.1)^{f}
71-80	244.0 (0.3)^{b}	3.11 (0.00)^{gh}	251.4 (0.3)^{b}	413.9 (0.5)^{bc}	59.5 (0.1)^{e}
81-90	235.9 (0.5)^{d}	3.12 (0.00)^{fgh}	242.2 (0.5)^{c}	412.7 (0.8)^{bcd}	62.8 (0.1)^{d}
91-100	232.7 (0.6)^{e}	3.12 (0.00)^{fg}	238.4 (0.6)^{d}	414.1 (1.0)^{bc}	64.7 (0.2)^{c}
101-110	230.1 (0.7)^{f}	3.13 (0.00)^{f}	236.0 (0.7)^{d}	415.3 (1.2)^{bc}	65.2 (0.2)^{bc}
111-120	227.3 (0.8)^{g}	3.13 (0.00)^{ef}	232.8 (0.8)^{e}	412.8 (1.2)^{bcd}	65.7 (0.2)^{b}
121-130	225.2 (0.9)^{g}	3.14 (0.01)^{e}	230.4 (0.9)^{e}	416.0 (1.5)^{b}	66.5 (0.3)^{a}
>130	226.5 (0.3)^{g}	3.15 (0.00)^{e}	232.1 (0.3)^{e}	422.1 (0.6)^{a}	66.8 (0.1)^{a}

[1] APY: adjusted pritein yield (kg); APP: adjusted protein percentage; MEPY: mature equivalen protein yield (kg); CI: calving interval (day); AAC: age at calving (month). Standard errors are within the parenthesis. $^{a\text{-}h}$ Means within a column that do not have a common superscript are significantly different ($p < 0.05$).

Table 3. Regression coefficients of productive and reproductive traits on dry period length and correlations between dry period length and performance traits in Holstein cows

Trait	Intercept ± SE	Regression ± SE	Correlation
RMY	7,541.82 ± 4.50**	–1.11 ± 0.03**	–0.07**
AMY	7,303.91 ± 4.39**	–0.88 ± 0.03**	–0.04**
MEMY	7,541.82 ± 4.50**	–1.11 ± 0.03**	–0.05**
AFY	2,32.31 ± 0.16**	–0.04 ± 0.001**	–0.05**
MEFY	239.86 ± 0.17**	–0.04 ± 0.001**	–0.06**
AFP	3.20 ± 0.001**	0.00001 ± 0.00001^{ns}	0.002^{ns}
MEFP	3.20 ± 0.001**	0.00001 ± 0.00001^{ns}	0.002^{ns}
APY	242.26 ± 0.19**	–0.04 ± 0.002**	–0.06**
MEPY	250.51 ± 0.20**	–0.05 ± 0.002**	–0.07**
APP	3.13 ± 0.001**	0.00006 ± 0.000009**	–0.02**
AAC	56.16 ± 0.05**	0.04 ± 0.0004**	0.16**
CI	342.15 ± 0.19**	0.74 ± 0.001**	0.64**

** $p < 0.01$. ns: non-significant.

within the DD class of 0-10 had the lowest values of RMY, MEMY, AMY, APY and MEPY, and cows within the DD class of 11-20 had the lowest AFY and MEFY ($p < 0.05$). Also, cows within the DD class of 0-10 had the greatest AFP, MEFP and APP ($p < 0.05$). Table 3 shows the regression coefficients of productive and reproductive traits on dry period length and the phenotypic correlation between dry days and subsequent performance of dairy cows. There were significant and negative relationships between dry days and RMY, MEMY, AMY, AFY, MEFY, APY and MEPY in Holstein cows ($p < 0.01$); therefore, the yields of milk, fat and protein decreased along with the increase in dry days. On the other hand, there were significant and positive relationships between dry days and APP, AAC and CI ($p < 0.05$); protein percentage, calving interval and age at calving increased along with increase in dry days. Also, there were non-significant relationships between AFP and MEFP and dry days of dairy cows. There were significant interaction effects of dry period length class by parity on the subsequent production and reproduction of dairy cows which were depicted in Figs. 2 to 5. Effects of DD on yield or percentage traits were, for the most part, consistent across lactations and the dry period length to maximize subsequent RMY, AMY, MEMY, APY and MEPY was generally the same (61-70) regardless of parity. There were decreasing trends for RMY, AMY, MEMY, APY and MEPY at the dry days of < 60 or > 70 over the parities. The dry period length to maximize subsequent second lactation AFY and MEFY was 51-60, but corresponding dry period length for third and greater lactation AFY and MEFY was 61-70. There were decreasing trends for AFP, MEFP and APP from dry days of < 10 to 61-70 over the lactations, but an increasing trends were observed for AFP, MEFP and APP at dry days of 70 onwards ($p < 0.001$). Therefore, second, third and fourth and greater lactation AFP, MEFP and APP minimized at the dry days of 61-70. Also, there were generally consistent phenotypic trends for AAC and CI over the parities. Second and third parity cows within the dry days of < 10 had the lowest AAC, and fourth and greater parity cows within the dry days of < 10 and 31-70 had the lowest AAC. On the other hand, there were increasing trends for second, third and fourth and greater lactation CI along with increase in dry days ($p < 0.001$).

Effect of variables affecting the DD of Holstein cows is shown in Table 4. DD was the lowest for the

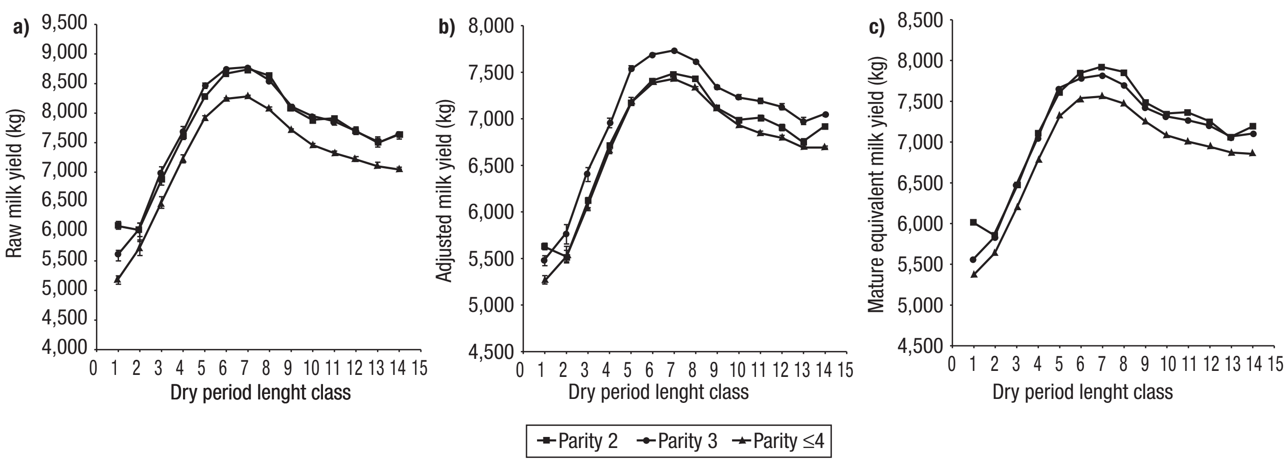

Figure 2. Distribution of raw (a), adjusted (b) and mature equivalent (c) milk yield over different dry period length classes and different parities in Holstein cows. Dry period length classes are described in Fig. 1.

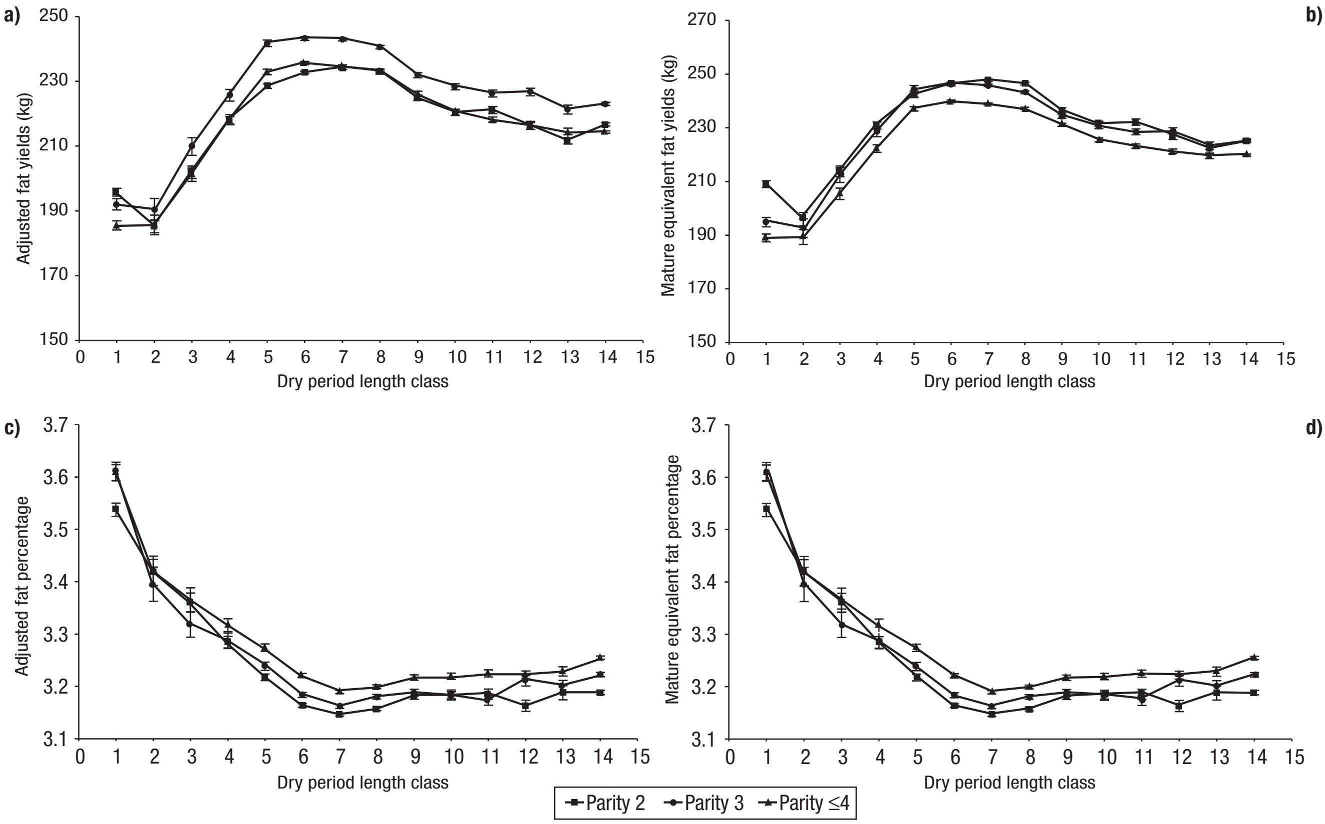

Figure 3. Distribution of adjusted (a), mature equivalent (b) fat yield, adjusted (c) and mature equivalent (d) fat percentage of milk over different dry period length classes and different parities in Holstein cows.

period of 2001-2006 ($p < 0.001$). Summer-calved cows had the lowest DD but spring- and winter-calved cows had the greatest DD ($p < 0.001$). On the other hand, primiparous cows had the lowest DD and cows in their parity 4 and greater had the greatest DD ($p < 0.001$; Table 4). There was significant interaction effect of calving year by season of calving on the DD and cows which calved during the spring season of calving and years 1983-1988 had the lowest DD ($p < 0.001$). Also, primiparous cows which calved during 1983-1988 or summer season had the lowest DD ($p < 0.001$). Also, there were significant effects of age at calving and previous milk yield on DD ($p < 0.001$). The regression coefficient of dry days on milk yield was -0.008 ± 0.00005 ($p < 0.001$); this indicated the reduction in dry days per kilogram of increase in milk yield of dairy cows. On the other hand, the regression coefficient of dry days on age at calving was 0.68 ± 0.03 (< 0.001);

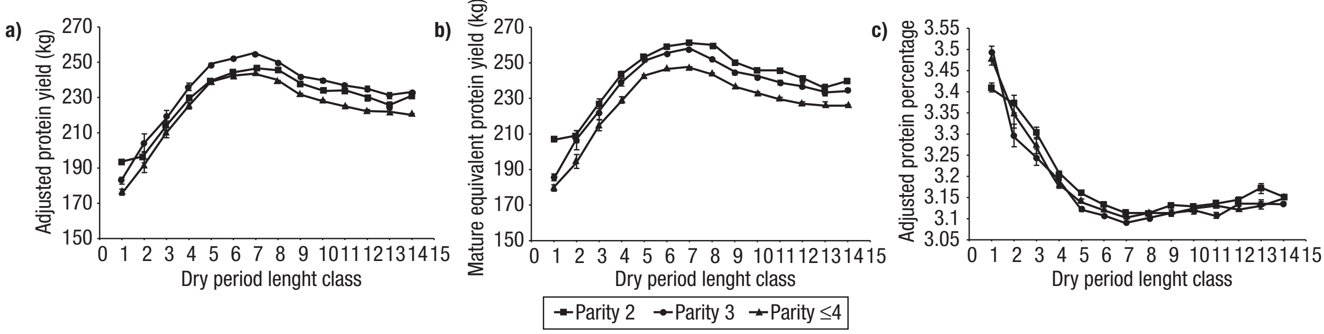

Figure 4. Distribution of adjusted (a) and mature equivalent (b) protein yield and adjusted protein percentage of milk (c) over different dry period length classes and different parities in Holstein cows.

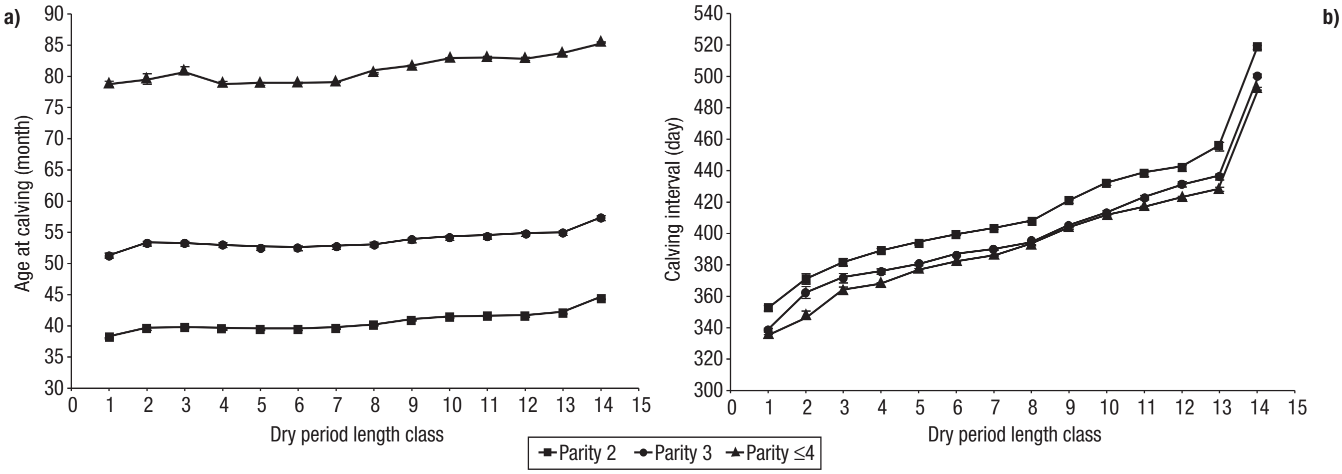

Figure 5. Distribution of age at calving (a) and calving interval (b) over different dry period length classes and different parities in Holstein cows.

this indicated the increase in dry days along with one month increase in calving age.

Discussion

The average of dry period length in the current study (100.46 days) was lower than the report of Amasaib *et al.* (2011) who stated to be 133 days in crossbred dairy cows of Sudan. However, Musa *et al.* (2005) reported 112 days for Sudanese cattle, while Ishag (2000) found that the dry period for crossbred dairy cattle was 90.5 days. It is commonly estimated that a two-month dry period provides a complete regeneration of udder glandular tissue and is favorable for the high production in the forthcoming lactation (Annen *et al.*, 2004; Andersen *et al.*, 2005). Capuco *et al.* (1997) showed that a dry period was necessary to replace mammary epithelial cells, thus providing one biological basis for the lower milk yield that has been observed with shortened dry periods. The results of analyses indicated that too short as well as too long dry periods have a negative effect on milk, fat and protein yield in forthcoming standard lactation. This confirms the earlier results by Borkowska *et al.* (2006), Winnicki *et al.* (2008), Pytlewski *et al.* (2009) and Węglarzy (2009). Similar to our results, Kuhn *et al.* (2007) reported dry periods of 30 d or fewer resulted in large reductions in subsequent lactation production and short dry period was beneficial for fat and protein percentages in the subsequent lactation of Jersey cows. Given the negative correlation between percentages and milk yield (Welper & Freeman, 1992), the highest percentages associated with shorter DD would be expected. Węglarzy (2009) observed the highest mean milk yield for 305-day lactation was obtained in the dry days of 61-90. Bachman (2002) and Gulay *et al.* (2003) have reported no loss with dry periods < 60 d. Sample sizes in both of those studies were small, however, and it has been shown (Kuhn & Hutchison, 2005) that even estimates in the wrong direction are not unlikely with such small sample sizes. On the other hand, an increase in yields of milk and protein and a decrease in milk fat content with an elongation of the dry period were recorded by Degaris *et al.* (2008). Also consistent with us, Kuhn *et al.* (2005a, 2007) observed the greatest number of dry periods was between 46 and 65 d in Jersey and Holstein

Table 4. Effect of different variables on the dry period length of Holstein cows

Variable		Number of observations	Dry period length*	*p*-value
Calving year	1983-1988	4,331	113.7 (1.5)^{a}	< 0.001
	1989-1994	44,815	105.5 (0.4)^{b}	
	1995-2000	162,555	100.8 (0.2)^{c}	
	2001-2006	173,016	98.5 (0.2)^{d}	
Calving season	Spring	89,827	101.9 (0.3)^{a}	< 0.001
	Summer	101,735	98.5 (0,3)^{c}	
	Fall	99,092	100.1 (0.3)^{b}	
	Winter	94,063	101.6 (0.3)^{a}	
Parity	1	132,309	93.2 (0.2)$^{d'}$	<0.001
	2	99,398	101.7 (0.3)^{c}	
	3	65,864	104.4 (0.4)^{b}	
	≥ 4	87,146	107.1 (0.3)^{a}	

Standard errors are within the parenthesis. Means within a column that do not have a common superscript $^{(a-d)}$ are significantly different ($p < 0.05$).

cows. Rémond *et al.* (1992), Madsen *et al.* (2004), and Rastani *et al.* (2005) also found higher protein percentages for cows with no dry period.

Several studies using Holsteins (Funk *et al.*, 1987; Kuhn *et al.*, 2005b) and Jerseys (Kuhn *et al.*, 2007) have investigated whether the effect of dry period length in the subsequent lactation depends on parity and have generally found either no or only small interactions with parity. Furthermore, even when DD effects were found to differ slightly across parities, the dry period length to maximize subsequent lactation performance was generally the same regardless of parity. Kuhn *et al.* (2005b), for example, found that dry periods of less than 20 d decreased subsequent lactation milk yield for Holsteins more in the second lactation than in later lactations, but 60 DD maximized yield in the following lactation regardless of parity. Inconsistent with the current results, Annen *et al.* (2004) found higher fat and protein percentages with fewer DD, but only for second lactation cows; there was no clear pattern for higher parity cows. It should be noted, however, that Annen *et al.* (2004) utilized bovine somatotropin (bST) in all treatment groups, which may have affected results for all traits since milk yield loss, generally associated with fewer DD, might have been mitigated by the use of bST in their study. Similar to the result of this study, Kuhn *et al.* (2007) observed the most notable effect of parity on dry period length was for first-parity cows to average about 3 to 5 fewer DD than later parity cows. This is likely due to the greater persistency of first-lactation cows (Stanton *et al.*, 1992). Thus, although cows produce more total milk over the entire lactation in second and later lactations, first-lactation cows actually have higher yields at the end of lactation, which in turn leads to slightly longer lactations, on average, and fewer DD. Also, consistent with us, Kuhn *et al.* (2007) reported recent years had lower mean DD than previous years and summer months had lower DD than other months in Jersey cows.

There is limited published research on the effect of dry period length on reproduction and fertility. Our current results showed a reduction in calving interval and age at calving after cows had shorter dry days than with other longer dry period lengths. Using shortened dry periods to improve fertility in either breed is not likely to be of much overall benefit because the "benefit" in fertility results only from lowered milk yield. It is, first of all, questionable whether improving fertility by lowering milk yield is a prudent economic choice (Kuhn *et al.*, 2007). However, even if improved fertility through lowered milk yield was shown to be of merit, there are almost certainly less expensive or more efficient ways to lower milk yield than by reducing dry period length, a practice that necessarily increases labor, time, and maintenance in the milking parlor, unless herd size is also reduced. Lower cost rations, for example, might lower milk yield and would simultaneously reduce costs rather than increase them, again if improved fertility through lowered milk yield was desired or found to be in some way a favorable alternative (Kuhn *et al.*, 2007). Similar to the results of this study, Kuhn *et al.* (2007) and Watters *et al.* (2009) indicated an improvement in reproductive performance of Holstein dairy cattle when dry period length was reduced. Contrary to the current results, Pezeshki *et al.* (2007) did not find a consistent improvement in reproductive measures with decreased dry period length. On the other hand, Grummer (2007) reported shortening or eliminating the dry period may be a more successful approach to improving reproductive efficiency than diet manipulation because shortening or eliminating the dry period may enhance dry matter intake during the transition period, decrease milk energy output, or both.

As conclusions, average DD was 100.46 days in Holstein cows. Calving year, season of calving and parity were identified as effective factors and had significant effects on the DD of dairy cows. Primiparous cows had the lowest DD and cows in their parity 4 and greater had the greatest DD. The mean of DD decreased over the years from 1983 to 2006 and summer calvers had the shortest DD. As with milk yield, fat and protein yields are maximized in the subsequent lactation with a 51-70 dry days period. Also, fat and protein percentages for Holstein cows were actually favored by shortened dry periods. Our current results showed a reduction in calving interval and age at calving after cows had shorter dry days than with other longer dry period lengths. This research is one of the few studies to examine DD effects on subsequent lactation, using a large dataset, for traits other than milk yield, and in particular percentage traits and reproduction.

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References

Amasaib EO, Fadel-Elseed AM, Mahala AG, Fadlelmoula AA, 2011. Seasonal and parity effects on some performance and reproductive characteristics of crossbred dairy cows raised under tropical conditions of the Sudan. Livest Res Rural Dev 23(4): http://www.lrrd.org/lrrd23/4/amas23078.htm. [Accessed 02 Jun 2012].

Andersen JB, Madsen TG, Larsen T, Ingvartsen KL, Nielsen MO, 2005. The effects of dry period *versus* continuous lactation on metabolic status and performance in periparturient cows. J Dairy Sci 88: 3530-3541.

Annen EL, Collier RJ, McGuire MA, Vicini JL, Ballam JM, Lormore MJ, 2004. Effect of modified dry period lengths and bovine somatotropin on yield and composition of milk from dairy cows. J Dairy Sci 87: 3746-3761.

Bachman KC, 2002. Milk production of dairy cows treated with estrogen at the onset of a short dry period. J Dairy Sci 85: 797-803.

Borkowska D, Januś E, Malinowska K, 2006. Zależność pomiędzy długością okresu zasuszenia krów a ich produkcyjnością w następnej laktacji. Rocz Nauk PTZ 2(3): 27-32.

Capuco AV, Akers RM, Smith JJ, 1997. Mammary growth in Holstein cows during the dry period: quantification of nucleic acids and histology. J Dairy Sci 80: 477-487.

Degaris PJ, Lean IJ, Rabieee AR, Heuer C, 2008. Effects of increasing days of exposure to prepartum transition diets on milk production and milk composition in dairy cows. Aust Vet J 86: 341-351.

Dias FM, Allaire FR, 1982. Dry period to maximize milk production over two consecutive lactations. J Dairy Sci 65: 136-145.

Funk DA, Freeman AE, Berger PJ, 1987. Effects of pervious days open, previous days dry, and present days open on lactation yield. J Dairy Sci 70: 2366-2373.

Ghavi Hossein-Zadeh N, Nejati-Javaremi A, Miraei-Ashtiani SR, Kohram H, 2009. Estimation of variance components and genetic trends for twinning rate in Holstein dairy cattle of Iran. J Dairy Sci 92: 3411-3421.

Ghavi Hossein-Zadeh N, Ardalan M, 2011. Evaluation of the potential effects of abortion on the productive performance of Iranian Holstein dairy cows. Anim Sci J 82: 117-121.

Grummer RR, 2007. Strategies to improve fertility of high yielding dairy farms: management of the dry period. Theriogenology 68S (S1): S281-S288.

Grummer RR, Rastani RR, 2004. Why re-evaluate dry period length? J Dairy Sci 87: E77-E85.

Gulay MS, Hayen MJ, Bachman KC, Belloso T, Liboni M, Head HH, 2003. Milk production and feed intake of Holstein cows given short (30-d) or normal (60-d) dry periods. J Dairy Sci 86: 2030-2038.

Gulay MS, Hayen MJ, Head HH, Wilcox CJ, Bachman KC, 2005. Milk production from Holstein half udders after concurrent thirty- and seventy-day dry periods. J Dairy Sci 88: 3953-3962.

Ishag IA, 2000. Impact of genetics and non genetic factors in productive and reproductive traits of crossbred cows raised under Sudan condition. MVSC thesis. University of Khartoum, Sudan.

Kuhn MT, Hutchison JL, 2005. Methodology for estimation of days dry effects. J Dairy Sci 88: 1499-1508.

Kuhn MT, Hutchison JL, Norman HD, 2005a. Characterization of days dry in US Holsteins. J Dairy Sci 88: 1147-1155.

Kuhn MT, Hutchison JL, Norman HD, 2005b. Minimum days dry to maximize milk yield in subsequent lactation. Anim Res 54: 351-367.

Kuhn MT, Hutchison JL, Norman HD, 2006. Effects of length of dry period on yields of milk fat and protein, fertility and milk somatic cell score in the subsequent lactation of dairy cows. J Dairy Res 73: 154-162.

Kuhn MT, Hutchison JL, Norman HD, 2007. Dry period length in US Jerseys: characterization and effects on performance. J Dairy Sci 90: 2069-2081.

Madsen TG, Andersen JB, Ingvartsen KL, Nielsen MO, 2004. Continuous lactation in dairy cows: effects on feed intake, milk production and mammary nutrient extraction. J Anim Feed Sci 13: 503-506.

Musa LMA, Ahmed MKA, Peters KJ, Zumbach B, Gubartalla KAE, 2005. The reproductive and milk performance merit of Butana cattle in Sudan. Arch Tierz 48: 445-459.

Pezeshki A, Mehrzad J, Ghorbani GR, Rahmani HR, Collier RJ, Burvenich C, 2007. Effects of short dry periods on performance and metabolic status in Holstein dairy cows. J Dairy Sci 90: 5531-5541.

Pytlewski J, Antkowiak I, Skrzypek R, Kęsy K, 2009. The effect of dry period length on milk performance traits of Black and White Polish Holstein-Friesian and Jersey cows. Ann Anim Sci 9: 341-353.

Rastani RR, Grummer RR, Bertics SJ, Gümen A, Wiltbank MC, Mashek DG, Schwab MC, 2005. Reducing dry period length to simplify feeding transition cows: milk production, energy balance, and metabolic profiles. J Dairy Sci 88: 1004-1014.

Rémond B, Ollier A, Miranda G, 1992. Milking of cows in late pregnancy: milk production during this period and during the succeeding lactation. J Dairy Res 59: 233-241.

Rémond B, Rouel J, Pinson N, Jabet S, 1997. An attempt to omit the dry period over three consecutive lactations in dairy cows. Ann Zootech 46: 399-408.

SAS, 2002. SAS User's guide v. 9.1: Statistics. SAS Institute, Inc. Cary, NC, USA.

Stanton TL, Jones LR, Everett RW, Kachman SD, 1992. Estimating milk, fat, and protein lactation curves with a test day model. J Dairy Sci 75: 1691-1700.

Stockdale CR, 2006. Reducing or eliminating the dry period of dairy cows. Aust J Exp Agric 46: 957-963.

Şükrü Gülay M, 2005. Altering the lactation cycle: is a 60-day dry period too long? Turk J Vet Anim Sci 29: 197-205.

Watters RD, Wiltbank MC, Guenther JN, Brickner AE, Rastani RR, Fricke PM, Grummer RR, 2009. Effect of dry period length on reproduction during the subsequent lactation. J Dairy Sci 92: 3081-3090.

Węglarzy K, 2009. Lactation productivity of dairy cows as affected by the length of preceding dry period. Anim Sci Pap Rep 27: 303-310.

Welper RD, Freeman AE, 1992. Genetic parameters for yield traits of Holsteins including lactose and somatic cell score. J Dairy Sci 75: 1342-1348.

Winnicki S, Głowicka-Wołoszyn R, Helak B, Dolska M, Jugowa JL, 2008. Effect of a dry period length on milk production and quality in next lactation. Prace i materialy Zootechniczne 67: S176.