Effect of Dry Period Length on Milk Production in Subsequent Lactation

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ABSTRACT

The effect of planned dry period lengths of 4, 7, and 10 wk on subsequent lactational yield was estimated with 366 cows in an experiment in which dry period was manipulated independently of milk yield prior to drying off. In two herds, all three treatments were compared within herd; in six herds, two treatments were compared within herd. Compared with a 7-wk planned dry period, a 3-wk decrease lowered the level of milk production by 2.8 kg of 4% FCM/d in the first 84 d of the subsequent lactation, whereas a 3-wk increase raised the level of milk production by .5 kg/d. In the first 168 d of the subsequent lactation, the difference between 4-wk and 7-wk planned dry periods was 2.7 kg/d, and the difference between 7- and 10-wk periods was .4 kg/d. There was no indication of interaction among planned dry period length and lactation number, days open in previous lactation, previous milk yield, breed, or health status with respect to effect on subsequent lactational yield.
(**Key words**: dry period, dairy cattle, milk production)

Abbreviation key: RDM = Red Danish breed, SDM = Danish Black and White breed, SFU = Scandinavian feed units.

INTRODUCTION

When a dairy farmer dries off a cow, it is assumed that the loss in the current lactation is compensated for by higher milk yield in the following lactation. Quantification of the effect of days dry on subsequent milk production is, therefore, critical for the choice of dry period length.

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Several authors have established the empirical relationship between days dry and subsequent milk production on observational (nonexperimental) data (3, 5, 9, 12, 13). They found that increasing the length of the dry period increased milk production by a diminishing return. Dias and Allaire (3) found interactions among the length of the dry period and calving intervals, yield in previous lactation, and lactation number.

In nonexperimental data, days dry are typically not independent of variation in milk production. Some cows cease lactation spontaneously before the planned drying off date, and the drying off decision for a cow may also be related to the expected milk yield by continuous milking. When days dry are related to milk production in nonexperimental data, estimates of the effect of the days dry period may be seriously biased. Examples are 1) interactions between the milk production ability and the dry period length and 2) interactions between the calving interval and the dry period length.

Effect of milking throughout pregnancy compared with a dry period of 8 to 9 wk was analyzed with two versus two quarters (10) and with identical twins (11). Both trials, however, had only five pairs of observations. Coppock et al. (1) estimated the effect of days dry in an experiment with 38 herds and five different dry periods (20, 30, 40, 50, and 60 d). Cows were assigned at random to treatments; however, cows with less than 9 kg/d of milk were allowed to be dried off. Consequently, the average differences in days dry between cows assigned to 20 and 60 d dry were only 10.8 d.

The purpose of the present study was to estimate the effect of preplanned lengths of the dry period on subsequent milk yield from an experiment in which the dry period was manipulated independently of milk yield prior to drying off, lactation number, and days open in previous lactation.

TABLE 1. Experimental design and number of cows per treatment within herd.

		Treatment		
Herd	Breed[1]	4 wk dry	7 wk dry	10 wk dry
1	SDM	29	31	27
2	RDM	18	19	24
3	SDM	19	19	. . .
4	SDM	. . .	22	23
5	SDM	22	. . .	20
6	Jersey	14	17	. . .
7	Jersey	. . .	15	16
8	Jersey	13	. . .	18
Total		115	123	128

[1]SDM = Danish Black and White; RDM = Red Danish.

MATERIALS AND METHODS

Experimental Design

The experiment was conducted on eight commercial farms by the National Institute of Animal Science in Denmark. Cows were dried off at 4, 7, or 10 wk before expected calving (treatments 4, 7, and 10, respectively). Within herd, all three treatments were compared in two herds. Two treatments were compared within herd in six herds (Table 1). Cows of the two breeds, Danish Black and White (SDM) and Red Danish (RDM) have similar live weight and milk production ability. The SDM cows were highly influenced by Holstein-Friesian (50 to 60% of the genes), whereas 10 to 20% of the genes in the RDM cows were Brown Swiss.

Cows were only allowed to be dried off earlier than planned if the daily milk yield was below 2 kg. Except in cases of serious illness, experimental cows were not allowed to be culled earlier than 12 wk after calving in the subsequent lactation. All cows determined pregnant by rectal palpation were assigned at random to treatment within parity (one or older) and within calving periods of 6 wk during 54 wk in 1988 and 1989.

Sixty-eight of 434 cows assigned to the experiment were removed for various reasons as shown in Table 2. Eight cows (seven in treatment 4 and one in treatment 10) that were dried off earlier than planned due to low milk yield were kept in the analysis.

Drying Off Procedures

The following procedure for drying off was applied. All cows were milked twice a day until the day of drying off when the herds were visited by a technician from the National Institute of Animal Science. The time of drying off was a fixed day of the week in each herd. The selected cows were separated from the other milking cows on the day of drying off. In herds

TABLE 2. Reasons for culling cows after assignment to various treatment.

Reason	Number of cows
Culled before the assignment was known by the farmer	33
Nonpregnant	5
Abortion	8
Serious illness or death around calving	4
Erroneous drying off time[1]	10
Erroneous insemination record	1
Serious illness or death 1 to 12 wk postpartum	7
Total	68

[1]More than 4 d deviation from planned.

TABLE 3. Production characteristics for the herds involved in the experiment.

Herd	Milk production prior to drying off at 308 d, 4% FCM (kg) 1st lactation	Others	70 d prior to expected calving: Milk yield 1st lactation	Others	Weight 1st lactation	Others	Body condition score 1st lactation	Others	Calving interval 1st lactation	Others
			(kg of 4% FCM/d)		(kg)				(d)	
1	6070	6898	16	14	530	568	3.3	3.6	365	371
2	6109	7192	17	15	493	570	2.5	2.9	349	344
3	6486	7381	15	13	571	599	3.0	3.2	362	368
4	6511	6984	14	11	591	650	3.1	3.5	380	363
5	7850	8894	16	14	577	612	2.7	3.0	391	378
6	5784	6049	12	11	367	369	2.2	2.2	382	357
7	4871	6530	6	9	367	417	3.0	3.3	410	397
8	5210	6341	10	13	338	375	2.7	2.7	399	367

1 and 2, cows were fed lactation ration until the day of drying off. In herds 3 to 8, cows were fed barley straw and water the last 2 milking d before drying off.

Feeding

During the first 3 d dry, all cows were given barley straw and water. From 3 d after drying off until 2 wk before expected calving, RDM and SDM cows were given 6 Scandinavian Feed Units (SFU)/d, and Jersey cows were given 4.5 SFU/d. From 2 wk before expected calving to calving, RDM and SDM cows were given 8 SFU/d, and Jersey cows were given 6.0 SFU/d. An SFU is equivalent to a net energy of 7.89 MJ. Crude protein percentage in the ration was between 10 and 12%. Minerals were given to ensure at least 33 g of Ca and 42 g of P (RDM and SDM) and 24 g of Ca and 30 g of P (Jersey) per day. All cows were fed flat rate feeding of concentrate independently of milk yield for at least 16 wk after calving. Production characteristics for cows in the experiment are shown for each herd in Table 3.

Recordings

Each herd was visited weekly on a fixed day by a technician to identify cows for the drying off procedure in the coming week. Heart girth and body condition score (6) were measured at three different times by the technicians: 10 wk before expected calving, at the time for drying off, and after calving. Technicians also recorded the udder condition of dry cows every week. Ease of calving was scored from 1 (easy) to 4 (veterinary-assisted) by the farmer. The calves were weighed within a week after birth. Weight after calving was calculated by a transformation of heart girth to live weight (2). Weight before calving was calculated as weight after calving plus weight of the calf times 1.7.

Daily production of milk, protein, and fat per cow was measured every 4 wk. Inseminations were performed and recorded by AI technicians. Local practicing veterinarians performed all treatments requiring injections or use of antibiotics and recorded diagnosis, date, and cow identification on the farm. Treatments and milking out performed in the dry period by the farmer were recorded similarly. All health related recordings were verified by the technicians.

Statistical Methods

Out of 72 periods, 21 periods had either less than 4 cows represented or one treatment not present. These periods were pooled with the previous period.

Twenty-nine cows were culled from 12 to 24 wk postpartum. Average milk production of 4% FCM 1 to 168 d postpartum was estimated for these cows using the average slope of the lactation curve within herd, treatment, and lactation number. Milk production 70 d before expected calving was estimated using the last observation before 70 d and a slope for the whole lactation for each cow.

Data were analyzed by analysis of variance using the general linear models procedure of

SAS (8). The variables examined are shown in Equation [1].

$$Y = b_0 + a + c + d + g + h + r + s + b_1X + b_2Z + b_3U + vW + e \quad [1]$$

where:

a = treatment (4, 7, 10),
c = lactation number (1, 2),
d = period within herd (1, 2, . . ., 51),
s = health factor in previous lactation (1, 2, 3, 4),
g = health factor in dry period (1, 2, 3, 4),
h = health factor 1 after calving (1, 2, 3, 4),
r = health factor 2 after calving (1, 2, 3, 4),
Y = lactational yield in subsequent lactation,
X = lactational yield in previous lactation,
Z = days open in previous lactation,
U = body condition score 10 wk before expected calving in previous lactation,
W = weight before calving within breed (1, 2),
b_1, b_2, b_3 = regression coefficients,
v = regression coefficients within breed (1, 2), and
b_0 = intercept.

The qualitative data concerning health and udder conditions are pooled in four variables in Equation [1]. These were created as explained in the Appendix.

Using data from herds 3 to 8 only and 4% FCM 1 to 84 d postpartum as response variable, the effect of period within herd in Equation [2] was split into breed and period within herd within breed. The interaction among breed and treatment was tested and found nonsignificant (P = .65). Using data from all eight herds, the effect of period within herd was split into group and period within herd within group. Group indicates drying off procedure (herds 1 and 2 versus herds 3 to 8). The interaction among group and treatment was tested and found nonsignificant (P = .71). Consequently, all data, regardless of breed and drying off procedure, were pooled. Breed as an index for weight as covariable in Equation [1] should be understood as RDM and SDM cows versus Jersey cows.

Based on the main effects shown in Equation [1], all combinations of first-order interactions (excluding period within herd) were included in our initial model. Effects were removed in five steps using P values for type 3 F tests of .75, .50, .25, .10, and .05 as thresholds. The model was further reduced until all interactions or main effects were below a P value of .05. Each model reduction was tested for overall significance from the initial model. No significant model reductions were conducted. The resulting model is shown in Equation [2].

$$Y = b_0 + a + d + g + h + r + b_1X + b_2Z + vW + wW + gr + e \quad [2]$$

where:

w = regression coefficients for weight before calving within breed and health factor 2 after calving (1, 2 . . . 8) and all other symbols are described in Equation [1].

Effect of treatment within herd was estimated by Equation [3].

$$Y = b_0 + a + d + b_1X + b_2Z + b_4W + e. \quad [3]$$

where:

d = effect of period (1, 2, . . ., 12),
b_4 = regression coefficient for weight before calving, and all other symbols are determined in Equation [1].

Average yield 1 to 84 d postpartum 1 to 168 d postpartum, and estimated yield 70 d before expected calving were compared as covariables for lactational yield in previous lactations. The covariables, which produced the smallest residual standard variation, were chosen for each response variable.

TABLE 4. Days dry per treatment.

Treatment	Days dry	
	$\bar{X}$	SD
4	29.6	9.4
7	49.9	7.2
10	70.6	7.7

RESULTS

Average days dry per treatment for all cows analyzed are shown in Table 4. Except for the eight cows dried off earlier than planned, days from drying off to expected calving were within the range of 1 wk.

An analysis of the treatment effect was conducted for each herd using Equation [3]. Least squares means for 4% FCM 1 to 84 d postpartum were estimated using Equation [3] and are shown in Figure 1. A 4-wk dry period compared with a 7-wk period decreased milk production in all four within-herd comparisons. Ten-wk periods compared with 7-wk periods produced less conclusive results.

Interactions between treatment and lactation number, treatment and milk yield in previous lactation, and treatment and days open in previous lactation were tested again by adding the effects one at a time to Equation [2], using 4% FCM 1 to 84 d postpartum as response. The P values for type 3 F tests were lactation number (P = .66), days open in previous lactation (P = .57), and 4% FCM 1 to 168 d postpartum in previous lactation (P = .82).

Least squares means for the variables kept in the resulting model (Equation [2]) are presented in Tables 5 and 6. A period of 4 wk dry compared with 7 wk dry decreased 4% FCM 1 to 84 d postpartum by 2.8 kg/d. A period of 10 wk dry increased 4% FCM 1 to 84 d postpartum by .5 kg/d compared with a 7-wk dry period. Evaluated by least significant differences, none of the differences between 7- and 10-wk dry periods was different from zero.

A regression analysis using first and second order planned dry period length instead of treatment as a class variable in Equation [2] provided the linear parameter value (2.38) and a quadratic parameter value (–.13). Both parameters were different from zero with P values of .002 and .018, respectively.

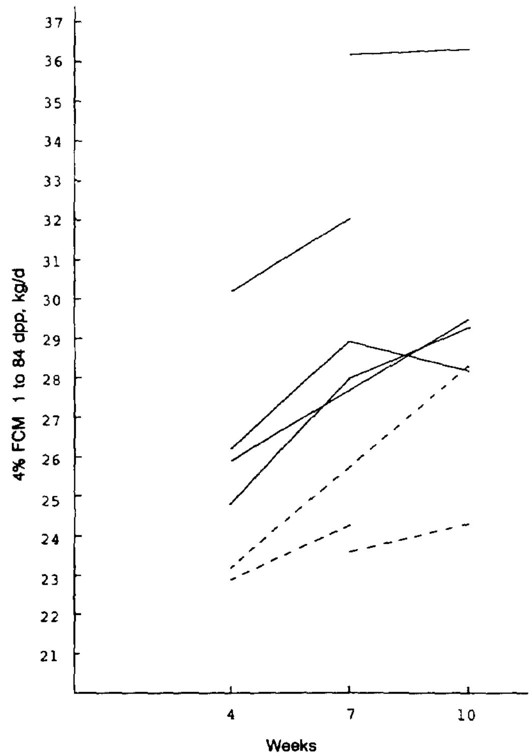

Figure 1. Effect of planned dry period length (weeks from drying off to expected calving) on milk production in the subsequent lactation. Dual purpose breeds (—), Jersey breed (- - -).

On average, the experimental cows in first lactation yielded 256 kg of 4% FCM 10 to 7 wk before calving and 239 kg of 4% FCM 7 to 4 wk before calving. Older cows yielded 233 kg of 4% FCM 10 to 7 wk before calving and 183 kg of 4% FCM 4 to 1 wk before calving. Consequently, on average there was a net loss in milk production at 4- and 10-wk dry periods compared with 7 wk.

DISCUSSION

The decrease in milk production in the subsequent lactation caused by decreasing the dry period from 7 to 4 wk is 2 kg of 4% FCM/d higher in this experiment compared with most field data analyses (9, 12, 13) and 1 kg of 4% FCM/d higher than Keown and Everett (5). The increased milk production caused by increasing

TABLE 5. Effect of planned dry period length on lactational yield in the subsequent lactation.

Variable	Days postpartum	Treatment 4	7	10	P value in F test	Least significant difference
Milk, kg/d	1 to 84	22.0	24.5	25.1	<.001	.8
Milk fat, kg/d	1 to 84	.93	1.06	1.07	<.001	.04
Protein, kg/d	1 to 84	.77	.83	.83	<.001	.03
4% FCM, kg/d	1 to 84	22.9	25.7	26.2	<.001	1.0
4% FCM, kg/d	1 to 168	21.2	23.9	24.3	<.001	.8
4% FCM, kg/d	168	18.7	21.0	21.2	<.001	1.0

the dry period from 7 to 10 wk is similar to findings on observational data by Keown and Everett (5).

This analysis failed to reveal an interaction between the dry period and lactation number, which was found in some of the observational studies (3, 12). Schaeffer and Henderson (9) found that average days dry in observational data increased with lactational number and decreased with 305-d yield in the lactation before the dry period. The high influence of Holstein-Friesian in the four SDM herds and the lack of interaction between breeds in the experiment do not indicate that the effect differs due to breed differences. In late lactation, first lactation cows produce more milk than older cows (7). A relatively higher proportion of older cows will, therefore, be dried off early due to low yield. When analyzed on observational data, this correlation between low yield and a long dry period could cause an interaction between days dry and lactation number; i.e., first lactation cows could give a higher response to long dry periods compared with older cows.

Dias and Allaire (3) found an interaction between calving interval and days dry on milk production. The explanation for this interaction could be that a cow with a short calving interval at a specified period before next calving produces more milk than a cow with a long calving interval.

TABLE 6. Percentage distribution of the categories, the health variables included in the final model, and least squares mean milk production [4% FCM, kg, 1 to 84 d postpartum] for each category (n = 366).

Health category[1]	(% of N)	Milk yield
Drying off to 14 d before calving,[2] g in Equation [1]		
No disease, milking out, or DCT[2,3]	83.7	25.3
Disease and no milking out or DCT	4.0	22.2
DCT with or without disease and no milking out	5.2	25.3
Milking out with or without disease or DCT	7.1	26.8
From 14 d before calving[2] to 84 dpp, h in Equation [1]		
Treatment for SEVERE or UDDER disease		
NO SEVERE and no UDDER	54.4	26.2
SEVERE and no UDDER	11.7	26.1
UDDER and no SEVERE	11.7	24.0
SEVERE and UDDER	4.4	23.5
CALVSCOR[4] and treatment for NON-SEVere disease, r in Equation [1]		
Uncomplicated with or without NON-SEV	64.2	27.2
Slightly complicated and no NON-SEV	28.4	26.5
Complicated or twins and no NON-SEV	6.3	26.3
NON-SEV and not uncomplicated or twins	6.8	19.7

[1]Abbreviations defined in the Appendix.

[2]Recordings made later than .5 times the dry period after drying off date were included if the actual dry period was less than 28 d.

[3]DCT = Dry cow therapy.

[4]CALVSCOR = Calving score.

In conclusion, increasing the dry period length increases milk production in subsequent lactation by a diminishing return. There is no evidence that first lactation cows, high yielding cows, cows with a short calving interval, or cows with various clinical health disorders respond very differently to dry period length than other cows.

REFERENCES

1 Coppock, C. E., R. W. Everett, R. P. Natzke, and H. R. Ainslie. 1974. Effect of dry period length on Holstein milk production and selected disorders at parturition. J. Dairy Sci. 57:712.

2 Davies, H. P., W. W. Swett, and W. R. Harvey. 1961. Relation of heart girth to weight in Holsteins and Jerseys. Nebraska Agric. Exp. Stn. Bull. 194.

3 Dias, F. M., and F. R. Allaire. 1982. Dry period to maximize milk production over two consecutive lactations. J. Dairy Sci. 65:136.

4 Enevoldsen, C., Y. T. Gröhn, and I. Thysen. 1990. Physical injuries in dairy cows: associations with season, cow characteristics, disease and production. Page 133 *in* Proc. Annu. Mtg. Soc. Vet. Epidemiology Prev. Med., M. Thrusfield, ed., Belfast, Ireland.

5 Keown, J. F., and R. W. Everett. 1986. Effect of days carried calf, days dry, and weight of first calf heifers on yield. J. Dairy Sci. 69:1891.

6 Kristensen, T. 1985. Methods for estimation of body conditions of dairy cows. Page 59 *in* Research in cattle production systems. V. Østergaard and J. Hindhede, ed. Rep. 615, Natl. Inst. Anim. Sci., Copenhagen, Denmark.

7 Oltenacu, P. A., T. R. Rounsaville, R. A. Milligan, and R. H. Foote. 1981. Systems analysis for designing reproductive management programs to increase production and profit in dairy herds. J. Dairy Sci. 64:2096.

8 SAS® User's Guide: Statistics, Version 5 Edition. 1985. SAS Inst., Inc., Cary, NC.

9 Schaeffer, L. R., and C. R. Henderson. 1972. Effects of days dry and days open on Holstein milk production. J. Dairy Sci. 55:107.

10 Smith, A., J. V. Wheelock, and F. H. Dood. 1967. The effect of milking throughout pregnancy on milk secretion in the succeeding lactation. J. Dairy Res. 34:145.

11 Swanson, E. W. 1965. Comparing continuous milking with sixty day dry periods in successive lactations. J. Dairy Sci. 48:1205.

12 Wilton, J. W., E. B. Burnside, and J. C. Rennie. 1967. The effects of days dry and days open on the milk and butterfat production of Holstein-Friesian cattle. Can. J. Anim. Sci. 47:85.

13 Wood, P.D.P. 1977. The effect of the dry period on the subsequent lactation in three half-sib groups of British Friesians. J. Agric. Sci. (Camb.) 89:737.

APPENDIX

The qualitative data concerning health and udder conditions were reduced to four variables according to the following three-step strategy. 1) Recorded events and conditions were categorized according to the observation periods: PRIOR = 14 d prior to the calving preceding the experimental treatment until the day of drying off, DP = from drying off until maximum (calving date — 14 d, calving date — dry period/2), and AFTER = from maximum (calving date — 14 d, calving date — dry period/2) to 84 d after calving. 2) Disease treatments within PRIOR were categorized as UDDER, SEVERE, and nonsevere (NON-SEV). Events and conditions recorded in DP were categorized as dry cow therapy (DCT), representing preventive antibiotic udder treatment; all other health-related treatments; milking out due to udder tension or suspicion about disease; and recordings of spontaneous milk flow. Disease treatments within the period AFTER and calving ease scores with twins as a category 5 were categorized as UDDER, SEVERE, NON-SEV, and CALVSCOR. 3) The variables created in 2 were pooled within the periods PRIOR, DP, and AFTER by means of the results from a log-linear modeling strategy (4) using Proc Catmod (8) to produce the variables g, h, r, and s (Equation [1]).