JARQ 24, 209–215 (1990)

Effect of Suckling Stimulation and Milk Yield on Postpartum Ovarian Activity and Uterine Involution in Grazing Beef Cows

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Abstract
In beef cows, a milk yield showed an inhibitory effect on both the postpartum ovarian activity and the uterine involution. The suckling stimulation, however, indicated a suppressive effect on the former, while a hastening effect on the latter. This conclusion was derived from the results of multiple regression analyses on suckling cows, which were subjected to restricted sucklings twice a day and early weaning. In estimating adequate intervals from calving to first ovulation, following were the relevant factors in order of decreasing importance:
parity > milk yield > body weight changes caused by nutrient conditions > suckling stimulation.
The factors affecting uterine involution could also be ranked as follows in decreasing order of importance: parity > milk yield > sucking stimulation. The uterine involution was more stable than the postpartum ovarian activity in terms of the sensitivity to some critical factors.

Discipline: Animal industry
Additional key words: early weaning, estrus, restricted suckling

Introduction

A one-year interval between calvings is the target in terms of the reproduction management of beef herds. In practice, however, it is difficult to achieve and maintain such an interval because the restoration of a full ovarian and uterine activity is delayed by various factors. In grazing Japanese Black cows, average intervals from calving to first estrus range from 30 to 92 days and those for conception are 100 to 165 days under general conditions. The period from calving to resumption of the estrous cycle and to first insemination is of vital importance to the number of resulting days open which are an indicate of reproductive efficiency[1,8].

Various factors have been identified as effective components on resumption of ovarian activity and uterine involution, including age, parity, undernutrition, calving season, suckling intensity, milk yield and management system. Among those factors, Vandeplassche[13] suggested that suckling intensity and milk yield be major factors in influencing ovarian activity and uterine involution. However, only limited information are available at present regarding the effects of suckling stimulation and milk yield and their interactions in connection with intact suckling Japanese Black cows[12]. This paper attempts to review briefly the results of several studies on the effects of suckling stimulation and milk yield on the resumption of ovarian activity and uterine involution in the postpartum period of the grazing Japanese Black cows.

Animals and management

A series of studies relating to the above-mentioned subject have been undertaken at the Chugoku National Agricultural Experiment Station, located 35°10′N lat. and 132°30′E long., Japan. Japanese

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Black cows that were derived from the experimental herd and maintained by the Station were employed for those studies. Those cows were allowed to graze during the period April to November until approximately two weeks before parturition. After the parturition, those cows and calves were maintained in pens during the experimental period. The rations for the cows were 20 kg of silage, and 2 kg each of hay and concentrate per day.

Changes of suckling behavior and milk yield[8]

Sixty-six Japanese Black cow-calf pairs were subjected to investigations on the changes of their suckling behaviors and milk yields at 10, 30 and 60 days postpartum, respectively[8]. Behavioral surveys were made for a 24 hr-period each with a time-laps video-recorder and a television camera. Data on daily milk yields for each sample were taken by a weigh-suckle-weigh method.

The changes of suckling behaviors and milk yields after calving are shown in Table 1. More frequent sucklings per day took place in Japanese Black cows than in Holstein-Friesian[14] and the crossbred of Angus and Herefod[9]. The average suckling times per event, however, were almost the same among these breeds[9,14]. Fluctuations in the suckling interval time and the milk yield decreased gradually with the lapse of days after calving. A negative correlation was recognized between the milk yields and the suckling events at 30 days ($r = -0.404$, $P < 0.01$) and 60 days ($r = -0.298$, $P < 0.05$) (Fig. 1). These results indicate that suckling behaviors play an important role on milk production.

Table 1. Effects of the duration after calving on suckling behavior and milk yield in Japanese Black cows[1)]

	Duration after calving (days)		
	10	30	60
No. of sucklings/day (times)	8.3 ± 2.6	8.9 ± 2.5^a	7.5 ± 1.6^b
Total suckling time/day (min)	66.2 ± 30.6^a	100.1 ± 29.4^b	86.0 ± 25.2^c
Average suckling time/event (min)	7.8 ± 2.2^a	11.3 ± 1.9^b	11.5 ± 3.1^b
Fluctuations of suckling interval time[2)]	44.4 ± 16.9^a	41.0 ± 14.6	36.7 ± 13.3^b
Milk yield/day (kg)	5.6 ± 1.2^a	5.1 ± 1.3^b	4.7 ± 1.2^c

1): Values in the table indicate means ± S.D.
2): Fluctuations of suckling interval time are expressed in coefficients of variation.
Significant ($P < 0.01$) differences within a colum are indicated by different superscripts.

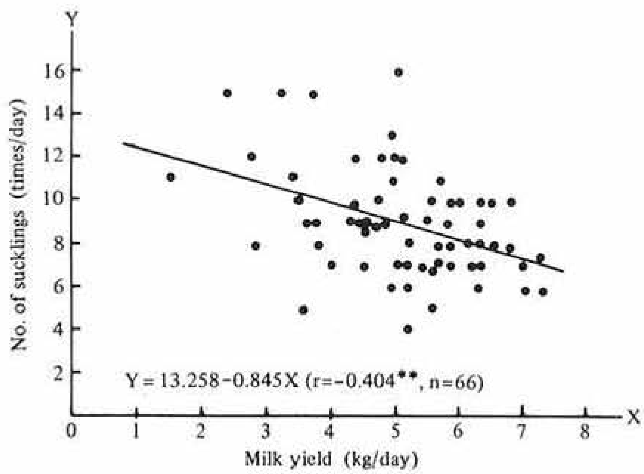

Fig. 1. Relationship between the milk yield and the number of sucklings on the 30th day postpartum

Models for prediction of postpartum reproductive function based on changes in milk yield and suckling stimulation[4,7]

An experiment was conducted to examine the effects of parity, months of calving, body weight changes, milk yield and suckling stimulation on postpartum first ovulation and uterine involution. The analyses were made on the basis of the records on 66 Japanese Black cows[4,7]. A curvilinear multiple regression analysis based on backward elimination methods was fitted, taking linear and quadratic terms of independent variables into account.

1) Outline of the reproductive performance

Postpartum intervals to first ovulation, first estrus and uterine involution in the cows under study are shown in Fig. 2. Overall means of the time requirements for first ovulation and first estrus were 35.5±6.8 and 48.0±10.8 days, respectively. The duration from calving to first ovulation in the first and second of calving was significantly longer than that in the seventh and ninth of calving number. Only 17% of all the cows exhibited estrus behavior in the first ovulation, while over 94% of those cows showed estrus signs in the second and third ovulations. Most of the corpora lutea formed after the first ovulation were small in size and had a significantly shorter life-span (14.1±4.9 days) than those after the second and third ovulation (21.3±1.7 days). This suggests that lower levels of follicle stimulating hormone (FSH) observed before the first ovulation

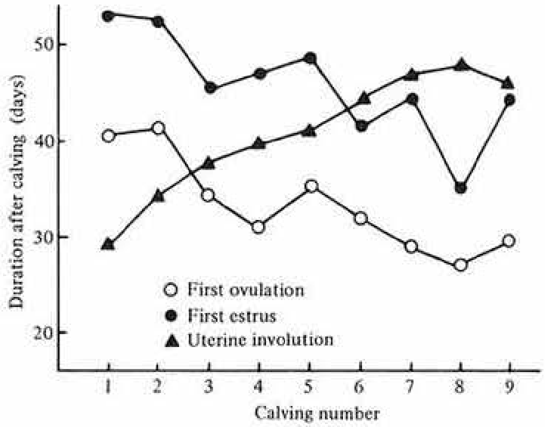

Fig. 2. Relationships between the postpartum intervals and the calving number in Japanese Black cows

be an important factor which contributes to reducing a life span of the subsequent corpus luteum[11].

The average duration required for uterine involution was 38.7 days, and longer periods were required with the increase in calving number. The involutionary progress during the period 7 to 20 days postpartum which exceedingly affected the uterine involution[2] was relatively slow with the increase in calving number.

2) Factors affecting the first postpartum ovulation

Table 2 shows basic data of original variables for the multiple regression analyses. The multiple regression equations for estimating recurrence intervals of postpartum first ovulation are as follows:

Table 2. Basic data of original variables for the first ovulation

	Mean	Minimum	Maximum	S.D.
Parity (X_1)	3.7	1	9	2.2
Month of parturition (X_2)	6.4	1	12	3.4
Body weight just after calving (kg) (X_3)	441.1	315.0	561.0	55.4
Body weight loss (kg)[1)] (X_4)	−9.2	−47.1	+31.7	16.0
Milk yield on the 30th day postpartum (kg/day) (X_5)	5.1	1.5	7.2	1.3
Number of sucklings[2)] (times/day) (X_6)	8.9	4	16	2.5
Total suckling time (min./day)[2)] (X_7)	100.1	35.0	216.7	29.4
Fluctuations of suckling interval time (%)[2)] (X_8)	41.0	16.1	86.6	14.6
Duration from calving to first ovulation (days) (Y)	35.5	23	59	16.8

1): Body weight loss in the period post-calving to 30th day postpartum.

2): Data on number of sucklings, total suckling time and fluctuations of suckling interval are taken on the 30th day postpartum, and fluctuations of suckling interval time are expressed in coefficients of variation.

$$Y = 37.157 - 1.842X_1 - 0.036X_3 - 0.112X_4 + 2.001X_5 + 0.521X_6 + 0.103X_8 + 0.364(X_1 - 3.7)^2 - 0.001(X_7 - 100.1)^2$$
(Adjusted $R^2 = 63.8\%$);

where, Y: Days from calving to first ovulation, X_1: Parity, X_3: Body weight just after calving, X_4: Body weight loss, X_5: Milk yield, X_6: Suckling events, X_7: Total suckling times per day and X_8: Frequency of suckling interval time. The measurements on X_4, X_5, X_6 and X_8 were each taken on the 30th day postpartum. The relative importance of the variables was: $X_1(42.3\%) > X_5(17.4\%) > X_4(11.8\%) > X_3(10.2\%) > X_7(7.5\%) > X_8(6.1\%) > X_6(4.8\%)$. In the above equation, quadratic effects of the parity and the total suckling times were significant, and the effects of the other variables were linear.

The interval from calving to first ovulation decreased gradually from 42.6 days in the first of calving number to 32.4 days in the sixth; beyond that it turned to increase gradually (Fig. 3). As shown in Fig. 4, conditional range of variations of the body weight just after calving and the milk yield are confined stepwise according to the increase of suckling events. Combination condition of the body weight just after calving and the body weight loss at 30 days postpartum for the occurrence of first ovulation within 40 days postpartum also changed (Fig. 5).

The multiple regression analysis above showed that the increase in milk yield and number of suckling events had inhibitory effects on the occurrence of first ovulation, and that the body weight changes indicating nutrient level affected the postpartum duration before the first ovulation as well as the effect of parity, milk yield and suckling stimulation. However, in case where the suckling frequencies are under control to maintain a few times a day at regular intervals, the total suckling times and fluctuation of the suckling interval times would decrease. Thus, it is suggested that the interval from calving to first ovulation be reduced under the condition of high milk yield and low body weight.

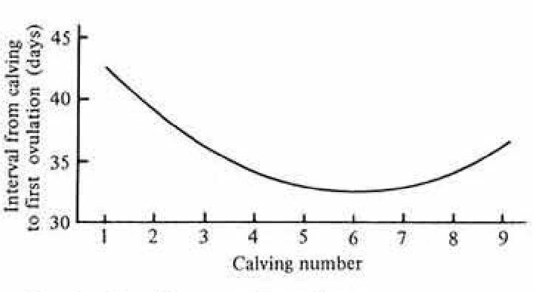

Fig. 3. Partial regression of first postpartum ovulation on calving number
Estimates of the first postpartum ovulation from the first to the ninth calving number are indicated in a quadratic curve on condition that other variables take mean values.

3) *Factors affecting uterine involution*

A multiple regression equation for estimating an

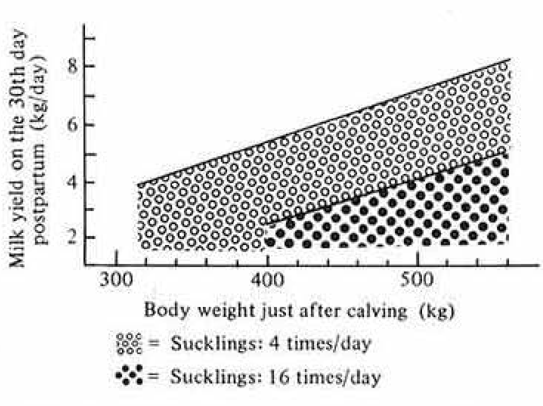

Fig. 4. Relationships among the body weight just after calving, the milk yield and the number of suckling events for the occurrence of first ovulation within 40 days postpartum in the case of the first calving number

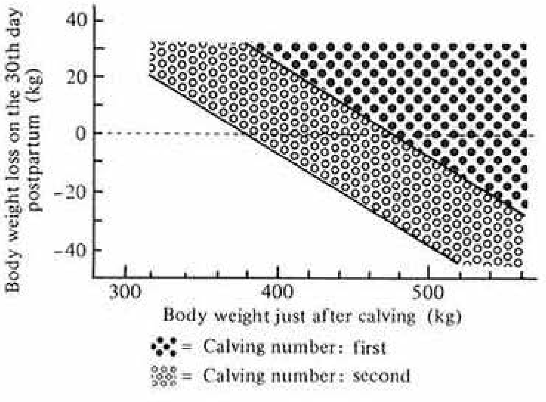

Fig. 5. Relationships among the body weight just after calving and the body weight loss at 30 days postpartum for the occurrence of first ovulation within 40 days postpartum

adequate duration of the uterine involution was formulated as follows:

$$Y = 22.633 + 2.152X_1 + 1.959X_5 - 0.361X_6$$
$$(\text{Adjusted } R^2 = 85.0\%);$$

where, Y: Time (days) required from calving to uterine involution, X_1: Parity, X_5: Milk yield (kg/day), and X_6: Number of suckling events (times/day). The measurements on X_5 and X_6 were taken at 10 days postpartum. Relative importance of independent variables of X_1, X_5 and X_6 were 75.2%, 21.7% and 3.1%, respectively. According to this model, it is suggested that the increase of parity and milk yield delay the involution of uterus, while the increase of suckling events accelerate it. Variables in relation to uterine involution were limited in number as compared with those for postpartum first ovulation. The uterine involution was not affected seriously by changes of body weight, which was an indication of nutrient level of beef cows.

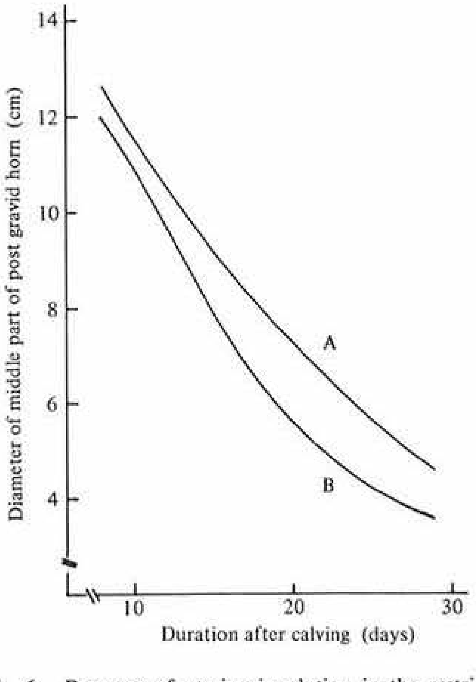

Fig. 6. Progress of uterine involution in the restricted suckling (twice a day) and the intact control beef cows
A: Restricted suckling cows,
B: Control cows.
Progresss of uterine involution is expressed by the growth of diameter of the post gravid horn.

4) Influence of restricted sucklings on uterine involution[6)]

Effects of restricted sucklings, i.e. twice a day from the third day after calving, were investigated for the uterine involution in the third calving of beef cows[6)]. Progress of the uterine involution was slower in the restricted suckling cows than the intact control cows (Fig. 6). Weight and size of the uterus removed on the 30th day postpartum in the restricted suckling cows were larger as compared with those of the control. The average height of surface epithelium of endometrium in ovarian quiescent cows of the restricted suckling and the control cows varied from 14.1 to 23.2 μm, but one of the restricted suckling cows which had first ovulation on the 24th day postpartum showed a high level of 28.2 to 35.2 μm. It is concluded that the restricted sucklings twice a day inhibit the morphological involution of uterus, and that such an interaction agrees with the result of the multiple regression analysis as stated above. However, the height of surface epithelium of endometrium is influenced by ovarian function regardless of uterine involution.

Effects of early weaning and LH-RH analogue administration on postpartum reproductive function

1) Effect of early weaning[3)]

In order to identify the effects of early weaning on the postpartum ovarian activity and the uterine involution, calves were removed from their dams at one week and four weeks of ages[3)]. With an early weaning, the interval required for first ovulation and resumption of estrus was considerably shortened in primiparous cows (Table 3). However, in multiparous cows, the difference in time requirements was small among the three groups under study. With the advancement of the weaning date, the duration required from calving to uterine involution was prolonged. The duration required for conception after calving was the shortest in 1-week weaning with a mean of 98 days, while in 4-week weaning and control, it was 107 and 122 days, respectively. These results indicate that the early weaning, especially in primiparous cows, accelerate postpartum ovarian recurrences, while the lack of suckling stimulation in early stage of postpartum days represses the uterine

Table 3. Effects of the early weaning on interval from calving to first ovulation, first estrus and uterine involution in Japanese Black cows

	Weaning	Calving no. groups			Mean ± S.D.[1)]
		1	2–5	6–10	
Interval (days) from calving to:					
First ovulation	1-week	26.3	23.4	26.4	25.2 ± 8.4[a]
	4-week	35.7	31.6	29.1	31.0 ± 6.7
	Control	77.0	43.8	27.3	47.3 ± 31.9[b]
First estrus	1-week	45.0	31.4	32.0	34.8 ± 13.6[a]
	4-week	38.7	39.2	37.1	38.1 ± 7.7
	Control	88.8	52.6	34.2	56.3 ± 32.8[b]
Uterine involution	1-week	36.0	43.8	47.8	41.2 ± 4.9[a]
	4-week	30.0	35.8	45.9	38.9 ± 6.1
	Control	32.0	34.0	41.6	37.2 ± 6.0[b]

1): a and b; $P<0.05$.

Table 4. Effects of the weaning and LH-RH-A[1)] 200 μg injection on intervals from calving to first ovulation and first estrus

	Treatment[2)]	Primiparous	Multiparous	Mean ± S.D.
Interval (days) from calving to:				
First ovulation				
Weaning + LH-RH-A	A	35.5[3)]	29.3	34.3 ± 4.2[a]
Weaning	B	35.0	32.3	33.7 ± 4.7[a]
Control + LH-RH-A	C	36.3	33.8	35.0 ± 3.4[a]
Control	D	63.1	38.4	50.8 ± 3.3[b]
First estrus				
	A	40.7	33.4	39.4 ± 4.8[a]
	B	48.0	37.8	42.9 ± 5.3[a]
	C	46.0	43.4	44.7 ± 3.9[a]
	D	72.2	48.6	60.4 ± 3.8[b]

1): (Des-Gly-NH_2[10], Pro-ethlmide[9])-LH-RH.
2): A; Weaning and injection of LH-RH-A in 4 weeks postpartum, B; Weaning in 4 weeks, C; LH-RH-A injected in 4 weeks postpartum, D; No treatment as a control.
3): Values in the table indicate means (a and b; $P<0.01$).

involution. However, the interval between calving and conception can be reduced with an early weaning in one or four postpartum weeks.

2) Effects of LH-RH analogue administration[5)]

The pulsatile LH pattern is prerequisite for the onset of ovarian activity. In this respect, it was suggested that suckling inhibit ovarian activity via its effect on gonadotrophin release[10)]. However, pituitary LH and FSH contents were not different between the suckled and the weaned beef cows in three postpartum weeks[15)]. Effects of LH-RH analogue administration and early weaning in four postpartum weeks were examined[5)] (Table 4).

Early weaning and LH-RH analogue injection significantly shortened the duration of postpartum interval to the first ovulation and the first estrus, compared with the intact control cows. The effectiveness for activating ovarian recurrence was remarkable in primiparous cows. There was no significant difference in the interval from first to second ovulation, the proportion of exhibiting estrus at each ovulation and the number of inseminations per conception among the four experimental groups. The results indicate that the LH-RH analogue injection of 200 μg as well as the early weaning in four postpartum weeks will be effective in inducing postpartum ovarian recurrences.

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(Received for publication, June 7, 1990)