Feed efficiency in once-calved and conventional systems of heifer beef production

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[1]*Agriculture Canada, Research Station, Lacombe, Alberta, Canada T0C 1S0; and* [2]*Department of Animal Science, University of Alberta, Edmonton, Alberta, Canada T6G 2P5.* *Contribution No. 729, received 16 September 1992, accepted 14 July 1993.*

Newman, J. A., Jones, S. D. M., Price, M. A. and Vincent, B. C. 1993. **Feed efficiency in once-calved and conventional systems of heifer beef production.** Can. J. Anim. Sci. **73**: 915–930. A total of 120 crossbred heifers (initial weight = 270 ± 3 kg) were used in a project to evaluate a once-calved-heifer system of beef production. They were reared on a cereal silage–grain diet and, beginning at an average age of 385 d, exposed during a 6-wk breeding period to bulls of breeds chosen for calving ease. Ninety-six heifers reared calves to weaning. The calves were weaned and the heifers were slaughtered 3, 5 or 7 mo after calving, and the feed conversion efficiency of these treatment groups was compared with that of a similar group of 32 heifers slaughtered at 457 d of age after a conventional feeding program. Feed conversion calculations included the combined cow–calf unit for heifers that had reared a calf and were based on weaning-day and end-of-test (27 Sept.) endpoints. During the post-calving period, the late-weaned cow–calf units tended to be more efficient to the point of weaning, but the early-weaned ones were significantly more efficient if the calf's performance from weaning to the end of test was considered. From the start of test to the weaning endpoint, conventionally reared heifers were significantly more efficient than early-weaned once-calved heifers on many of the bases studied. To the end-of-test endpoint, however, they did not differ significantly (e.g., 411.4±20.5, vs. 402.1±29.0, 441.0±29.0 and 460.2±29.0 MJ DE kg^{-1} lean product weight for conventionally reared vs. 3-, 5- and 7-mo-weaned once-calved heifers). These results suggest that animals in a once-calved-heifer system of beef production can utilize digestible energy as efficiently as those in a conventional system if conception failure and calf losses can be controlled.

Key words: Beef production, heifers once-calved, feed efficiency

Newman, J. A., Jones, S. D. M., Price, M. A. et Vincent, B. C. 1993. **Valorisation des aliments dans un système de production de génisses de boucherie abattues après un vêlage comparé au système classique de production.** Can. J. Anim. Sci. **73**: 915–930. Cent-vingts génisses croisées d'un poids initial de 270 ± 3 kg étaient utilisées dans une expérience évaluant le système de production de génisses de boucherie après un vêlage. Le régime alimentaire était fait d'ensilage de céréales immatures et de grain. À partir d'un âge moyen de 385 j, elles étaient exposées, pendant une période de mise à la reproduction de six semaines, à des taureaux de races choisies pour la facilité de vêlage. Quatre-vingt-seize génisses élevaient leurs veaux jusqu'au sevrage. Le sevrage des veaux et l'abattage subséquent des génisses se faisaient à 3, 5 ou 7 mois après le vêlage, puis on comparait l'indice de consommation de ces génisses à celui d'un groupe semblable de 32 génisses abattues à l'âge de 457 j au terme d'un programme d'engraissement classique. L'indice de consommation, calculé jusqu'au jour du vêlage et jusqu'à la fin de l'essai (27 sept.), englobait les paires vache-veau pour les génisses qui élevaient un veau. Durant la période post-vêlage, les paires vache-veau à sevrage tardif valorisait moins bien les aliments jusqu'au sevrage, alors que chez les paires en sevrage plus précoce, l'indice de consommation était significativement meilleur lorsqu'il tenait compte des performances du veau, du sevrage à la fin de l'essai. Du début du test au sevrage, les génisses en élevage classique valorisaient significativement mieux les aliments que les génisses abattues après un vêlage, et cela sur plusieurs des paramètres considérés. Toutefois, calculées du début à la fin du test, les valeurs n'étaient pas significatives (c.-à-d. respectivement, 411,4±20,5, 402,1±29,0, 441,0±29,0 et 460,2±29,0 MJ ED par kg de viande maigre pour les génisses en élevage classique et les génisses abattues 3, 5 et 7 mois après le vêlage). Il ressort de ces résultats que faire élever un veau par les génisses avant de les abattre est un moyen aussi efficace de valoriser l'énergie digestible que le système de production classique, pour autant qu'on puisse régler les problèmes de non-conception et de mortalité des veaux.

Mots clés: Production des bovins de boucherie, génisses primipares, valorisation des aliments

Beef cattle in Canada and most other industrialized countries typically reach market weight at an age of 12–24 mo, depending upon the production system used. Heifer calves grow more slowly than bull and steer calves (Berg and Butterfield 1976) and have lighter carcasses at the same carcass fatness (Berg et al. 1979). In conventional beef production systems heifers are generally considered less efficient than steers or bulls in the conversion of feed energy to live weight or muscle gain. An alternative method of rearing heifers for beef production would be a once-calved system, in which the heifer is slaughtered after producing a calf. Although this system would increase slaughter age, it would also reduce the size of the conventional breeding herd because the slaughter heifers would produce part of the calf crop. Thus, a once-calved system might make more efficient use of feed energy than the conventional feedlot heifer system. Few studies have attempted to evaluate the overall feed conversion efficiency of a once-calved system. Instead, investigators have tended to examine separate segments of it, and overall efficiency has been calculated from simulated data (Boucqué et al. 1980; Brethour 1987).

A once-calved-heifer system in Canada would require that the heifer reach market condition while still in the youthful carcass grade category (i.e., by about 30 mo of age). Therefore, they would have to calve by about 2 yr of age, when the risk of calving difficulty is high (Laster et al. 1973). Since high levels of calving difficulty are unacceptable, the heifers would be bred to bulls of easy-calving breeds (Red Angus and Corriente in this study).

The objective of this study was to measure the feed conversion efficiency of once-calved-heifer beef production systems in which the calves were weaned at approximately 3, 5 and 7 mo and to compare these results with the efficiency realized by comparable heifer calves in a conventional feedlot production system. Consumption of dry matter, digestible energy and protein is presented. The carcasses were dissected (Vincent et al. 1991); for analyses conducted across feeding periods, the product is expressed in terms of lean (tissue) weight as well as live weight and carcass weight. However, a comprehensive economic analysis, which would have to address many additional issues, will not be attempted in this paper.

MATERIALS AND METHODS

Acronyms and Abbreviations

Several non-standard acronyms and abbreviations used in this paper are listed and defined below:

	Treatment labels
OTW	On-test weight — heifers were penned by OTW quartile (1 = lightest to 4 = heaviest) in the rearing period
OCH	Once-calved-heifer system of beef production
CONV	Conventional heifer (calf) feedlot system of beef production
PBRIT	Proportion of British ancestry — low (7/16 to 9/16) vs. high (9/16 to 14/16)
BLBRD	Bull breed — Red Angus vs. Corriente
WNAGE	Weaning age of calf — approximately 3, 5, or 7 mo
CLVTM	Calving time within the calving season — early vs. late
	Trait labels
DMAD	Dry matter consumed per animal day (where applicable, heifer and calf were considered a single animal unit) (kg)
ADG	Average daily gain per heifer or heifer-calf unit (kg)

DMEFF	Dry matter consumed per unit of gain (kg kg^{-1})
DEEFF	Digestible energy consumed per unit of gain (MJ kg^{-1})
PREFF	Protein consumed per unit of gain (kg kg^{-1})

Animals and Management

ONCE-CALVED HEIFERS. One hundred and twenty crossbred heifer calves ranging from 7/16 to 14/16 British breed composition and containing mainly Hereford, Angus, Red Angus, Charolais and Simmental breeding were selected for this study. Their average birth date was 14 Apr. They were weaned at an average age (±SEM) of 171±2 d, at which time their average body weight was 205±3 kg. Seventy-seven days after weaning, when they weighed an average of 270±3 kg, the experiment began. The heifers were divided into three uniform treatment groups of 40, designated OCH 3 mo, OCH 5 mo and OCH 7 mo (i.e., calves to be weaned at 3, 5 and 7 mo of age respectively, with heifers to be slaughtered on the day following weaning). Heifers were fed diets consisting of silage (grass or cereal), a barley concentrate and (or) an energy–mineral supplement that was fed throughout the breeding season (Table 1). The diets were fed to appetite, and their energy density was adjusted to promote growth and development without excessive fat deposition. Details of diet composition and daily feed intake are provided in Table 2.

Heifers were single-sire mated in pen groups to either Red Angus or Corriente sires (two pens mated to each breed per treatment). The breeding season lasted from 4 May to 15 June. The heifers were pregnancy tested approximately 90 d after the bulls were withdrawn, and the non-pregnant heifers from all groups were moved to a separate pen. The open heifers were fed silage for 21 d, and then a combination of silage (70% as fed) and barley

Table 1. The ingredients and nutrient composition of feeds used in the experiment

Ingredients (g kg^{-1})		Nutrient composition (%)	
Barley concentrate			
Rolled barley (No. 1 feed)	732.5	Dry matter[z] (g 100 g^{-1})	88.0
Rolled oats (No. 1 feed)	150.0	Crude protein[z] (g 100 g^{-1})	11.9
32% protein supplement, not more than 16% from non-protein sources	50.0	Est. DE (MJ kg^{-1})[y]	14.6
Dried molasses beet pulp	50.0		
Ca–P supplement (27-13 or equiv.)	2.5		
Ground limestone	10.0		
Salt (cobalt iodized)	4.25		
ADE vitamin supplement[x]	0.75		
Energy–mineral breeding supplement (pelleted)			
Barley	877.0	Dry matter (g 100 g^{-1})	88.0
$CaPO_4$	62.5	Crude protein (g 100 g^{-1})	13.1
MgO	41.0	Est. DE (MJ kg^{-1})	13.0
Binding agent	12.5		
Salt (cobalt iodized)	5.0		
Trace-mineral mix	1.0		
Selenium	1.0		
Silage, cereal or forage			
		Dry matter (g 100 g^{-1})	29.0
		Crude protein (g 100 g^{-1})	10.4
		Acid det. fiber[z] (g 100 g^{-1})	36.8
		Est. DE (MJ kg^{-1})	10.9

[z]Dry matter, crude protein and acid detergent fiber values are based on monthly analyses by the Alberta Soil and Feed Testing Laboratory. Crude protein and fiber are reported on a dry matter basis.
[y]Digestible energy estimated from published values — average Alberta values for comparable silages (Agdex 1986); values from Ensminger and Olentine (1978) for other feed components.
[x]IU kg^{-1} = 10 000 000 vitamin A; 1 000 000 Vitamin D; 10 000 vitamin E.

Table 2. Diet composition and daily feed (dry matter) intake throughout the experiment, by feeding group and period[z]

	On test to breeding	Breeding	End breeding to 6 wk pre-calving	6 wk pre-calving to end calving	End calving to 3-mo weaning[y]	End calving to 5-mo weaning	End calving to 7-mo weaning
Once-calved heifers, periods as indicated							
Duration (d)	134	47	187	95	47	102	158
Diet components ($g\ 100\ g^{-1}$)							
Silage	63.8	69.1	96.4	72.2	25.7	58.0	94.2
Barley concentrate	36.2	—	—	27.8	74.3	42.0	5.8
Breeding supplement	—	30.9	3.6	—	—	—	—
Daily feed intake ($kg\ d^{-1}$)	6.0	7.1	7.9	7.8	15.7	15.3	13.5
Open heifers, after pregnancy test							
Duration (d)	21	53	47				
Diet components ($g\ 100\ g^{-1}$)							
Silage	100.0	53.7	34.0				
Barley concentrate	—	46.3	66.0				
Daily intake ($kg\ d^{-1}$)	6.5	10.0	9.0				
Heifers that lost calves, after completion of the calving period							
Duration (d)	60						
Diet components ($g\ 100\ g^{-1}$)							
Silage	39.7						
Barley concentrate	60.3						
Daily intake ($kg\ d^{-1}$)	17.3						
Conventionally reared heifers, beginning at an average age of 8 mo							
Duration (d)	39	195					
Diet components ($g\ 100\ g^{-1}$)							
Silage	61.5	34.0					
Barley concentrate	38.5	66.0					
Daily intake ($kg\ d^{-1}$)	3.9	7.6					

[z]Column headings apply only to the once-calved-heifer category.
[y]To average weaning date for 3-, 5- and 7-mo weaning.

concentrate was fed for a further 100 d. The pregnant heifers were fed silage ad libitum until 6 wk prior to the beginning of the calving period, at which time 11% barley concentrate (as fed) was added.

CONVENTIONALLY REARED HEIFERS. A CONV comparison group was established for slaughter in the same season as the OCH heifers. Since the conventionally finished heifers attained slaughter condition at least a year sooner than the OCH group, they had to be drawn from a group of calves that were born a year later and did not match the OCH heifers exactly in breed composition or weaning age. The CONV group contained 32 heifer calves all sired by Red Angus bulls. Sixteen had Hereford × Angus dams, and 16 had Charolais dams. These calves had an average birth date of 17 Mar. They were weaned at an average age of 197±4 d when their average body weight was 207±4 kg. Forty-two days after weaning, at an average body weight of 231±6 kg, these heifers were weighed on test. They were assigned by random selection to one of two pens per breed of dam and fed a diet consisting of silage and barley concentrate as described in Table 2.

CALVING AND POST-CALVING MANAGEMENT. Calving lasted from 7 Feb. to 28 Mar. During this period the heifers were confined in pens with access to roofed shelters and were fed a diet consisting of 89% silage and 11% barley concentrate (as fed). Calves were permanently identified as soon as possible after calving.

Following calving the proportion of barley concentrate was increased to 50% (as fed) for 50 d then decreased to 10% for the remainder of the trial. From birth to the end of the test on 27 Sept. calves had access to a commercial pelleted creep feed (18.7% crude protein), which was included in the feed consumption record.

Heifers that lost their calves at or shortly after parturition were divided into two lost-calf pen groups and fed a diet consisting of 35% barley concentrate (as fed). They were slaughtered in pen groups when it was estimated by ultrasonic measurement (Aloka Echo Camera, model SSD-210DXII, Aloka Co., Ltd., Mitaka-shi, Tokyo 181, Japan) that they had an average of 8 mm of back fat over the grading site. This is the average rib fat depth of commercial carcasses and was therefore considered an appropriate endpoint for these heifers.

WEANING AND SLAUGHTER. Within each OCH treatment group, the heifers were processed in two drafts 1 wk apart. The slaughter date was an average of 86±7, 135±8 and 192±8 d after calving for the 3-, 5- and 7-mo groups, respectively. The CONV cattle were slaughtered at an average age of 461 d, after 222 d on a feedlot regime. Beginning at 08:00 on the morning preceding the slaughter day, the designated heifers and their calves were weighed, and ultrasonic fat depth measurements were made on the heifers. The calves were then returned to their pens, and the heifers were held in separate pens without access to feed or water until 16:00, when they were transported to the abattoir. Slaughter took place on the following day after approximately 24 h without access to feed.

Body Components and Carcass Dissection

All animals were stunned by captive bolt and weighed before (slaughter weight) and after exsanguination, which was performed by severing the major blood vessels in the neck. Blood weight was calculated by subtracting the post-exsanguination weight from the slaughter weight. Body components were weighed as they were removed. These consisted of the body organs (kidneys, liver, heart, spleen, pancreas, lungs and trachea), the body fat depots (kidney, mesenteric and omental), the external body components (hide, tail, feet, udder, head and tongue), the alimentary tract tissues (small intestine, large intestine, rumen, reticulum, omasum and abomasum) and the remaining body components (bladder, reproductive tract, diaphragm, adrenal glands and blood). The alimentary tract tissues were weighed empty of digesta. Empty body weight was calculated as the sum of all the body components excluding the digesta and urine.

All carcasses were weighed warm before being shrouded and cooled. At 24 h post-slaughter the shrouds were removed, and the left sides were fabricated into eight commercial wholesale cuts (chuk, rib, shank, plate, brisket, round, long loin and flank). The long loin comprised the short loin and sirloin butt. The weight of lean in each wholesale cut was determined after removal of all fat and bone. Lean content of the carcass was calculated as twice the lean weight of the left side.

To estimate gains in carcass weight and lean-tissue weight it was necessary to obtain data for the body composition of a weaned calf that could serve as an estimate of the initial composition of the OCH group and the final composition of their calves.

The data used were mean values for a contemporary group of thirty 7- to 8-mo-old calves that included equal numbers of Hereford, Angus, and Hereford × Angus crossbreds. Although not of exactly the same breeding or age distribution as the project calves, this group was considered as providing an acceptable estimate of calf carcass composition because genetic variation in carcass composition is relatively small in cattle this young (Berg and Butterfield, 1976) and because the carcass data were derived in the same facility with the same methodology as used for the project cattle. The resulting data for calf composition were as follows: warm carcass weight = 51.3 g 100 g^{-1} and lean- tissue weight = 30.7 g 100 g^{-1}, both expressed as a proportion of live weight (J. L. Aalhus and S. D. M. Jones, unpubl.).

Feed Intake Record and Feed Analyses

Feed consumption was recorded daily for each pen throughout the trial. Samples of the feeds used were collected at approximately monthly intervals for analysis by the Alberta Animal Nutrition Laboratory, and the results were used to estimate the heifers' dry matter and crude protein consumption. The digestible energy content of silage was estimated from the laboratory's acid detergent fiber analyses, using the formula developed by the Alberta Ruminant Feed Evaluation Unit (Mathison et al. 1984). For concentrate feed ingredients, digestible energy content was estimated from NRC values (National Research Council, 1984). Weighted trial average feed composition was used in calculating the heifers' overall nutrient consumption. By this method, minor variation between silage pits could have caused the difference between CONV and OCH heifers' energy consumption to be underestimated by up to 1%, but this was considered inconsequential because differences of the order of 20% are generally required for statistical significance.

Penning Plan and Regrouping

Initially, the heifers were each allocated to one of 12 pen groups, but pen groups were revised before breeding and during the calving period, thus creating the four periods described below during which pen groups were stable:

1) THE REARING PERIOD — a 134-d period extending from the initial (on-test) weighing to the pre-breeding weighing. The heifers were penned in three replicate sets of four pens allocated according to OTW by quartiles, with stratification between pens. Thus, the four quartiles of the OTW distribution constituted the only treatment effect in the data set during this period.

2) THE BREEDING AND GESTATION PERIOD — a 234-d period extending from the pre-breeding weighing to the pre-calving weighing. During this period the heifers were penned in three replicate sets of four pens to which they had been allocated according to PBRIT (low vs. high) and BLBRD (Red Angus × Corriente).

3) THE LATE GESTATION AND CALVING PERIOD — a 105-d period during which the calves were born. As they calved, the heifers were moved into the post-calving penning pattern (described below). The reallocation to pens was carried out within PBRIT and replicate, so these were the only effects that could be evaluated for this period.

4) THE POST-CALVING PERIOD — a 183-d period from the post-calving weighing to end of test (27 Sept.). During this period the heifers and (or) their calves were penned in two replicate sets of 12 pens to which they had been allocated according to WNAGE (3, 5 or 7 mo), CLVTM (early vs. late) and PBRIT (low vs. high). To the extent possible, pen groups were balanced for breed of sire and sex of calf during this period. The heifers were withdrawn for slaughter at approximately 3, 5 or 7 mo after calving, but the calves remained in their post-calving pens until the end of test.

The CONV heifers were born, weaned and placed on test 1 yr later than the OCH group but were slaughtered contemporaneously with them in the summer of 1988. During their entire feeding period these heifers were penned in two replicate sets of two pens allocated by PBRIT (1/2 or 1).

Animal Care Standard

The Lacombe Research Station is certified by the Canadian Council on Animal Care, and this research was conducted in full compliance with the Council's Animal Care Guidelines.

Analysis of Data

The general linear model of the Statistical Analysis System Institute, Inc. (1989) was used to analyze the data; and, where the *F*-test indicated $P < 0.10$, mean separation was carried out using the PDIFF option. The analyses were conducted in the following three formats: (1) separate within-period analyses; (2) across-period analysis from the beginning of the test to weaning–slaughter of the heifers; and (3) across-period analysis from the beginning of the test to end of test (27 Sept.). Across-period analyses included the conventionally managed heifer group and evaluated feed conversion efficiency on a carcass and lean yield as well as a live-weight basis.

WITHIN PERIOD. Because the experiment plan varied among periods, the analytical model varied also. For the rearing period, OTW quartile was the only effect; for the gestation period, the model included PBRIT, BLBRD and their interaction; for the calving period, the model included only the PBRIT effect; and for the post-calving period, the model included PBRIT, WNAGE, CLVTM and their two-way interactions. The post-calving period data were analyzed using two endpoints: the weaning endpoint at which the WNAGE treatments differed in calf age; and the end-of-test endpoint at which the treatments had the same average calf age but differed in the time elapsed since weaning. Although there were a few significant interactions (Table 3), their significance was marginal, or they did not result in a re-ranking of treatment means. So these interactions have been ignored in the presentation and discussion of the results.

ACROSS PERIODS. Since the OCH were penned by OTW quartile (not PBRIT) during the rearing period, the data could not be analyzed across period without a credible estimate of rearing-period feed consumption for the PBRIT pen groupings that were constituted in subsequent periods. Such an estimate was obtained by allocating to each heifer a pro-rata share of the feed consumed by her rearing pen group. The method assumes that each heifer consumed the same quantity of feed as her pen mates — an assumption considered acceptable because the live-weight range within these pen groups was narrow.

Across-period analyses could be conducted only with WNAGE as the main effect and PBRIT pen groups used as replications within WNAGE. This approach is questionable for the end-of-test endpoint because in that case (only) PBRIT means differed significantly, but since the primary impact of this deviation from good statistical practice is to render the significance tests more conservative, and since the differences between the results for weaning and end-of-test endpoints are of interest, this analysis is nonetheless presented.

HEIFERS THAT FAILED TO CONCEIVE OR WEAN A CALF. Initially, across-period analyses to the weaning and the end-of-test endpoints were conducted excluding data for OCH that failed to wean a calf. This provides results for the ideal situation in which every heifer entering the program rears

Table 3. The significance level of treatment main effects and interactions presented by feeding period for a once-calved-heifer production system[z]

Period[y]	Trait	OTW	PBRIT	BLBRD	PBRIT × BLBRD	WNAGE	CLVTM	WNAGE × PBRIT	WNAGE × CLVTM	PBRIT × CLVTM
GRO	DMAD	0.0001								
	ADG	NS								
	DEEFF	0.042								
BRD	DMAD		NS	NS	NS					
	ADG		NS	0.062	NS					
	DEEFF		NS	0.084	NS					
CLV	DMAD		NS							
	ADG		NS							
	DEEFF		NS							
PTC 1	DMAD		NS			0.007	NS	0.049	NS	NS
	ADG		NS			NS	NS	NS	0.066	NS
	DEEFF		NS			NS	0.066	NS	0.048	NS
PTC 2	DEEFF		0.029			0.0001	NS	0.068	0.016	NS

[z]Trait and treatment abbreviations as defined in the text.
[y]Period definitions: GRO, rearing; BRD, breeding and gestation; CLV, calving; PTC 1, post-calving to weaning endpoint; PTC, 2, post-calving to end-of-test endpoint.
NS, not significant at $P > 0.10$.

a calf, and it permits treatment comparisons that are not confused by an apparently random incidence of failure to conceive or rear the calf. But because the impact of these losses is also of interest, a second across-period analysis was conducted, this one dealing with feed efficiency to the end-of-test endpoint after adjusting the data for each pen to the overall incidence of open heifers and calf losses. This method required the assumption that WNAGE treatments did not influence conception or survival rates, which is likely because all affected heifers were removed from their original pen groups before the WNAGE treatments were applied.

Open heifers were fed in a single pen, and heifers that lost calves were fed in two pens allocated according to PBRIT. Thus, standard errors were not computed for their performance means or for the across-period means in which their data were incorporated.

RESULTS AND DISCUSSION

Results by Period

SIGNIFICANCE OF EFFECTS. The significance levels of effects analyzed within period are presented in Table 3 for DMAD, ADG and DEEFF. Of the interactions evaluated, only the WNAGE × CLVTM interaction for the post-calving period to end of test achieved unequivocal significance ($P = 0.016$). However, since this interaction did not involve re-ranking of WNAGE treatment means and since no WNAGE treatment mean changed significantly between early and late CLVTM, this interaction was deemed to be spurious, so only the main effect results are reported. There were other interactions that achieved marginal significance (e.g., $P = 0.048$). In these cases, the interaction arose from the presence of one or two aberrant pen-group means rather than from any rational pattern of re-ranking, so these interactions also have been disregarded.

Because the post-calving period analysis to end of test involved variable periods during which only the calf was on test, the DMAD and ADG traits were not considered comparable, and only efficiency traits were analyzed.

THE REARING PERIOD. For the 134-d rearing period, the OCH were divided into four quartiles based on pre-test body weight. Individual dry matter consumption ranged from 5.54 to 6.63 kg d^{-1}, with the heavier pen groups tending to consume more feed ($P < 0.0001$, Table 4). However, the rearing treatments did not differ in ADG, which averaged 0.72–0.78 kg d^{-1}. As a result, the lighter pen groups demonstrated superior efficiency of live-weight gain ($P = 0.043$). DMEFF varied from 7.11 to 9.28 kg kg^{-1}; DEEFF ranged from 87.0 to 113.6 MJ kg^{-1}, and PREFF ranged from 0.78 to 1.02 kg kg^{-1}, with the lightest quartile differing significantly from the heaviest for all three traits. This result is consistent with expectation. Since the least efficient pen groups were the heaviest, their inferior efficiency was probably a consequence of a higher maintenance requirement and perhaps more fat deposition.

THE GESTATION PERIOD. For the 234-d gestation period, the OCH were penned by PBRIT and BLBRD. Neither effect was a significant source of variation (Table 3). PBRIT treatment means (Table 4) show that, in general, dry matter consumption remained at a level only very slightly higher than that recorded in the rearing period (DMAD = 6.73 kg d^{-1}), ADG dropped to about 0.38 kg d^{-1}, and efficiency deteriorated markedly (DEEFF = 201.8 MJ kg^{-1}).

THE CALVING PERIOD. During the 105-d calving period OCH with calves sired by Red Angus and Corriente bulls were reallocated within replicate to new pen groups, balanced to the extent possible for BLBRD and calf sex, but differing in CLVTM (early vs. late) to reduce the age spread of calves within a pen. As a result of pen reallocation, feed data can be analyzed only for the effects of PBRIT represented in three replicates. Beginning with the calving period, the total feed consumption, body weight and weight gains of the calves were included in the pen totals.

PBRIT did not significantly affect DMAD, ADG or DEEFF ($P > 0.2$, Table 3). Overall, DMAD increased to about 8.2 kg as a result of increased energy allocation after

Table 4. Least-squares means for dry matter consumption, daily gain and feed efficiency by period for a once-calved-heifer production system[z]

Period[y]	Treatment		Days	DMAD[z] (kg)	ADG (kg)	DMEFF (kg kg^{-1})	DEEFF (MJ kg^{-1})	PREFF (kg kg^{-1})
GRO	OTW	1[z]	134	5.54*a*	0.78	7.11*a*	87.0*a*	0.778*a*
		2		6.15*b*	0.76	8.05*ab*	98.5*ab*	0.880*ab*
		3		5.94*b*	0.75	7.96*ab*	97.4*ab*	0.871*ab*
		4		6.63*c*	0.72	9.28*b*	113.6*b*	1.020*b*
		SEM		0.084	0.043	0.42	5.2	0.047
		$P\leq$		0.0001	NS	0.043	0.043	0.043
BRD	PBRIT	Low	234	6.76	0.36	18.53	206.3	1.979
		High		6.70	0.39	17.72	197.4	1.895
		SEM		0.092	0.017	0.78	8.7	0.084
		$P\leq$		NS	NS	NS	NS	NS
CLV	PBRIT	Low	105	8.15	0.87	9.39	111.7	1.014
		High		8.23	0.78	10.51	125.0	1.136
		SEM		0.259	0.051	0.609	7.22	0.065
		$P\leq$		NS	NS	NS	NS	NS
PTC 1	WNAGE	7 mo	158	13.4*a*	1.71	7.83	100.5	0.904
		5 mo	102	14.7*b*	1.84	8.01	105.3	0.919
		3 mo	46	14.9*b*	1.89	8.10	110.6	0.937
		SEM		0.31	0.085	0.275	3.71	0.032
		$P\leq$		0.007	NS	NS	NS	NS
PTC 2	PBRIT	Low	183	NA	NA	6.29*a*	88.6*a*	0.827*a*
		High		NA	NA	7.02*b*	92.8*b*	0.866*b*
		SEM				0.095	1.23	0.011
		$P\leq$				0.027	0.029	0.026
	WNAGE	7 mo	183	NA	NA	7.78*a*	100.0*a*	0.908*a*
		5 mo		NA	NA	7.04*b*	93.5*b*	0.865*b*
		3 mo		NA	NA	5.74*c*	78.7*c*	0.765*c*
		SEM				0.116	1.51	0.014
		$P\leq$				0.0001	0.0001	0.0001

[z]Trait and treatment abbreviations as defined in the text.
[y]Period definitions: GRO, rearing; BRD, breeding and gestation; CLV, calving; PTC 1, post-calving to weaning endpoint; PTC 2, post-calving to end-of-test endpoint.
a–c Means not followed by the same letter differ significantly ($P < 0.05$).
NS, not significant at $P > 0.10$.
NA, not applicable.

the beginning of the last trimester of pregnancy. ADG increased to about 0.75 kg d^{-1} (based on cow and calf weight gain), and DEEFF improved to about 118 MJ kg^{-1} (Table 4). It is likely that the improved efficiency resulted primarily from the increased level of energy consumption, but the inherent efficiency of calf growth was also beginning to influence the results at this stage.

THE POST-CALVING PERIOD. Results for the post-calving period were analyzed in two ways. The period began on 5 Apr., after all heifers had calved, and in the weaning endpoint analysis, it ended with the weaning–slaughter of the heifers at approximately 3, 5 or 7 mo post-calving. For this analysis, the length of the period averaged 45.5, 101.6 and 157.4 d for the three treatment groups. The end-of-test endpoint analysis covered a 183-d period that included the performance of the heifers to weaning–slaughter and the performance of the calves to a fixed date (27 Sept.) in their birth year. Since this brought the calves to a life stage very similar to that at which their dams began the project 2 yr earlier, it provides a more complete assessment of the efficiency achieved through the full cycle of an OCH production system.

The penning pattern permitted analysis of the effects of PBRIT, WNAGE and CLVTM. The analysis included all two-way interactions (Table 3), but the marginally significant interactions detected were discounted as explained above.

POST-CALVING PERIOD TO THE WEANING ENDPOINT. Of the main effects, only DMAD was significantly affected by WNAGE in the weaning endpoint analysis. The 3- and 5-mo WNAGE treatments consumed more dry matter per day than the 7-mo treatments (14.9 or 14.7 vs. 13.4 kg d^{-1}, Table 4). This effect could be a result of declining cow appetite as milk production decreased, the weather got warmer and the cows deposited more body fat. These factors would have had a greater impact on the 7-mo weaning–slaughter treatment group, which was slaughtered in September than the 3-mo treatment group, which was slaughtered in May. Reduction in dry matter consumption by cows was only partially offset by increased feed consumption by calves as WNAGE increased. Neither PBRIT nor CLVTM affected daily feed consumption significantly ($P > 0.6$).

To the weaning endpoint, total (cow and calf) ADG ranged from 1.71 for the 7-mo treatment to 1.89 kg d^{-1} for the 3-mo one (Table 4). The differences between treatment means were not significant, but it must be noted that this uniformity was achieved only because increasing calf ADG of 0.67, 0.99 and 1.44 kg d^{-1} tended to offset decreasing cow ADG of 1.04, 0.85 and 0.45 kg d^{-1} in the 3-, 5- and 7-mo WNAGE treatments.

DEEFF to the weaning endpoint was not affected significantly by any of the main effects. However, there was a trend toward greater efficiency for the late-weaned treatments (100.5 vs. 110.6 MJ kg^{-1} for 7- vs. 3-mo weaning, Table 4). Since feed composition did not differ much among treatments prior to weaning, the same trend was apparent in DMEFF and PREFF.

POST-CALVING PERIOD TO THE END-OF-TEST ENDPOINT. In this analysis WNAGE treatments did not differ in the length of the feeding period but did vary in the proportion of the feeding period that contained feed consumption and gain for the calf only (i.e., the proportion following slaughter of the cow). Thus, mean daily feed consumption and gain data across the entire period could not be compared directly, and only measures of efficiency were included in the end-of-test endpoint analysis. The analysis showed that within this period the lower PBRIT heifers were significantly more efficient on a dry matter, digestible energy or crude protein basis (e.g., 88.6 vs. 92.8 MJ kg^{-1} DEEFF, $P = 0.029$, Table 4). The effect of WNAGE treatments was highly significant ($P <$ 0.0001). DEEFF improved from 100.0 MJ kg^{-1} for 7-mo weaning to 78.7 MJ kg^{-1} for 3-mo weaning, and DMEFF and PREFF also improved as WNAGE decreased to 3 mo (Table 4). This trend, however, was opposite to that for the same trait calculated to the weaning endpoint only.

Across-period analyses

To move closer to commercial relevance, the data were anlyzed across periods with the addition of data for the CONV treatment group of heifers reared and finished as long yearlings and slaughtered in the same season as the three OCH groups. This analysis was confined to efficiency traits expressed on a live-weight, a dressed carcass-weight and a lean-weight basis.

BODY COMPONENT YIELDS. Treatment groups exhibited some significant differences in body component yields. CONV heifers had a higher proportion of body fat depots (kidney, mesenteric and omental) than 3-, 5- and 7-mo weaned OCH (75.4 vs. 61.8, 67.5 and 66.7 g kg^{-1}) and a lower proportion of alimentary tract tissues (57.9 vs. 62.8, 60.8 and 60.3 g kg^{-1}, Table 5).

There was no difference in the proportion of warm carcass weight to empty body weight among the three OCH groups. However, the OCH 5-mo group had a significantly higher proportion of carcass weight relative to empty body weight than the CONV heifer group. Other studies have found the dressing percentage of OCH to be lower than for yearling heifers (Lalande et al. 1981; Roux et al. 1987). The heifers that failed to rear a calf had the highest proportion of carcass weight relative to empty body weight. Other studies (Lalande et al. 1981; Bond et al. 1986; Roux et al. 1987; Waggoner et al. 1988) have reached similar conclusions.

EFFICIENCY TO THE WEANING ENDPOINT. Results are presented in Table 6 for the

Table 5. Least-squares means ± SEM for slaughter weight and proportions of body components at slaughter of once-calved and conventionally reared heifers

			OCH[x]		
	CONV[z]	No calf[y]	3 mo	5 mo	7 mo
Slaughter weight (kg)	397.0±8.7*a*	489.0±11.6*bc*	479.0±8.7*b*	517.0±8.6*c*	503.0±8.8*bc*
Body components (g kg^{-1})[w]					
Warm carcass	639.9±2.6*a*	664.1±3.5*c*	643.6±2.6*ab*	647.6±2.6*b*	645.7±2.6*ab*
Depot fat	75.4±2.2*a*	58.4±3.0*b*	61.8±2.2*bc*	67.5±2.2*c*	66.7±2.2*c*
Alimentary tract	57.9±0.7*a*	58.1±1.0*ab*	62.8±0.7*c*	60.8±0.7*b*	60.3±0.7*b*
Internal organs	37.8±0.5*ab*	38.5±0.7*a*	40.9±0.5*c*	38.5±0.5*a*	36.5±0.6*b*
External components	139.8±1.8	139.0±2.4	141.6±1.8	137.1±1.8	144.3±1.9
Residual[v]	45.8±1.8	36.3±3.4	45.1±2.9	46.5±1.7	45.0±2.0

[z]Conventionally reared slaughter heifers.
[y]Heifers from a once-calved rearing system that failed to rear a calf.
[x]Once-calved heifers that nursed calves for 3, 5 or 7 mo.
[w]Expressed as a proportion of empty body weight (excludes digesta and urine).
[v]Reproductive tract, diaphragm, adrenal glands, blood and bladder (empty).
a–c Means not followed by the same letter differ significantly ($P < 0.05$).

Table 6. Least-squares means ± SEM for feed conversion efficiency across periods to the weaning endpoint for conventionally finished heifers and once-calved-heifer/calf pairs weaned at 3, 5 and 7 mo[z]

		OCH			
	CONV	3 mo	5 mo	7 mo	$P\leq$
		Live weight basis			
DMEFF (kg kg^{-1})	9.17± 0.25*a*	10.57± 0.35*b*	10.18± 0.35*b*	10.03± 0.35*ab*	0.063
DEEFF (MJ kg^{-1})	100.7 ± 2.9*a*	126.5 ± 4.1*b*	123.2 ± 4.1*b*	121.2 ± 4.1*b*	0.005
PREFF (kg kg^{-1})	0.94± 0.03*a*	1.15± 0.04*b*	1.20± 0.04*b*	1.11± 0.04*b*	0.009
		Carcass weight basis			
DMEFF (kg kg^{-1})	19.2 ± 0.56	20.4 ± 0.79	19.2 ± 0.79	19.3 ± 0.79	NS
DEEFF (MJ kg^{-1})	211.2 ± 6.3*a*	243.6 ± 8.9*b*	232.4 ± 8.9*ab*	233.7 ± 8.9*ab*	0.087
PREFF (kg kg^{-1})	1.98± 0.06*a*	2.22± 0.08*b*	2.11± 0.08*ab*	2.14± 0.08*ab*	NS
		Lean weight basis			
DMEFF (kg kg^{-1})	37.4 ± 1.84	40.8 ± 2.60	39.9 ± 2.60	37.8 ± 2.60	NS
DEEFF (MJ kg^{-1})	411.4 ±20.1	487.8 ±28.4	483.0 ±28.4	457.5 ±28.4	NS
PREFF (kg kg^{-1})	3.85± 0.19	4.45± 0.27	4.39± 0.27	4.19± 0.27	NS

[z]Excludes heifers that failed to conceive or rear the calf to weaning.
[y]Abbreviations as defined in the text.
a,b Means not followed by the same letter differ significantly ($P < 0.05$).
NS, not significant at $P > 0.10$.

across-period analyses of feed conversion efficiency to the weaning endpoint, incorporating only data on heifers with calves that completed the test.

On this basis, the WNAGE effects arising in the post-calving period were diluted by the incorporation of data for all periods. Differences among the 3-, 5- and 7-mo weaning groups were not significant, but the 7-mo treatment tended to be more efficient than the 3-mo treatment, especially on a lean-weight basis (Table 6). The CONV treatment exhibited greater efficiency than any of the OCH treatments in all comparisons. The superiority of the CONV treatment was significant on a live-weight basis (e.g., DEEFF = 100.7 vs. 126.5, 123.2 or 121.2 MJ kg^{-1}, $P = 0.005$) and, for DEEFF only, on a carcass-weight basis (DEEFF = 211.2 vs. 243.6, 232.4 or 233.7 MJ kg^{-1}, $P = 0.087$), but it was not significant on a lean-weight basis (e.g., DEEFF = 411.4 vs. 487.8, 483.0 or 457.5 MJ kg^{-1}, $P = 0.178$).

EFFICIENCY TO THE END-OF-TEST ENDPOINT. Results of across-period analyses of feed conversion efficiency to the end-of-test endpoint are presented in Table 7. Again OCH were included only if they had a calf that completed the test. As observed above for the post-calving period, the change from a weaning to an end-of-test basis reversed the ranking of the OCH treatments. Although differences among OCH treatments never achieved significance, the early-weaned treatments always tended to be more efficient. Also, on this basis the OCH treatments became more competitive with the CONV treatments. Indeed, the 3-mo weaning treatment was more efficient than the CONV treatment in some comparisons (especially on a lean-weight basis), although the differences on a lean-weight basis were not statistically significant (e.g., DEEFF weight = 411.4, 402.1, 441.0 and 460.2 for CONV, OCH 3 mo, OCH 5 mo and OCH 7 mo, $P > 0.20$). As noted above, the significance test associated with this analysis was conservative because it was necessary to use the PBRIT mean square as the error mean square for significance testing, and for the post-calving to end-of-test period, PBRIT was a significant effect.

Although these cattle were, to the extent possible, managed contemporaneously and fed from the same feed sources, it cannot be

Table 7. Least-squares means ± SEM for feed conversion efficiency across periods to the end-of-test endpoint for conventionally finished heifers and once-calved-heifer–calf pairs weaned at 3, 5 and 7 mo[z]

		OCH			
	CONV[z]	3 mo	5 mo	7 mo	$P \leq$
Live-weight basis					
DMEFF (kg kg^{-1})	9.17 ± 0.25	8.94 ± 0.36	9.44 ± 0.36	10.09 ± 0.36	NS
DEEFF (MJ kg^{-1})	100.8 ± 3.0*a*	109.3 ± 4.2*ab*	115.4 ± 4.2*b*	122.1 ± 4.2*b*	0.026
PREFF (kg kg^{-1})	0.94 ± 0.03*a*	1.03 ± 0.04*ab*	1.07 ± 0.04*b*	1.12 ± 0.04*b*	0.036
Carcass-weight basis					
DMEFF (kg kg^{-1})	19.2 ± 0.58	17.3 ± 0.81	18.0 ± 0.81	19.5 ± 0.81	NS
DEEFF (MJ kg^{-1})	211.2 ± 6.5	211.8 ± 9.2	220.0 ± 9.2	235.9 ± 9.2	NS
PREFF (kg kg^{-1})	1.97 ± 0.06	1.99 ± 0.09	2.03 ± 0.09	2.17 ± 0.09	NS
Lean-weight basis					
DMEFF (kg kg^{-1})	37.4 ± 1.86	32.9 ± 2.64	36.1 ± 2.64	38.0 ± 2.64	NS
DEEFF (MJ kg^{-1})	411.4 ± 20.5	402.1 ± 29.0	441.0 ± 29.0	460.2 ± 29.0	NS
PREFF (kg kg^{-1})	3.85 ± 0.19	3.79 ± 0.27	4.09 ± 0.27	4.23 ± 0.27	NS

[z]Excludes heifers that failed to conceive or rear the calf to weaning.
[y]Abbreviations as defined in the text.
*a,b*Means not followed by the same letter differ significantly ($P < 0.05$).
NS, not significant at $P > 0.10$.

assumed that the treatment groups should rank the same for all measures of efficiency presented here. Cattle in the late-weaned treatments did consume a greater proportion of high-energy, high-protein cow and calf feeds, also differences in relative efficiency amongst live-, carcass- and lean-weight bases could arise from differences between treatment groups in carcass dressing percentage and lean yield.

CONCEPTION FAILURE AND DEATH LOSSES. In practice, the efficiency of a OCH production system cannot be measured without consideration of the heifers that die or fail to rear calves. In this experiment 11.7% of the initial population failed to conceive, 7.5% calved but failed to rear their calves, and one heifer (0.8%) died as a result of calving. Since the incidence of open heifers and calf losses was uniform across the treatment groups, the performance of the heifers in each of these categories was calculated using experiment mean performance to the point at which they were moved into separate open and lost-calf feeding groups. Actual performance was used thereafter. For the heifer that died, the assumption was made that such loss was equally likely in all WNAGE treatment groups, and the efficiency of each was discounted in proportion to the feed consumed by this heifer prior to her death.

The results on within-period and overall bases are presented in Table 8. After removal from the main experiment, these groups were fed in a single pen (open heifers) or in two pens (heifers that had lost calves), and it was not possible to compute standard errors for them. Open heifers, separated from the main herd at pregnancy testing in October and slaughtered in January, demonstrated inferior efficiency to OCH on a live-weight basis, but on a carcass-weight basis they were comparable to, and on a lean-weight basis slightly superior to, OCH 7 mo (e.g., DEEFF weight = 461.3 vs. 411.4, 434.4, 465.8 and 481.3 MJ kg^{-1} for open vs. CONV. OCH 3 mo, OCH 5 mo and OCH 7 mo to end of test). As expected, heifers that lost calves were very inefficient. These heifers were separated from the main herd as they lost their calves and were slaughtered in April–May. On a lean-weight basis, they exhibited DMEFF of 53.4 kg kg^{-1}, DEEFF of 639.8 MJ kg^{-1} and PREFF of 5.83 kg kg^{-1}.

ACROSS-PERIOD TO END OF TEST, INCORPORATING OPEN HEIFERS AND DEATH LOSSES. In terms of commercial application, perhaps the most useful presentation of results for the OCH system would be one that incorporated the full cycle from fall calf to fall calf (i.e., the end-of-test basis presented in Table 7) discounted for the incidence of open heifers and death losses as described in the preceding section. In Table 9 the data from this experiment are presented this way. The estimated feed consumption of the heifer that died and the feed conversion efficiency of those that failed to calve or rear their calves are incorporated with weighting according to their incidence in the experiment. On this basis, the CONV heifer groups regained a modest advantage in feed conversion efficiency over the OCH groups, and, within OCH treatments, earlier weaning tended to confer greater efficiency on a lean-weight basis (e.g., DEEFF weight = 411.4, 425.3, 456.6 and 472.0 MJ kg^{-1} for CONV, OCH 3 mo, OCH 5 mo and OCH 7 mo).

Boucqué et al. (1980) compared the feed to live-weight conversion of maiden and once-calved heifers in France. They concluded that although the latter increased meat production, the system was neither biologically nor economically efficient. Their study sustained a high indidence of conception failure (16%), cesarean deliveries (35%) and calf losses (19.4%), which dictated a lower overall efficiency than that realized in this experiment. Bond et al. (1986) found that daily gains in heifers were higher during both the 170 d prior to and the 7, 21 and 42 d after calving compared with non-bred heifers of the same age. Feed efficiency was better for the bred heifers before parturition but poorer when calculated using a 24 h post-partum body weight. However, since these efficiency calculations did not take into account the growth of the

Table 8. Average daily gain and efficiency of heifers that began a once-calved-heifer production program but failed to conceive or rear the calf to weaning[z]

	Days	ADG (kg)	DMAD (kg)	DMEFF (kg kg^{-1})	DEEFF (MJ kg^{-1})	PREFF (kg kg^{-1})
Open heifers						
		Live-weight basis, by period[y]				
GRO	134	0.76	6.2	8.1	98.9	0.86
BRD 1[x]	159	0.46	7.0	15.6	174.9	1.68
BRD 2[x]	75	0.72	8.9	12.4	151.5	1.35
Post breeding	48	0.41	8.9	21.7	290.0	2.47
Overall	416	0.60	8.0	13.3	159.6	1.46
		Carcass-weight basis				
Overall	416	0.39	8.0	20.5	246.3	2.25
		Lean-weight basis				
Overall	416	0.21	8.0	38.4	461.3	4.21
Heifers that lost calves						
		Live-weight basis, by period				
GRO	134	0.76	6.2	8.1	98.9	0.86
BRD	234	0.42	6.8	16.3	181.1	1.74
CLV	72	−0.26	8.2	NA	NA	NA
PTC[w]	53	1.24	19.6	15.8	207.5	1.78
Overall	493	0.50	8.0	16.1	193.2	1.76
		Carcass-weight basis				
Overall	493	0.30	8.0	27.0	323.4	2.94
		Lean-weight basis				
Overall	493	0.15	8.0	53.4	639.8	5.83

[z]Trait abbreviations as defined in the text.
[y]Period definitions: GRO, rearing; BRD, breeding and gestation; CLV, calving; PTC 1, post-calving to weaning endpoint; PTC 2, post-calving to end-of-test endpoint.
[x]BRD 1 and BRD 2 are the portions of the BRD period before and after pregnancy test when the open heifers were separated from those that were pregnant.
[w]Heifers that failed to rear their calves were separated from those with calves during the PTC period.
NA, not applicable (negative gain).

live calf, and since they were conducted over a limited period, they cannot be directly compared with the present results. Waggoner et al. (1988) also conducted a study on once-calved heifers and reported that during a 112-d post-partum period, feedlot average daily gains were higher for 2-yr-old open heifers than for calved heifers (not including the gain of the calf). This result is in contrast with that reported by Bond et al. (1986), but neither study covered the full OCH production cycle.

Taylor et al. (1985) concluded that, within normal limits, variation in the time of slaughter for once-calved heifers would have little effect on their overall efficiency. Our study suggests that this may not be true if the very efficient growth of early-weaned calves is taken into account.

While a full economic analysis is beyond the scope of this paper, it seems appropriate to draw attention to a number of factors not included in these analyses that would influence the commercial viability of a OCH production system. Inherent in the comparisons presented in this paper is the assumption that the calves produced in the OCH system are slaughtered at end of test, which

Table 9. Average feed conversion efficiency across periods to the end-of-test endpoint for conventionally finished heifers and heifers in a once-calved production system including heifers that failed to conceive (11.7%) or rear the calf (7.5%) and one that died (0.8%)[z]

		OCH[y]		
	CONV	3 mo	5 mo	7 mo
Live-weight basis				
DMEFF (kg kg^{-1})	9.2	10.0	10.4	10.9
DEEFF (MJ kg^{-1})	100.8	121.1	125.9	131.4
PREFF (kg kg^{-1})	0.94	1.13	1.16	1.20
Carcass-weight basis				
DMEFF (kg kg^{-1})	19.2	18.3	18.9	20.1
DEEFF (MJ kg^{-1})	211.2	223.4	230.0	242.8
PREFF (kg kg^{-1})	1.97	2.08	2.11	2.23
Lean-weight basis				
DMEFF (kg kg^{-1})	37.4	35.0	37.5	39.1
DEEFF (MJ kg^{-1})	411.4	425.3	456.6	472.0
PREFF (kg kg^{-1})	3.85	3.97	4.21	4.33

[z]Trait and treatment abbreviations as defined in the text.
[y]Once-calved heifers that nursed calves for 3, 5 or 7 mo.

was not true here and would not be in any commercial application. The fact that these calves could be used to begin a new cycle of either CONV or OCH production gives them a value higher than slaughter price and would improve the profitability of a OCH system. Some death losses must be expected in a CONV system, even though none were experienced in this experiment, and this would reduce the profitability of the CONV system. A major advantage of the OCH system would be a reduction in the size of the breeding herd required to maintain feedlot cattle numbers. On the other hand, our OCH cycle lasted more than twice as long as our CONV cycle, which would increase feedlot capital costs significantly for that system. Also, since feed requirements differed between the two systems, the balance between low- and high-cost feed energy requirements would be an important factor in determining profit.

CONCLUSIONS

1. During a 134-d growing period beginning shortly after weaning, heavier heifer calves consumed more feed, gained no faster and converted feed energy marginally less efficiently than those that began the test at a lighter weight.
2. When the post-calving feed conversion efficiency of OCH–calf pairs was calculated to the point of weaning only, late-weaned (7-mo) groups tended to be more efficient, although differences were not significant. But when calculated to the end of September in the calving year (i.e., including calf efficiency to the age at which the heifers began the experiment), the early-weaned (3-mo) group was more efficient by a highly significant margin ($P < 0.0001$).
3. Once-calved heifers had a lower proportion of kidney, mesenteric and omental fat depots and a higher proportion of alimentary tract tissues than conventionally reared slaughter heifers.
4. When calculated on a full-cycle basis (i.e., from beginning to end of test), OCH groups weaned at 3 mo utilized feed as efficiently as conventionally finished heifers. Groups weaned at 5 and 7 mo tended to be less efficient.
5. Open heifers from the once-calved system, separated from the pregnant heifers in October and slaughtered in January–February, demonstrated feed energy efficiency comparable to 7-mo-weaned OCH–calf pairs on a lean-weight basis.
6. Heifers that calved but lost the calf before weaning demonstrated very poor feed efficiency, requiring almost 1.5 times as much feed energy per unit of gain as the least efficient OCH–calf pairs.
7. When adjusted for the proportion of open heifers (0.117), calf losses (0.075) and heifer-death losses (0.008), the CONV-heifer rearing and finishing system tended to be somewhat more efficient (about 6%, on a lean-weight basis) than the most efficient OCH treatment in this experiment, but this difference was not statistically significant.

APPLICATION

These results establish that a OCH beef production system can equal a conventional heifer rearing and finishing system in feed conversion efficiency if conception failure and calf losses can be adequately controlled. They also establish that, on a full cycle basis, efficiency in a OCH system dictates early weaning of the calf and slaughter of the heifer to remove the burden of her inefficient growth while retaining the benefit of very efficient calf growth. This study dealt with feed conversion efficiency expressed in several ways, but a number of other factors would have important effects on the actual profitability of a OCH production system.

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