The effects of catch-up (compensatory) growth on reproductive performance of beef heifers

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Boadi, D. and Price, M. A. 1996. **The effects of catch-up (compensatory) growth on reproductive performance of beef heifers.** Can. J. Anim. Sci. **76**: 523–529. Fifty-four heifer calves were allocated to five feeding/weaning treatments at birth in April/May 1990: 1) VEW (n = 11) dams feed-restricted for 3 mo before and 2 mo after calving; calves weaned in June onto grain-supplemented pasture and then into a drylot in October; 2) EW1 (n = 10) dams not restricted; calves weaned in August (unsupplemented pasture) into drylot in October; 3) EW2 (n = 10) dams not feed-restricted; calves weaned directly into drylot in August; 4) LW1 (n = 12) dams feed restricted for 3 mo before, but not after calving; calves weaned directly into drylot in October; 5) LW2 (n = 11): dams not restricted; calves weaned directly into drylot in October. The very early (VEW) and early (EW1, EW2) weaned heifers grew significantly slower than the later-weaned ones (LW1, LW2) from birth to September, and were still significantly lighter at 12–13 mo of age (May 1991). Recovery of liveweight-for-age was achieved by EW2 heifers by 18 mo and VEW and EW1 by about 23 mo of age. Early weaning treatments delayed age but not weight at first estrus ($P < 0.05$) yet the number of heifers conceiving and calving, and all associated reproductive data, including rebreeding success were unaffected by treatment ($P > 0.05$). Despite a delay in first estrus, reproductive efficiency and calving performance were not impaired by early feed restriction in heifers conceiving at 15 mo of age.

Key words: Beef heifers, feed restriction, fertility, reproduction, catch-up growth

Boadi, D. et Price, M. A. 1996. **Effets de la croissance compensatoire sur les performances de reproduction des génisses d'élevage de boucherie.** Can. J. Anim. Sci. **76**: 523–529. Cinquante-quatre génisses ont été réparties dès la naissance en avril-mai 1990 entre cinq régimes d'alimentation-sevrage, soit 1, STP (sevrage très précoce) n = 11, mères rationnées 3 mois avant et 2 mois après le vêlage, veaux sevrés en juin, mis au pâturage avec complément de grain, puis en parc d'élevage en octobre; 2, SP1 (n = 10), mères non rationnées sevrage en août et mise à l'herbe sans complément, puis en parc d'élevage en octobre; 3. SP2 (n = 10), mères non rationnées, sevrage en août et passage immédiat en parc; 4. ST1 (sevrage tardif n = 12), mères rationnées 3 mois avant le vêlage, sevrage en octobre et mise immédiate en parc; 5. ST2 (n = 11), mères non rationnées, sevrage en octobre et mise immédiate en parc. Les génisses en sevrage très précoce (STP) et précoce (SP1 et SP2) profitaient significativement plus lentement que celles sevrées tard (ST1 et ST2) jusqu'en septembre et demeuraient plus légères aux alentours de 12 à 13 mois (mai 1991). Les génisses avaient rattrapé le poids normal dans le traitement SP2 et vers l'âge de 23 mois environ dans les traitements STP et SP1. Le sevrage précoce retardait l'âge à la puberté ($P < 0,05$), sans toutefois abaisser le poids des animaux. Et pourtant, le nombre de génisses pleines arrivant au vêlage et tous les paramètres de reproduction associés, y compris la remise à la reproduction étaient sensiblement les mêmes ($P > 0,05$) dans tous les traitements. Malgré un certain retard de la puberté, l'efficience de reproduction et les performances de vêlage ne se ressentaient pas du rationnement en début de croissance chez les génisses fécondées à l'âge de 15 mois.

Mots clés: Génisses d'élevage de boucherie, rationnement, fertilité, reproduction, croissance compensatoire

Catch-up growth is a self-correcting response restoring a previously underweight animal to its genetically determined growth channel (Ashworth and Milliard 1986; Carstens et al. 1988; Drouillard et al. 1991). Catch-up may not occur, however, if hyperplasia is compromised because feed restriction occurs too early in life, is too severe or is main-

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Abbreviations: EW1, dams not restricted; calves weaned in August (unsupplemented pasture) into drylot in October; **EW2**, dams not feed-restricted; calves weaned directly into drylot in August; **LW1**, dams feed restricted for 3 mo before, but not after calving; calves weaned directly into drylot in October; **LW2**, dams not restricted; calves weaned directly into drylot in October; **VEW**, dams feed-restricted for 3 mo before and 2 mo after calving; calves weaned in June onto grain-supplemented pasture and then into a drylot in October tained for too long (Maynard et al. 1979). Most studies of this phenomenon in cattle have concentrated on postweaning growth of steers or bulls (Fox et al. 1972; Baker et al. 1985; Wright et al. 1987). Apart from the work of Yambayamba and Price (1991), there has been little reported work on feed restriction in heifers with respect to reproductive performance.

Little information is available on the long-term effects of feed restriction in early life (preweaning) on subsequent growth and reproductive performance particularly in heifers. Overfeeding of prepubertal heifers by producers, ostensibly to avoid stunting and to ensure early puberty, is common, but may lead to other problems, including reduced longevity and impaired milking ability (Pinney et al. 1972). Information on the ability of heifers to recover from restricted prepubertal feeding would enable producers to reduce feed cost (Morrison et al. 1989) without jeopardizing the reproductive potential of their replacement heifers.

The present study was undertaken to establish the pattern and degree of compensation in beef heifers subjected to various periods of prepubertal feed restriction, and to investigate the longer-term effects of the feed restriction on reproductive performance.

MATERIAL AND METHODS

Animals and Feeding Treatments

This study used 54 heifer calves born in an experiment described by Boadi and Price (1996). They were allocated at birth (April/May, 1990) to five feeding/weaning treatments, and suckled their dams on native range until weaning. The treatments in presumed decreasing order of nutritional severity, were:

VEW (n = 11): The dams were relatively underfed for about 3 mo before (54.7 MJ DE d^{-1}) and 2 mo after (99.6 MJ DE d^{-1}) calving (Boadi and Price 1996; Table 1); the calves were weaned at about 2 mo of age (21 June) onto range with access to a supplementary diet of alfalfa/brome hay (7.24 kg animal^{-1} d^{-1}), rolled oats (7.44 kg animal^{-1} d^{-1}) and a proprietary dairy calf starter (2.02 kg animal^{-1} d^{-1} of CO-OP® calf starter – Product No. 51102; Federated Cooperative Ltd, Saskatoon, SK). They were moved at about 6 mo of age (October) into a drylot.

EW1 (n = 10): The dams were fed grain and roughage (153 MJ DE d^{-1}) on winter (frozen, snow covered) range before calving; after calving they continued to receive the supplement (109.5 MJ DE d^{-1}) while grazing increasingly nutritious alfalfa, brome, fescue spring pasture (Boadi and Price 1996; Table 1). The supplement was discontinued at the end of May. The calves were weaned at about 4 mo of age (August) onto native range and then at about 6 mo of age (October) moved into the drylot.

EW2 (n = 10): The dams were fed as EW1 dams; the calves were weaned at about 4 mo of age (August) directly into drylot.

LW1 (n = 12): The dams were fed as VEW dams (54.7 MJ DE d^{-1}) before calving, and as EW1 and EW2 dams (109.5 MJ DE d^{-1}) after calving; the calves were weaned directly into drylot at about 6 mo of age (October).

LW2 (n = 11): The dams were fed as EW1 dams; the calves were weaned directly into drylot at about 6 mo of age.

In the drylot the 54 heifer calves were fed as a single group in a 42.7 × 35.9 m pen after October. They received ad libitum alfalfa/brome hay for 10 d, when they first entered the drylot and then they were fed at a rate of 2.3 kg head^{-1} d^{-1} rolled barley and 2.3 kg head^{-1} d^{-1} alfalfa/brome hay; water, trace-mineralized salt and straw bedding were provided freely. The heifers were weighed and moved out of drylot at about 13 mo of age (23 May 1991) to graze alfalfa (*Medigo sativa*), brome (*Bromus* spp.) and fescue (*Festuca* spp.) range. They were exposed to three bulls as a single breeding group for 58 d starting 18 June 1991. The heifers were condition-scored for fatness when they were about 18 mo of age (11 October) using a five-point subjective system (Lowman et al. 1973) where 0 = emaciated and 5 = grossly fat. Heifers were moved to a new area at the onset of calving (20 March 1992). Within 24 h after birth, calves were identified and weighed, and the dams were also weighed, body condition scored and their udders were scored (1 = small ideal teats, 2 = ideal teats, 3 = large teats, 4 = very large (bottle) teats, 5 = pendulous udder). Ease of calving was scored on a scale of 0 to 5 (0 = no assistance, 1 = slight assistance, 2 = a puller used easily, 3 = a puller used with difficulty, 4 = veterinarian required, and 5 = Caesarean birth). Neonatal mortality (stillbirths and death within 24 h after birth) was also recorded. Heifers, with the exception of those which had not calved or had calving ease scores of 3 or greater and udder scores of 4 or greater, were weighed and bred as a single group to two bulls on 20 June 1992 (second breeding) for a 58-d breeding season. Liveweight and condition scores of heifers, as well as liveweights of their calves were recorded periodically until weaning on 17 October 1992, when the 2-yr-old heifers were pregnancy tested by rectal palpation. Subsequent calving data (rebreeding performance) of the heifers were recorded as described previously.

Reproductive Status

From 17 January 1991 to 3 June 1991, blood samples were taken twice weekly from each heifer by jugular venipuncture into 10 mL heparinized vacutainers (Becton Dickinson, Franklin Lakes, NJ; 143 USP units of sodium heparin) and assayed for plasma progesterone (P_4) to determine age at first estrus. Samples were centrifuged at 2500 rpm for 15 min at 4°C 1 h after collection and the plasma was pipetted into sterile vials and stored at –20°C for later radioimmunoassay. The age at first estrus was defined as the first day that plasma P_4 concentration exceeded 1 ng mL^{-1} and remained elevated ≥4 ng mL^{-1} for at least 7 d, which was taken to indicate the presence of a functional corpus luteum. Blood sampling ceased on 3 June to allow heifers a period

Table 1. Composition of feed as fed to dams (kg animal^{-1} d^{-1})

	EW1, EW2 and LW2 Dams[z]		LW1 Dams[z]		VEW Dams[z]	
	Precalving[y]	Postcalving[y]	Precalving[y]	Postcalving[y]	Precalving[y]	Postcalving[y]
Ingredient						
Barley grain (kg)	1.90	3.20	2.91	3.20	2.91	3.26
Alfalfa/brome hay (kg)	10.70	6.00	0.96	6.00	0.96	4.62
Green feed (oats) (kg)	1.42	–	–	–	–	–
Calculated analysis[x]						
Dry matter (kg)	12.5	8.2	3.4	8.2	3.4	7.0
Digestible energy (MJ)	153.5	109.5	54.7	109.5	54.7	99.6

[z]See text for description of treatments.
[y]Precalving: 26 January to 3 April; Postcalving: 4 April to 22 May for EW1, EW2, LW1 and LW2 dams and 4 April to 20 June for VEW dams.
[x]Calculations based on table values (National Research Council 1984).

of rest prior to breeding which began 18 June; 21 heifers had not begun cycling by that date. Liveweights at first estrus were estimated by linear interpolation between the nearest weights taken before and after the date of first estrus (Ferrell 1982).

Similarly, pregnancy was assessed from plasma P_4 concentrations in blood samples collected twice weekly between 17 September 1991 and 11 October 1991. The criterion used for pregnancy determination was that P_4 concentration should be ≥4 ng mL^{-1} and remain so throughout the sampling period. Heifers with P_4 concentrations lower than 1 ng mL^{-1} at any stage in the sampling period were recorded as non-pregnant. Pregnancy was also checked manually by rectal palpation on 11 October 1991.

Hormone Assays

Plasma samples were assayed for P_4 by a double antibody radioimmunoassay (Rawlings et al. 1980). After thawing in water at about 40 to 50°C, 200, 100, and 50 µL of plasma in duplicates were extracted with 4 mL of petroleum ether for 5 min, and the extracts assayed using an anti-serum raised in rabbit against 4-pregnene-11x-o1-3, 20-dione hemisuccinate, and goat anti-rabbit gamma-globulins as the second antibody. Within assay extraction efficiency was used to correct the progesterone concentrations determined for each sample. The mean recovery of titrated P_4 across assays was 72 ± 10.1% (mean ± SEM n = 10). Standard curves ranged from 0.003313 to 1.6 ng tube^{-1}. Sensitivity of the assays (defined as mean of B maximum dose –((2 × SD of B max. dose) × mean of B maximum dose^{-1}) was 91.3 ± 4.1% (mean ± SEM n = 10) equivalent to 0.97 ng tube^{-1}. The intra- and inter-assay coefficients of variation were 5.76 and 10.54%, respectively.

Statistical Analyses

Liveweights, daily gains, body condition scores, age and weight at first estrus were subjected to least squares analysis of variance using the General Linear Model (Type III) procedure (SAS Institute, Inc. 1989) to study the effects of preweaning feed restriction. The model used was:

$$Y_{ij} = \mu + T_i + E_j(_i)$$

where Y_{ij} = trait under consideration; µ = overall mean; T_i = treatment groups with (i = 1... 5) and $E_j(_i)$ = the error term.

For statistical analysis, 3 June was recorded as the date of first estrus for the 21 heifers that had not cycled prior to this date, provided they calved before 4 April, i.e. within one estrous cycle (21 d) plus one gestation length (approximately 285 d).

For the effects of early feed restriction on reproductive performance, the calving and weaning data were analyzed by least square analyses of variance using GLM in SAS in the model:

$$Y_{ijk} = \mu + T_i + S_j + TS_{ij} + E_k\,(_{ij})$$

where Y_{ijk} = trait under consideration; µ = overall mean; T_i = treatment with (i = 1... 5); S_i = sex of calf with (j = 1, 2); TS_{ij} = treatment × sex of calf interaction and $E_k\,(_{ij})$ = error term. Differences among means were tested for significance by paired t-test comparisons for unequal treatment groups (Steel and Torrie 1980). Chi-square at P = 0.05 was used to test percentage data (heifers cycling, pregnant, calf mortality and assisted births) (Steel and Torrie 1980).

RESULTS

Growth of Heifer Calves

There were no significant treatment effects on birthweight or birthdate (Table 2). By June when they were weaned, the VEW heifers were significantly lighter than those in the other four treatment groups. This difference persisted through to August when the next two groups (EW1 and EW2) were weaned, but by late September the VEW heifers had caught up to the recently weaned EW1 and EW2 heifers in liveweight. By September the two later-weaned groups (LW1 and LW2) were significantly heavier than the three early-weaned groups (Table 2). These treatment differences persisted throughout the drylot period and were still apparent when the heifers left the drylot the following May.

Before the start of breeding at about 14 mo of age (12 June 1991) the VEW heifers were significantly lighter than the early-weaned heifers (EW1 and EW2) which in turn were significantly lighter than the late-weaned (LW1 and LW2) heifers. These liveweight differences were still apparent in the fall (October 1991) when the heifers were pregnancy checked. By the middle of winter (26 February 1992), there were no longer any significant treatment differences in liveweight among the heifers, most of which were in an

Table 2. Least squares means ± SE of liveweights and gains of heifer calves

Trait	Treatment groups					P
	VEW[z]	EW1[z]	EW2[z]	LW1[z]	LW2[z]	
No. of heifers	11	10	10	12	11	
Birthdate[y]	110.0 ± 4.1	107.4 ± 4.3	118.5 ± 4.3	108.1 ± 3.9	113.0 ± 4.1	0.34
Liveweights, kg						
Birth (1990 April/May)	35.5 ± 1.5	32.8 ± 1.6	34.4 ± 1.7	32.9 ± 1.9	36.6 ± 1.5	0.33
1990 19 June	76.6 ± 4.9*b*	84.5 ± 5.1*ab*	76.6 ± 5.1*b*	95.8 ± 4.7*a*	90.5 ± 4.9*a*	0.02
1990 21 August	129.4 ± 5.2*c*	153.7 ± 5.5*b*	154.0 ± 5.5*b*	170.9 ± 5.0*a*	161.4 ± 5.2*ab*	0.001
1990 24 Sept.	165.7 ± 5.7*b*	167.5 ± 5.9*b*	173.3 ± 5.9*b*	204.6 ± 5.5*a*	197.5 ± 5.7*a*	0.001
1990 13 Nov.	181.2 ± 6.5*b*	184.1 ± 6.7*b*	184.5 ± 6.7*b*	225.3 ± 6.1*a*	216.8 ± 6.4*a*	0.001
1991 23 May	246.5 ± 7.3*b*	255.5 ± 7.9*b*	259.0 ± 7.9*b*	285.1 ± 7.2*a*	286.2 ± 7.5*a*	0.007
1991 12 June[x]	254.6 ± 8.1*c*	276.3 ± 8.5*b*	280.1 ± 8.5*b*	302.5 ± 7.7*a*	304.4 ± 8.1*a*	0.003
1991 11 Oct.[w]	349.7 ± 10.6*b*	368.0 ± 11.6*b*	372.1 ± 12.2*ab*	400.5 ± 10.6*a*	397.4 ± 11.1*a*	0.03
1992 26 Feb	405.1 ± 12.3	403.4 ± 13.9	421.3 ± 13.9	415.8 ± 12.3	436.5 ± 11.5	0.29
Condition scores						
1991 11 Oct.	2.5 ± 0.1	2.6 ± 0.1	2.4 ± 0.1	2.7 ± 0.1	2.7 ± 0.1	0.34
1992 26 Feb.	2.9 ± 0.1	3.0 ± 0.1	3.1 ± 0.1	2.9 ± 0.1	2.9 ± 0.1	0.62

[z]For description see text.
[y]Day of the year (day 1 = 1 January).
[x]Breeding weight.
[w]Pregnancy testing weight.
a–c, Means within rows followed by a different letters differ significantly at $P < 0.05$.

advanced state of pregnancy. No treatment effects on body condition score (fatness) was detected in either the fall or the winter (Table 2).

Reproductive Performance

By 3 June 1991, when blood sampling ended, 23 of the 54 heifers had begun cycling (Table 3) ranging from a high of 9 out of 12 and 7 out of 11 in the LW1 and LW2 groups, to a low of 1 out of 11 and 2 out of 10 in the VEW and EW1 groups respectively. There was a significant treatment effect on the number of cycles prior to June 3; the two later-weaned groups experiencing significantly more cycles than the three early-weaned groups. Early weaning and feed restriction of their dams did not affect weight at first estrus of heifers, but the VEW, EW1, and EW2 heifers were older ($P < 0.05$) at first estrus than the later-weaned heifers (Table 3).

Interestingly, treatment had no effect on pregnancy rate, (83% at pregnancy checking in the fall), number of calves born (80%), or their birth dates or birth weights. Neither did it significantly affect dams' weight, condition or udder scores at calving, number of assisted births or neonatal mortality (Table 3), although almost half of the VEW heifers required some assistance at calving. One calf in the LW2 group and one in the VEW group died neonatally.

There were no effects of treatment on the number of calves weaned (as a proportion of the heifers exposed to bulls the previous summer), the birth to weaning rate of gain or weaning weights of their calves (Table 4). At the start of the second breeding period (20 June 1992) liveweights and condition scores of the 37 heifers which had given birth without difficulty were not affected by treatment ($P > 0.05$; Table 4). Neither were there any treatment differences ($P > 0.05$) in the proportion of heifers pregnant or their liveweights or condition scores when they were pregnancy checked at about 29 mo of age (17 October 1992). There were no incidents of dystocia during the second calving period, nor were there any significant treatment differences in dams' liveweight, condition or udder scores, nor calving dates or calf birth weights.

DISCUSSION

The absence of catch-up growth exhibited by the very early (VEW) and early-weaned (EW1 and EW2) heifers during the 1990 summer agrees with the general observation in studies on younger animals (Berge et al. 1991; Osoro and Wright 1991). Morgan (1972) found that during refeeding, the liveweight gains of calves reared from birth to 16 wk on a low plane of nutrition were at no time higher than that of continuously well-fed calves, while calves underfed from 16 to 32 wk expressed some degree of catch-up during refeeding. Wright et al. (1987) suggested that animals have the ability to compensate only if feed restriction is applied at a stage when the potential exists for an appreciable quantity of fat to be deposited.

Growth of the heifer calves through their first summer indicated that restricting their dams for 3 mo before calving did not in itself reduce lactation, but that continuing the restriction after calving did. The cows were in condition score 3.5 when the restriction began in January 1990 and 2.5 when they calved in April/May (Boadi and Price 1996). These fat levels presumably provided an energy buffer until calving, but were not sufficient to buffer the VEW dams, which continued to be restricted after calving. By 13 November, when the five groups of heifers were together in the drylot, the liveweights of the VEW heifers had caught up to the early-weaned (EW1 and EW2) heifers, but these three early-weaned groups had not caught up to the later-weaned groups (Table 2). During the course of the next 6 mo in the drylot, there was no indication of catch-up growth by the early-weaned groups relative to the later-weaned groups. This was expected because feed was restricted and therefore competitive and it would be anticipated that the heavier,

Table 3. Least squares means ± SE of reproductive performance of heifers

Trait	Treatment groups[z] VEW	EW1	EW2	LW1	LW2	P
No. of heifers	11	10	10	12	11	
% cycling by 3 June	9.1	40	20	75	63.6	0.06
No. cycles to 3 June	0.2 ± 0.4*b*	0.6 ± 0.4*b*	0.7 ± 0.4*b*	2.1 ± 0.4*a*	1.1 ± 0.4*a*	0.007
Age at 1st estrus (d)	426.3 ± 6.5*c*	407.8 ± 5.0*b*	412.7 ± 6.5*bc*	388.8 ± 3.9*a*	397.0 ± 4.2*a*	0.005
Wt. at 1st estrus (kg)	269.1 ± 13.4	269 ± 10.3	294.3 ± 13.4	279.6 ± 8.2	290.9 ± 8.7	0.38
% pregnant on 11 Oct.	82	80	80	75	100	0.56
% of calves born[y]	82	70	70	75	100	0.33
Calving date[x]	103 ± 3.8	98.3 ± 4.0	99.6 ± 4.5	100.3 ± 3.8	100.3 ± 3.3	0.94
Calf birth wt. (kg)	33.3 ± 1.4	31.8 ± 1.5	32.3 ± 1.6	33.3 ± 1.4	34.8 ± 1.2	0.57
Dam wt. (kg)[w]	379.4 ± 13.6	377.8 ± 14.6	409.3 ± 16.0	389.0 ± 13.6	411.3 ± 11.6	0.25
Dam condition score[w]	2.2 ± 0.1	2.1 ± 0.1	2.3 ± 0.2	2.3 ± 0.1	2.3 ± 0.1	0.86
Udder score	1.9 ± 0.3	1.5 ± 0.3	2.0 ± 0.3	1.5 ± 0.3	2.0 ± 0.3	0.53
Calf mortality (%)	11.1	0.0	0.0	0.0	9.1	0.65
Assisted births (%)	44.4	14.3	0.0	0.0	18.2	0.08

[z]For description see text.
[y]Proportion of calves born per cow exposed to the bull.
[x]Day of the year (day 1 = 1 January).
[w]Calving weight and condition score (0 = emaciated to 5 = grossly fat) of heifers 24 h postcalving.
a–c Means within a row followed by different letters differ significantly at $P < 0.05$.

Table 4. Least squares means ± SE of weaning performance of calves and rebreeding of heifers

Trait	Treatment groups[z] VEW	EW1	EW2	LW1	LW2	P
Number of dams bred	11	10	10	12	11	
Calves						
% weaned	73	70	70	75	91	0.77
Weaning wt., kg	199.0 ± 8.3	212.4 ± 8.9	206.5 ± 9.7	202.5 ± 8.3	205.0 ± 7.4	0.85
Rates of gain[y] (kg d^{-1})	0.88 ± 0.04	0.94 ± 0.04	0.91 ± 0.04	0.89 ± 0.04	0.90 ± 0.03	0.84
Rebreeding heifers (1992 20 June)						
Number exposed	8	6	6	9	8	
Liveweight (kg)	409.4 ± 12.1	395.5 ± 14.0	434.8 ± 14.8	407.7 ± 12.1	428.3 ± 12.1	0.27
Condition score	2.5 ± 0.2	2.4 ± 0.2	2.5 ± 0.2	2.5 ± 0.2	2.5 ± 0.2	0.64
% pregnant[x]	100	100	100	89	100	0.76
Liveweight (kg)	430.8 ± 13.1	422.3 ± 15.1	475.4 ± 15.9	447 ± 12.9	461.1 ± 13.1	0.10
Condition score	3.1 ± 0.2	2.8 ± 0.2	3.1 ± 0.2	3.0 ± 0.2	3.1 ± 0.2	0.81
Number calving	8	6	6	8	8	
Calving date[w]	102.4 ± 7.2	119.8 ± 9.1	113.8 ± 9.1	119.3 ± 7.2	115.0 ± 7.	0.49
Calf birth wt. (kg)	36.9 ± 1.6	33.4 ± 2.1	34.0 ± 2.1	33.3 ± 1.6	37.4 ± 1.6	0.29
Dam weight (kg)	476.5 ± 10.8	463.8 ± 10.8	488.3 ± 11.5	471.0 ± 13.6	483.4 ± 13.6	0.58
Dam condn score	2.5 ± 0.1	2.7 ± 0.1	2.4 ± 0.1	2.4 ± 0.1	2.4 ± 0.1	0.49
Udder score	2.1 ± 0.3	1.7 ± 0.3	2.0 ± 0.3	2.0 ± 0.3	1.8 ± 0.3	0.70

[z]For description see text.
[y]Birth to 1992, 17 October.
[x]Pregnancy tested on 1992, 17 October.
[w]Day of the year (day 1 = 1January).

later-weaned heifers would maintain their advantage in a competitive feeding situation.

During the summer of 1991, the heifers had access to adequate good-quality range grazing, and the early-weaned groups were able to demonstrate catch-up growth. By the following February, when they were weighed prior to the beginning of calving, there were no significant treatment effects on liveweight.

Early weaning the heifer calves delayed age at first estrus, and reduced the number of heifers which had cycled by 3 June 1991. Despite the relatively small number of heifers used in each group, the results of this study agree with the general findings of increased age at puberty following reduced feed intake (Morrison et al. 1989). Puberty is generally acknowledged to be more weight than age dependent in cattle (Joubert 1963; Newman and Deland 1991) and this was confirmed here, since there were no significant treatment differences in weight at first estrus.

Interestingly, despite the large treatment differences in the number of heifers which had cycled prior to the beginning of breeding, there was no significant treatment effect on the number that became pregnant. It is not clear whether this is a result of the bull effect (Joubert 1963), or the spring flush of pasture. Joubert (1963) noted that once estrus was initiated by favorable nutritional conditions, there should be little difficulty in getting the heifer in calf.

The absence of any effect of preweaning feed restriction on calving performance could be expected, as all heifer groups had similar mean liveweights and condition scores prior to calving. Makarechian et al. (1988) also found no significant differences in the percent calf crop born, birth weight, and birth dates of calves born to either early-weaned or late-weaned heifers. Fleck et al. (1980), however, reported a significantly lower calf birth weight and higher incidence of dystocia in heifers with low first winter gains. The similarity of calving dates among the treatments shows that, although more of the later-weaned heifers were observed to be cycling prior to the beginning of breeding, they do not appear to have conceived any earlier than the early-weaned groups. Neither did treatment significantly influence calf mortality or the incidence of calving difficulty.

Richardson et al. (1978) reported that early-weaned heifers had a lower perinatal calf mortality compared with late-weaned heifers; there was no detectable trend towards this in the present study. Makarechian et al. (1988) reported no significant differences in the incidence of calving difficulty between early-weaned (30%) and late-weaned (29.8%) heifers. Overall there was no significant treatment effect on the ability of heifers to successfully wean a calf of acceptable liveweight. These findings agree with those of Richardson et al. (1978) and Makarechian et al. (1988). The successful rebreeding performance indicates that the early postnatal nutritional regimen of the heifers in this study had no detrimental effects on their long-term reproductive efficiency.

CONCLUSION

Although the number of heifers used was small, it can be concluded that the variety of calfhood nutritional regimens applied in this study had no permanent effects on growth or reproductive performance of these heifer calves. They were able to exhibit catch-up growth when given an opportunity to do so. Early weaning of calves allows cows to increase their body condition score prior to winter. It is clear that under the conditions of this study, early weaning of heifer calves did not compromise their reproductive potential. Other research has shown that early-weaned males calves can achieve normal slaughter weight and grade at a normal age. Therefore producers who do not sell calves at weaning may be well advised to consider earlier weaning in their herds.

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