EFFECTS OF BODY COMPOSITION, PRE- AND POSTPARTUM ENERGY LEVEL AND EARLY WEANING ON REPRODUCTIVE PERFORMANCE OF BEEF COWS AND PREWEANING CALF GAIN[1]

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ABSTRACT

Mature Charolais × Angus rotational cross cows were adjusted to moderate body condition by d 190 of gestation then randomly blocked to a maintenance (ME) or low-energy (LE) diet. At parturition, the 128 cows were randomly allotted within prepartum (PRP) diet to a high-energy (HE) or LE diet. At d 30 postpartum (PP), cows were randomly blocked to two treatments in which calves were weaned early (EW) or normally (NW) at 7 mo of age. Cows receiving a LE PRP diet had lighter calves at birth (34.7 vs 39.0 kg) and 105 d (127.9 vs 144.6 kg). Prepartum and PP energy interacted to affect postpartum anestrous interval (PPI, d) and cycling activity (%), respectively (LE-LE = 72.6, 33.3; LE-HE = 54.3, 56.3; ME-LE = 65.7, 52.9; ME-HE = 68.4, 54.3). High PP energy averaged over PRP diet increased ($P < .10$) pregnancy rate by 22.7% and 105-d calf weight by 15.1 kg. Early weaning reduced PPI by 24.3 d ($P < .01$) and first service conception rate by 21.7% ($P < .10$). Cycling activity within 60 d PP was affected ($P < .01$) by PRP diet and suckling status (LE-EW = 62.5, LE-NW = 26.7, ME-EW = 88.9, ME-NW = 13.3%). Thin cows had a longer PPI but had a higher first service conception rate than moderate and fleshy cows. Higher pregnancy rates were observed in cows approaching or maintaining average body condition from parturition to conception than for cows moving away from moderate body condition. Results suggest that fleshy and thin cows at parturition should be managed to approach moderate body condition before the breeding season to optimize reproductive performance and preweaning calf gain. (Key Words: Beef Cows, Energy, Early Weaning, Body Condition, Reproduction.)

J. Anim. Sci. 1990. 68:1438–1446

Introduction

Profitability in the beef cattle industry is influenced largely by the percentage of cows in the herd that consistently are able to maintain a 365-d calving interval (Lemenager and Martin, 1982). Interval from calving to first estrus and pregnancy rate in healthy beef cows mated to fertile bulls are influenced by prepartum nutrition (Whitman, 1975), postpartum nutrition (Wiltbank et al., 1962), body condition (Richards et al., 1986), suckling status of the cow (Moss et al., 1985) and dystocia (Laster et al., 1973). Duration of postpartum anestrus can be reduced by providing high-energy feedstuffs (Dziuk and Bellows, 1983) and maintaining cows in optimal body condition (Wiltbank et al., 1962; Whitman, 1975; Richards et al., 1986) during both gestation and early lactation.

Limited data exist that consider pre- and postpartum energy intake, body condition, suckling status and reproductive performance in an integrated system. The objective of this study was to investigate the combined effects of these factors on beef cow reproductive

[1]Journal Paper No. 11,619, Purdue Univ. Agric. Exp. Sta.

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Received April 7, 1988.

Accepted March 3, 1989.

TABLE 1. COMPOSITION[a] AND INTAKE OF PRE- AND POSTPARTUM EXPERIMENTAL DIETS

Ingredient	Prepartum LE[b]	Prepartum ME[b]	Postpartum LE[b]	Postpartum HE[b]
	%			
Shelled corn		45.5		49.0
Corn silage		39.1		42.2
Ground corn cobs	77.9	3.7	76.4	
Soybean meal, 49%	19.3	8.9	22.1	7.1
Dicalcium phosphate	2.3	1.5	.5	
Dyna-Mate[c]		.4		.4
Limestone		.4	.5	.9
Trace mineralized salt[d]	.5	.5	.4	.4
Magnesium oxide[e]			.1	
Intake, kg/d[f]	5.8	5.8	7.7	8.7
NE_m intake, Mcal/d[g]	7.4	10.6	10.1	16.9

[a]Percentage on a DM basis.

[b]LE = low energy (70% NRC); ME = maintenance energy (100% NRC); HE = high energy (130% NRC).

[c]18% K, 11% Mg, 22% S. Registered trademark of International Minerals and Chemical Corp., Terre Haute, IN.

[d]95% NaCl, .35% Zn, .28% Mg, .175% Fe, .035% Cu, .007% I, .007% Co.

[e]58% Mg.

[f]Average daily DM intake per cow.

[g]Average energy intake per cow.

performance and preweaning calf gain. Furthermore, an effort was made to identify the proper body composition necessary to minimize the postpartum anestrous interval (**PPI**), the days from calving until first ovulation, and optimize conception rate.

Materials and Methods

Cows were bred by natural service and were pregnancy-tested prior to the beginning of the study. All cows were managed similarly and maintained on orchardgrass (*Dactylis glomerata*), red (*Trifolium pratense*) and ladino clover (*Trifolium repense*) pasture and provided ad libitum access to a mixture of 50% dicalcium phosphate and 50% trace mineralized salt (Table 1). At mid-gestation, 160 mature Charolais × Angus rotational cross cows were assigned a pre-trial body condition score (**BCS**) on a scale ranging from 1 = very thin to 5 = very fat (Table 2).

All cows were equilibrated to BCS 3 between d 130 to 190 of gestation. When cows averaged 190 d of gestation, they were moved to 16 drylot pens (eight cows/pen) and initial cow weights were obtained. At this time, cows were assigned randomly within age, percentage Charolais, weight and pre-trial BCS groups to either a maintenance (**ME**) or low-energy (**LE**) diet to attain target BCS of either a 3 or 2, respectively, by parturition. At parturition, 128 cows were blocked randomly by calving date, within prepartum energy level, to either a LE or high-energy (**HE**) group to approach BCS of 1.5 or 2.5 (from a BCS 2) and 2.5 or 3.5 (from a BCS 3) by 30 d postpartum. Any cow that failed to produce a live calf or that experienced dystocia was removed from the study at parturition. On d 30 postpartum, cows were allotted randomly to either a slaughter group (n = 64) or a nonslaughter group (n = 64). Slaughtered cows were used for validation of body composition prediction methods (Houghton et al., 1990a) and for collection of reproductive tissue data. Cows not slaughtered were allotted randomly to either an early weaned (**EW**) group (n = 32), in which calves were removed and weighed at 30 ± 2 d of age, or a normally weaned (**NW**) group (n = 32), in which calves remained with the cows and were weaned at an average of 7 mo of age. Results reported herein relate to data collected from these cows.

All cows calved between February 15 and April 30. At parturition, calves were weighed, assigned a vigor score from 1 to 5 (1 = very weak, 3 = average and 5 = very vigorous) and moved with their dams to one of 16 drylot postpartum pens that were equipped with calf rest areas.

Cows were weighed and assigned a BCS prior to feeding at 0800 at 30-d intervals prior to calving and every 7 d thereafter. To maintain consistency, two scorers were used throughout the study and independently assigned a visual BCS to each cow. These two body condition scores, statistically similar (R^2 = .96; $P < .01$) between the two scorers, were averaged.

Diets were formulated to a constant level of protein, vitamins and minerals to meet NRC (1984) requirements and fed at nearly constant DM quantities within stage of production. Energy levels were set to force cows to maintain (ME = 100% NRC) or lose (LE = 70% NRC) weight during gestation and to gain (HE = 130% NRC) or lose (LE = 70% NRC) weight during lactation (Table 2). At 60 d postpartum, NW calves and all cows not slaughtered were weighed, moved to a large drylot location and group-fed an early lactation, maintenance diet (NRC, 1984). Sixty days postpartum was chosen because the average cow in a spring calving cow herd is exposed to the bull at approximately this time.

To help determine onset of estrus following parturition, blood samples were collected twice weekly for 60 d postpartum via jugular venipuncture for progesterone analysis. Radioimmunoassays (Mosley et al., 1979) were used to quantify progesterone with levels of ≥ 1 ng/ml used to identify cows that passed through the estrual phase of their cycle. Although estrus activity was recorded during the first 60 d postpartum, cows were not inseminated. Beginning at 60 d postpartum, and upon relocation into the larger drylot, cows were observed for a minimum of 30 min twice daily (dawn and dusk) for signs of estrus. In addition, penile-deviated, vasectomized bulls were allowed continuous contact with the cows. Upon estrus detection by visual detection or surgically altered bulls, cows were artificially inseminated (AI) at 12 ± 2 h after standing heat by one of two technicians using semen from a single bull. Cows were allowed 45 d to conceive before terminating the breeding season at 105 d postpartum. All cows and calves were weighed, and cows were assigned a BCS at the end of the breeding season and at normal weaning. Pregnancy status was determined by rectal palpation and calves were weaned at an average of 205 d postpartum. Conception dates were verified by calving dates.

Data were analyzed using the SAS (1982) least squares ANOVA. Classes included prepartum and postpartum diet, suckling status, pre-trial BCS, percentage Charolais and season. The two-way interaction between prepartum and postpartum energy levels and the three-way interaction between prepartum and postpartum energy level and suckling status

TABLE 2. BODY CONDITION SCORING (BCS) SYSTEM FOR BEEF CATTLE

Group	BCS[a]	Description
Thin condition	1	**EXTREMELY THIN** with severe muscle wasting may appear humped in the back with feet close together; usually weak; extremely prominent backbone, hooks, pins and ribs. Similar to condition scores 1 and 2 in the 9-point system.
	2	**THIN** with little or no wasting of muscle structure; vigorous; little or no fat in rump, rib or brisket; prominent backbone, hooks, pins and ribs but normal appearing muscle structure. Similar to condition score 3 in the 9-point system.
Moderate condition	3	**IDEAL CONDITION.** Thrifty with normal muscle structure; some evidence of fat deposited in the forerib, brisket and crops but limited around the tailhead; some smoothness over the shoulder, ribs, backbone, hooks and pins. Similar to condition score 5 in the 9-point system.
Fat condition	4	**FAT** but still firm; vigorous; considerable fat deposited over forerib; brisket protruding; tailhead full (bulging); very smooth over backbone with no skeleton visible except at hooks. Similar to condition score 7 in the 9-point system.
	5	**VERY FAT** with considerable softness; very fat over the forerib and shoulder; large, prominent brisket; broad flat topline; large patchy fat deposits around the tailhead; body curvature becomes square in appearance. Similar to condition scores 8 and 9 in the 9-point system.

[a]This system was expanded for more accuracy using a minus (–), average (O) and plus (+) for each BCS to represent slight deviations within the description of each condition score. For analysis purposes, $3^- = 2.67$, $3^O = 3.00$, $3^+ = 3.33$, for example.

TABLE 3. EFFECTS OF ENERGY INTAKE BY THE COW ON CALF WEIGHTS

	Prepartum wt, kg		Postpartum wt, kg	
Item	LE[a]	ME[a]	LE[a]	HE[a]
Birth	34.7 ± 1.2[b]	39.0 ± 1.4[c]		
60 d	102.9 ± 6.0	113.0 ± 6.9	100.8 ± 7.7[d]	115.1 ± 5.0[e]
105 d	127.9 ± 6.3[b]	144.6 ± 7.3[c]	128.7 ± 8.1[d]	143.8 ± 5.3[e]
205 d	205.5 ± 12.1	220.7 ± 13.9	207.7 ± 15.7	218.5 ± 10.1

[a]LE = low energy; ME = maintenance energy; HE = high energy.

[b,c]Means ± SE in the same row, within prepartum diet, with different letters in their superscripts differ ($P < .05$).

[d,e]Means ± SE in the same row, within postpartum diet, with different letters in their superscripts differ ($P < .05$).

also were evaluated. Cow age, days on prepartum diet and initial cow weight were included as covariates. Additional independent variables that were tested included BCS at parturition, ovulation and conception; change in BCS and cow weight 1) from parturition to breeding, 2) 30 d prior to breeding, 3) from parturition to ovulation and 4) 30 d prior to ovulation; whether cows were bred on the first, second or third postpartum estrus; and AI technician effects. Traits measured included calf weights at birth, 60, 105 and 205 d, calf vigor and subsequent health status, PPI, first service conception rate, pregnancy rate, estrual activity by 60 and 105 d postpartum, and the number of days cows remained open following parturition. Non-significant ($P > .10$) effects were placed in the error term; comparisons among main effects were made using Student's *t*-test (Steel and Torrie, 1980).

Results and Discussion

Dietary energy intake by the cow affected ($P < .05$) preweaning calf gain (Table 3). The interaction between prepartum and postpartum energy level was not significant for any measure of calf performance. Low energy intake prior to parturition resulted in lighter calves ($P < .05$) at birth and 105 d by 4.3 and 16.7 kg, respectively, compared with calves out of cows receiving a ME-prepartum diet. Although not significant, these calves also tended to be lighter at 60 and 205 d. These results are similar to those reported by Wiltbank et al. (1965), who cautioned that low energy intake by the cow during late gestation could have an adverse effect on both calf survival and performance.

Postpartum energy intake by the cow affected calf performance in a manner similar to prepartum energy. Cows that received a LE-postpartum diet had lighter calves ($P < .05$) at 60 and 105 d by 14.3 and 15.1 kg, respectively. Calves from cows fed the HE-postpartum diet tended to maintain a weight advantage through 205 d compared with calves nursing LE-postpartum cows. Similarly, Richards et al. (1986) reported that cows receiving LE diets during early lactation weaned lighter calves than cows receiving HE-postpartum diets.

When combined, prepartum and postpartum energy intake by the cow resulted in similar calf weaning weights when cows received

TABLE 4. EFFECTS OF PRE- AND POSTPARTUM ENERGY INTAKE ON CALF WEANING WEIGHT (205 DAYS) AND REPRODUCTIVE PERFORMANCE

	Pre- and postpartum energy combinations			
Item	LE-LE[a]	LE-HE[a]	ME-LE[a]	ME-HE[a]
205-d calf wt, kg	185.7 ± 13.4[b]	206.7 ± 12.0[bc]	201.9 ± 15.8[bc]	219.0 ± 12.3[c]
PPI[a], d	72.6 ± 5.8[b]	54.3 ± 4.2[c]	65.7 ± 4.4[b]	68.4 ± 5.5[b]
In estrus within 60 d, %	33.3 ± 10[b]	56.3 ± 10[c]	52.9 ± 11[bc]	54.3 ± 12[bc]

[a]LE-LE = low prepartum, low postpartum energy intake; LE-HE = low prepartum, high postpartum energy intake; ME-LE = maintenance prepartum, low postpartum energy intake; ME-HE = maintenance prepartum, high postpartum energy intake; PPI = postpartum interval.

[b,c]Means ± SE in the same row with a similar letter in their superscript do not differ ($P < .05$).

either ME-LE or LE-HE combinations (Table 4). Calf weaning weights were 33 kg lighter ($P < .05$), however, when cows received LE-LE compared with ME-HE combinations. Neither prepartum nor postpartum energy intake by the cow nor cow BCS had an effect ($P > .10$) on calf vigor at parturition or subsequent calf health.

Prepartum and postpartum energy intake interacted significantly to affect length of the PPI and the percentage of cows that expressed estrus within 60 d after calving (Table 4). Compared with other energy groups, the PPI was reduced ($P < .05$) by nearly 15 d in cows that received a LE-prepartum diet followed by a HE-prepartum diet. The LE-HE diet combination also allowed a higher percentage of cows to exhibit estrus by 60 d postpartum compared with cows fed the LE-LE combination. No interaction ($P > .10$) existed, however, between prepartum and postpartum energy for pregnancy rate. High postpartum energy intake resulted in an improved pregnancy rate (91.2 ± 8 vs 74.3 ± 9%; $P < .10$) compared with cows receiving a LE-postpartum diet.

Holloway et al. (1975), Davis et al. (1977), Dunn and Kaltenbach (1980) and Richards et al. (1986) also reported that increased postpartum energy intake and weight gain are essential for thin cows if they are to have an acceptable PPI and pregnancy rate. Wiltbank et al. (1962) found that when prepartum and postpartum energy levels were combined, the percentages of Hereford cows diagnosed pregnant were 95, 77, 95 and 20, respectively, for cows fed high-high, high-low, low-high and low-low energy levels. Wiltbank et al. (1965) later reported that when cows were provided high energy intakes after calving, and not inseminated or exposed to a bull for at least 60 d, fertility should be normal even though a low plane of nutrition was experienced prior to calving.

Cow BCS at parturition affected length of the PPI (Table 5) with thin cows (BCS < 3^-) exhibiting an extended PPI of over 80 d, which represents a postpartum anestrous interval 28 to 58 d longer ($P < .10$) than that exhibited by either moderately conditioned or fleshy cows (BCS ≥ 3^-). These data suggest that cows must be in moderate to nearly moderate body condition at parturition to maintain an acceptable PPI of 60 d or less. These findings agree with previous research conducted by Whitman (1975), Dunn and Kaltenbach (1980) and Richards et al. (1986), who observed increased estrual activity within 60 d postpartum when cows calved in good to moderate body condition (≥ 5 where 1 = emaciated and 9 = obese). Similarly, Graham (1982), using a 5-point BCS system, reported that cows with a BCS of 2.5 or greater at parturition exhibited a shorter PPI than cows with a BCS of 1.5 to 2.0.

Fleshy cows (BCS > 3^+) at parturition exhibited a shorter ($P < .10$) PPI than moderately conditioned or thin cows (Table 5). However, fleshy cows (BCS ≥ 3^+) at breeding had over a 29 percentage point reduction in first service conception rate ($P < .05$) compared with thinner cows (Table 6). It is important to realize, however, that first service conception rates observed in the moderately conditioned and thin cows were unusually high (≥ 80%), whereas those reported for the fleshy

TABLE 5. EFFECTS OF BODY CONDITION SCORE (BCS) AT PARTURITION ON POSTPARTUM INTERVAL (PPI)

BCS[a]	PPI, d
2^+	88.5 ± 10.9[b]
3^-	69.7 ± 12.8[c]
3^O	59.4 ± 8.3[c]
3^+	51.7 ± 9.8[c]
4^-	30.6 ± 14.3[d]

[a]Body condition scores are expanded using a minus (–), average (O) and plus (+). For analysis purposes, 3^- = 2.67, 3^O = 3.00, 3^+ = 3.33, for example.

[b,c,d]Means ± SE in the same column with different letters in their superscripts differ ($P < .10$).

TABLE 6. EFFECTS OF BODY CONDITION SCORE (BCS) AT BREEDING ON FIRST SERVICE CONCEPTION RATE

BCS[a]	First service conception rate, %
2^O	100 ± 13[b]
2^+	100 ± 12[b]
3^-	94 ± 9[b]
3^O	80 ± 8[bc]
3^+	70 ± 11[c]
4^-	67 ± 13[c]

[a]Body condition scores are expanded using a minus (–), average (O) and plus (+). For analysis purposes, 3^- = 2.67, 3^O = 3.00, 3^+ = 3.33, for example.

[b,c]Means ± SE in the same column with a similar letter in their superscript do not differ ($P < .05$).

TABLE 7. EFFECTS OF POSTPARTUM BODY CONDITION SCORE (BCS) CHANGE ON PREGNANCY RATE

BCS status[ab]	Pregnancy rate, %
≤ 3° and decreasing BCS	69 ± 10[d]
< 3° and increasing BCS	100 ± 9[c]
3^- to 3^+ and maintaining BCS	100 ± 8[c]
> 3° and decreasing BCS	94 ± 9[c]
≥ 3° and increasing BCS	75 ± 10[d]

[a]Body condition score at parturition combined with postpartum change in BCS.

[b]Body condition scores are expanded using a minus (–), average (O) and plus (+). For analysis purposes, $3^- = 2.67$, $3^O = 3.00$, $3^+ = 3.33$, for example.

[c,d]Means ± SE in the same column with different letters in their superscripts differ ($P < .05$).

cows were considered acceptable at 67 to 70%.

Cow BCS at parturition also combined with change in BCS prior to breeding to affect pregnancy rate (Table 7). Thin cows at calving that lost condition, and fat cows that gained condition, exhibited lower ($P < .05$) pregnancy rates compared with cows that maintained moderate condition or that moved toward moderate condition postpartum. These results suggest that cows must be fed to obtain nearly moderate body condition by breeding to obtain optimal pregnancy rates.

Other researchers have implicated excessive condition as a possible cause of infertility in cattle (Marshall and Peel, 1910; Quinlin, 1929) and sheep (Gunn et al., 1969). In contrast, Kilkenny (1978) reported that cows in poor body condition at breeding had lower conception rates and longer calving intervals compared with moderately and highly conditioned cows. Other researchers report no difference in pregnancy rate due to fatness (Pinney, 1962; Wiltbank et al., 1965; Graham, 1982). Several of these studies suggest that excessive condition may result from sterility, rather than vice versa.

Although fatter cows at parturition appear to exhibit a reduced PPI (Table 5), data from this study suggest that overconditioned cows at breeding may exhibit reduced pregnancy (Table 7) and first service conception rates. Because slightly thin to moderately conditioned cows (BCS = 3^- to 3^O) could be fed lower-quality feed (Lemenager et al., 1980), exhibit an acceptable PPI of approximately 60 d and have a higher pregnancy rate than overconditioned cows, it may be concluded that profit potential could be improved if overconditioned cows are avoided.

To further define the level of fatness or body reserve necessary for optimal reproductive efficiency, BCS must be related to actual lipid content of the carcass and(or) empty body. Several researchers have shown that BCS is relatively accurate in describing a cow's level of body reserve or energy content. Empty body fat (Dunn et al., 1983) and carcass fat (Wagner, 1984) were correlated highly (r = .86 and .91, respectively) to the 9-point BCS system. Similar data also were collected in this integrated study from the 64 cows that were identically managed and slaughtered at 30 d PP (Houghton et al., 1990a,b). Using BCS and cow weight, carcass lipid (r = .70; $P < .01$) and total empty body lipid (r = .74; $P < .01$) were estimated (Houghton et al., 1990a). Results suggest that cows maintained in moderate condition from precalving through breeding should possess no less than 15.8% carcass lipid or 13.3% total empty body lipid at parturition to obtain an acceptable PPI of approximately 60 d. However, additional data collected by Houghton et al. (1990a,b) suggest that cows can possess as little as 12.4% total empty body lipid at parturition and still obtain an acceptable PPI (< 60 d) and pregnancy rate (> 91.0%) if they were provided 130% of the 1984 NRC energy requirement for 60 d postpartum. These data further suggest that cows should not be allowed to exceed 20.0% carcass lipid or 17.8% total empty body lipid at breeding to optimize pregnancy rate.

These levels of body fat are lower than those reported by Bartle et al. (1984), who used urea dilution to determine cow body energy reserves. In that study, Hereford and Hereford × Angus cows with greater than 20% empty body fat were able to reach estrus by 60 d postpartum even when energy intake was below NRC requirements. Additionally, the PPI was reported in that study to decrease until cows reached 22% empty body fat. Differences between these two studies may be attributed partially to the techniques used to determine body composition, to the biological type of cows used and to the definition of total empty body composition. Houghton et al. (1990a) defined total empty body lipid as the amount of lipid present in the four major fat depots in the body, namely, the carcass, viscera, udder and liver. All other body parts were assumed to be nearly equal in composition across BCS

(Lemenager, unpublished data) and were not included.

Changes in body condition (ΔBCS) and body weight (ΔWT) during the postpartum period also were found to have an effect ($r = .60$; $P < .01$) on the number of days cows remained open following parturition. This relationship was described by the regression equation $Y = 78.62 + 11.54 (X_1) - .24 (X_2)$, where Y = days open, X_1 = ΔBCS and X_2 = ΔWT. Cows that lost a full BCS and 60 kg of body weight remained open for slightly more than 81 d, whereas cows that gained a full BCS and 60 kg of body weight remained open for an average of slightly over 75 d. These results may be biased, however, because cows were not exposed to breeding before 60 d postpartum. Few results are published that relate days open to postpartum ΔBCS and ΔWT, but researchers have reported the importance of rapid weight gain (rather than energy intake) during early lactation on improved pregnancy rates (Wiltbank et al., 1962; Dunn et al., 1969; Whitman, 1975; Dunn and Kaltenbach, 1980; Dziuk and Bellows, 1983; Hancock et al., 1984). In contrast, Oxenreider and Wagner (1971), Folman et al. (1973) and Butler et al (1981) reported that body weight changes, per se, were not highly related to ovarian function in early postpartum cows.

Change in prepartum weight and BCS did not influence ($P > .10$) subsequent reproductive performance in this study. In contrast, Dunn and Kaltenbach (1980) reported that prepartum weight change influenced subsequent reproductive performance for beef cows in moderate body condition at calving. They reported that 69 and 74% of cows in moderate body condition that gained weight prior to parturition had shown estrus by 60 d postpartum, compared to 51 and 48% for those that lost weight prior to parturition.

Another factor that influences reproductive performance of beef cows is suckling status of the cow. One of the first to describe the effect of suckling on the PPI was Clapp (1937), who found the average interval from calving to first estrus was 46 d for cows milked four times per day versus 72 d for cows suckling calves. Since then, several studies have verified that suckling can delay resumption of estrus by 24 to 54 d in the postpartum cow (Graves et al., 1968; Wiltbank, 1970; Short et al., 1972; England et al., 1973). Similar results were found in this study when cows with calves weaned at 30 d postpartum (EW) exhibited a 24-d reduction ($P < .01$) in lactational anestrus compared with NW cows (53.1 ± 3.6 vs 77.4 ± 3.5 d). Although EW reduced the PPI, it adversely affected ($P < .10$) first service conception rate (71.4 ± 11 vs 91.2 ± 10%) compared with NW when cows were exposed to breeding at 60 d postpartum. Pregnancy rate for the breeding season was not affected, however, by early weaning. This response is in contrast to research conducted by Laster (1975), who reported improved pregnancy rates of 26, 16 and 8 percentage points in 2- and 3-yr-old heifers and mature cows, respectively, when calves were weaned 8 d prior to the start of a 42-d breeding season. Similarly, Reeves et al. (1978) reported a slight advantage in pregnancy rate for cows subjected to a once-daily suckling management procedure compared with normally suckled cows.

In an effort to explain the 20 percentage point reduction in first service conception rate noted in the EW cows in this study, average breeding dates were compared between EW and NW groups. Statistical analysis indicated no difference between groups (78.7 vs 79.9 d postpartum). This was expected because individual cows were not inseminated prior to 60 d postpartum. An explanation for the reduction in first service conception rate observed in this study is unclear at this time, but the response was not highly significant ($P < .10$) and the first service conception rate observed in the NW cows was unusually high (91.2%).

An earlier study by Whitman (1975) indicated possible interactions between nutritional status, body condition of the cow and suckling. He reported that when energy intake is

TABLE 8. EFFECTS OF PREPARTUM ENERGY INTAKE AND EARLY WEANING ON EXHIBITION OF ESTRUS (%) WITHIN 60 DAYS POSTPARTUM

Prepartum diet	Suckling status	
	EW[a]	NW[a]
LE[b]	62.5 ± 12[c]	26.7 ± 12[d]
ME[b]	88.9 ± 12[c]	13.3 ± 11[d]

[a]EW = early weaned at 30 d postpartum; NW = normally weaned at 7 mo.

[b]LE = low energy; ME = maintenance energy.

[c,d]Means ± SE in the same row with different letters in their superscripts differ ($P < .01$).

marginal, suckling and subsequent nutritional stress of lactation may reduce the energy available for reproduction. An interaction between prepartum energy intake and suckling status of the cow also was evident in this study. When calves were EW at 30 d postpartum, estrual activity of cows was increased ($P < .01$) within 60 d postpartum compared with NW cows, with an additional advantage expressed by cows that received adequate prepartum energy (Table 8). Further support of this concept was provided by Wiltbank (1982), who suggested that calves probably need to be weaned from cows that are thin at calving before acceptable pregnancy rates can be obtained. Removing calves from cows at 30 to 45 d postpartum might be considered in some production systems to decrease the PPI and improve overall efficiency, even though it appears that first service conception rate may be reduced somewhat. An example might be when forage quality and(or) quantity are inadequate to support lactation and optimal calf performance. In this situation, it may be more efficient and economical to feed early weaned calves directly rather than providing cows expensive supplemental feed to support lactation.

In summary, this study and studies by Dunn and Kaltenbach (1980), Graham (1982) and Richards et al. (1986) suggest that cows should be grouped by BCS prior to calving and fed to attain moderate body condition by parturition. Care must be taken, however, not to overcondition cows (BCS > 3^+ or total empty body lipid > 17.8%) as they enter the breeding season because of a possible decrease in first service conception and pregnancy rates. Cows should be in moderate body condition (BCS = 3^o or total empty body lipid = 15%; Houghton et al., 1990a,b) by the beginning of the breeding season for optimal pregnancy rates. When cows are thin both at calving (total empty body lipid ≤ 12.4%) and prior to the breeding season, cows should be provided a HE diet following parturition to reduce PPI and improve pregnancy rate. These results further suggest that moderate use of low-quality forages during gestation may be possible without a detrimental effect on reproductive efficiency. This is true if cows are not allowed to become excessively thin (BCS < 2^+ to 3^- or total empty body lipid < 12.4%) prior to parturition and they are managed properly postpartum to obtain near moderate body condition (BCS = 3^o or 15.0% total empty body lipid) before the breeding season. Early weaning of calves also can be considered to improve reproductive efficiency of beef cows when feed supplies are inadequate to support lactation.

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