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thesis entitled

THE EFFECT OF EARLY WEANING BEEF CALVES
ON FEEDLOT PERFORMANCE, CARCASS CHARACTERISTICS,
COW PERFORMANCE, AND ECONOMIC RETURN

presented by

JENNIFER M. BARKER

has been accepted towards fulfillment
of the requirements for

Master of Science degree in Ruminant Nutrition

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Major professor

Date 10-15-99

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By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Animal Science

1999

ABSTRACT

THE EFFECT OF EARLY WEANING BEEF CALVES ON FEEDLOT PERFORMANCE, CARCASS CHARACTERISTICS, COW PERFORMANCE, AND ECONOMIC RETURN

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Jennifer M. Barker

As the beef industry evolves from a segmented to a vertically coordinated industry, early weaning calves may be a viable management strategy for cow-calf producers that retain ownership of calves through harvest. Over two years, effects of early weaning beef calves on feedlot performance, carcass characteristics, economic return to the cow-calf enterprise, and cow performance were determined. Calves were assigned to one of two weaning treatments: 1) weaned at an average age of 100 d (**EW**), or 2) weaned at an average age of 200 d (**NW**). Early weaned steers tended to have lower average daily gain for the finishing period than NW steers. However EW steers were more feed efficient, had lower daily dry matter intake, and consumed less total feed during the finishing period than NW steers. Early weaning resulted in a lower cost of gain, however, EW steers had lighter carcass weights than NW steers when harvested at a constant fat thickness. This resulted in less return to the cow-calf enterprise by early weaning than normal weaning. Early weaning decreased feed consumption and improved feed efficiency during the finishing period. However, return to the cow-calf enterprise was decreased due to lighter weight carcasses. Early weaning resulted in greater weight gain of cows during the summer grazing period and higher cow body condition scores prior to the winter feeding period relative to normal weaning.

To new beginnings . . .

ACKNOWLEDGMENTS

I wish to express my sincere thanks to Drs. Black, Doumit, Hawkins, and Rust for serving on my graduate committee. Their guidance is greatly appreciated. Special thanks are extended to Dr. Dan Buskirk for serving as my major advisor. Not only do I appreciate his assistance in completion of this research and thesis, but also his flexibility in allowing me teaching opportunities, involvement in extension activities, and leadership roles in youth livestock programs throughout my graduate program.

I would like to thank Paul Naasz and the crew at the Upper Peninsula Experiment Station in Chatham, MI. Without their assistance in data collection, I would have made several more long trips across the bridge to the "Northland". I am forever indebted to Ken Metz and the crew at the Beef Cattle Teaching and Research Center. They were always there to lend a helping hand.

The people at Michigan State University set it apart from many other academic institutions. I have had the opportunity to work with leaders within academia, research, and the livestock industry. For that, I am eternally grateful.

I thank Justin Ransom and Brett and Nicole Barber for their friendship. I want to thank my parents for their love and support. They have taught me to set high expectations and that through hard work and dedication those expectations can be met. Finally, I wish to express my sincere gratitude to Mike Neef for his unconditional love and friendship. As I close this chapter of my life and start a new one with him as my husband, I am ready to face whatever may lie ahead.

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INTRODUCTION

Traditionally, the beef industry has been divided into several independent production enterprises which include cow-calf operations, backgrounders, and feeders. Economic return to each of these segments has been governed by different production traits and has been independent of return to other segments. For example, reproductive efficiency is the most economically important trait in cow-calf enterprises, while feed efficiency and rate of gain are two of the most economically important traits in fed-cattle enterprises (Melton, 1995). Antagonism often exists between traits that improve return to different segments. Cundiff et al. (1986) stated that selection for increased postweaning growth rate and feed efficiency decreases reproductive performance of females. Therefore, management practices in segmented production systems are often implemented for the benefit of a particular segment with little regard to other segments.

Traditionally, calves are weaned at approximately seven months of age to maximize gross return to cow-calf enterprises which market calves at weaning. As the beef industry progresses toward coordinated production systems, entities within coordinated systems may retain ownership of the live animal or product beyond their segment. If ownership is retained, economic return to multiple segments or the entire system take precedence over that of any single segment. In coordinated production systems in which cow-calf enterprises retain ownership of calves, weaning calves at younger ages may increase production efficiency through the entire system resulting in greater return.

When early weaning precedes or coincides with the breeding season, reproductive performance may be improved (Laster et al., 1973; Lusby et al., 1981). In order to maintain a 365 d calving interval, beef cows must rebreed within approximately 80 d postpartum. Failure to become pregnant within this finite period is the primary reason that females fail to wean a calf annually (Dziuk and Bellows, 1983). Weaning eliminates energy demands of lactation allowing for reallocation of energy to reproductive functions. As well, the inhibitory effect of the suckling stimulus on estrus is removed at weaning and allows for resumption of normal estrous cycles (Short et al., 1990; Williams et al., 1990).

Early weaning allows for quicker recovery of body energy reserves that are lost due to large energy demands during early lactation (Purvis et al., 1995; Myers et al., 1999a and 1999b). If energy reserves are recovered during the grazing season prior to the winter feeding period, less harvested feed will be required for females to reach adequate condition by the subsequent parturition. This may have significant economic impact because feed costs account for at least 50% of all costs incurred by cow-calf enterprises (Strohbehn, 1997).

Early weaning improves postweaning feed efficiency without sacrificing performance. Results of previous studies have shown that early weaned calves are more feed efficient than those weaned at a traditional age of 200 d (Gill et al., 1993a; Myers et al., 1999a and 1999b). Early weaned calves are likely to have lighter average body weights during the finishing period and therefore, have lower maintenance requirements relative to normal weaned calves. Early weaned calves may have lower daily dry matter intake (DMI) during the finishing period than normal weaned calves (Gill et al., 1993a; Myers et al., 1999a and 1999b). However, this may not result in decreased total feed consumption because early weaned calves have longer finishing periods than calves normal weaned at approximately seven months of age.

The National Beef Quality Audit (NCBA, 1995) stated that decreasing harvest age and increasing marbling will enhance product palatability and better meet demand of consumers. Early weaning will decrease harvest age if calves are fed a finishing diet immediately following weaning. It has also been reported that early weaning increases marbling and quality grades (Myers et al., 1999a). Implementation of management schemes that increase carcass quality, without sacrificing carcass weight or yield grade, may result in more economic return in value-based carcass pricing structures.

Therefore, the objectives of this research were to:

1) Determine effects of early weaning (100 d of age) beef steers with high marbling potential on feedlot performance and carcass characteristics.

2) Compare economic return to the cow-calf enterprise of beef steers early weaned at 100 d of age to that of beef steers normal weaned beef at 200 d of age.

3) Determine effect of early weaning beef calves at 100 d of age on cow weight, body condition and subsequent reproductive performance.

CHAPTER 1

Review of Literature

Impact of cow body weight and condition on reproductive performance

The highest energy demand in the production cycle of beef cows is during early lactation. When energy requirements are not met by the diet, body energy reserves will be mobilized (NRC, 1996). When females experience postpartum negative energy balance, reproductive performance suffers (Rutter and Randel, 1984; Perry et al., 1991). Houghton et al. (1990) reported that pregnancy rate was 31% lower for females that had calved in moderate condition and then lost condition from parturition through the breeding season relative to those that had maintained or gained condition during the same time period.

Prevention of negative energy balance by manipulation of postpartum dietary energy may improve reproductive performance. Richards et al. (1986) examined effects of varying energy in postpartum diets on reproductive performance of multiparous females. Dietary treatments that varied in energy level to achieve body weight gain (.30 kg/d), weight maintenance, or weight loss (-.56 kg/d) were assigned at parturition. Body condition score (BCS) of the females ranged from 4 to 7 (1 to 9 scale; 1 = extremely thin, 9 = obese) at parturition. Reproductive performance was not affected by postpartum weight change when females had a BCS ≥ 5 at parturition, however, weight gain or weight maintenance improved reproductive performance of females that had a BCS ≤ 4 at parturition. Weight gain and weight maintenance increased the percentage of females exhibiting estrus by d 40 of the breeding season relative to those females that lost weight (96 versus 79%, respectively). Pregnancy rate increased by 35 or 21 percentage units at d 40 of the breeding season when weight was gained or maintained, respectively, by females having a BCS ≤ 4 at parturition. Overall pregnancy rate also increased by 24 percentage units after a 60 d breeding season when females with a BCS ≤ 4 at parturition had gained or maintained weight relative to those that had lost weight during the postpartum period.

Several researchers have reported that body condition of females at parturition affects reproductive performance (Dziuk and Bellows, 1983; Selk et al., 1988; Osoro and Wright, 1992). Richards et al. (1986) reported that cows with a BCS ≤ 4 at parturition were likely to have longer intervals from calving to first estrus and from calving to pregnancy relative to females calving with a BCS ≥ 5 (61 versus 49 d and 90 versus 84 d, respectively). Spitzer et al. (1995) reported that as BCS at parturition of primiparous females increased from 4 to 5, pregnancy rate improved by 24 percentage units after a 60 d breeding season. Lalman et al. (1997) reported that body condition at parturition had more influence on length of the postpartum interval than did body condition change from parturition to 90 d postpartum ($R^2 = .37$ versus $R^2 = .27$, respectively).

Poor body condition may be more detrimental to the reproductive performance of young females than mature cows because young females have additional energy requirements for growth. Rae et al. (1993) examined effects of BCS and BCS × parity on reproductive performance of 3734 beef cows from eight commercial herds in Florida. In agreement with the aforementioned studies, BCS was positively related to pregnancy rate

(BCS ≤ 3, 4, or ≥ 5; pregnancy rate = 30.9, 60.4, and 89.1%, respectively). The BCS × parity interaction was also statistically significant. When the BCS of young females (parity ≤ 3) was ≤ 3, pregnancy rate was lower than that of mature females (parity 4 - 7) in the same condition (23.1 versus 47.5%, respectively). When BCS was 4, pregnancy rate of young females was also lower than that of mature females in the same condition (53.9 versus 71.6%, respectively). When BCS was ≥ 5, pregnancy rate of females was similar among parities.

Impact of the suckling stimulus on reproductive performance

The act of suckling, independent of energy required for lactation, has an inhibitory effect on resumption of estrous cycles of postpartum beef cows. Wiltbank and Cook (1958) reported that the postpartum anestrus interval was 30 d longer in females that were suckled twice daily relative to those being milked twice daily. Increased frequency of suckling bouts may also prolong the postpartum anestrus period (Wyatt et al., 1977; Wettemann et al., 1978).

Ovulation is controlled by a complex cascade of hormonal signals from the pituitary, hypothalamus, and ovary. The act of suckling interferes with release of hormones, primarily luteinizing hormone (LH) and gonadotropin releasing hormone, required for resumption of normal estrus cycles (Short et al., 1990; Williams, 1990). Ovulation is preceded by pulsatile release of LH. This release of LH is suppressed in postpartum, suckled cows (Carruthers and Hafs, 1980; Williams et al., 1983; Williams, 1990). Removal of the suckling stimulus increases LH concentration in blood (Short et al., 1972; Walters et al., 1982; Edwards, 1985; Faltys et al., 1987) and shortens the postpartum anestrous period (Short et al., 1972; Smith and Vincent, 1972; Carter et al., 1980; Faltys et al., 1987). Concentration of LH in blood increases linearly from 24 through 96 h after calf removal (Walters et al., 1982). Edwards (1985) reported that removal of calves from acyclic cows (35 d postpartum) for 56 h increases the frequency of LH release and LH concentration in blood to that of cyclic cows.

Energy status of females may also affect ovarian activity following removal of the suckling stimulus. Bishop et al. (1994) reported that the magnitude of reproductive response due to removal of the suckling stimulus was contingent upon body condition of females. A greater percentage of acyclic females in good condition (BCS $\geq$ 5) had luteal activity within 25 d after calf removal compared to cows in poorer condition (BCS < 5; 100 vs 43%, respectively).

Impact of early weaning on reproductive performance

When early weaning precedes or coincides with the breeding season, reduced energy demand and removal of the suckling stimulus may collectively enhance reproductive performance. Laster et al. (1973) examined effects of early weaning (67 d) eight days prior to the breeding season on reproductive performance of 308 females. Reproductive performance of females $\geq$4 years old was not affected by early weaning, however, early weaning improved reproductive performance of younger females. The percentage of 2- and 3-year-old females with early weaned (EW) calves exhibiting estrus during the 42 d breeding season increased by 29 and 27 percentage units, respectively, over that of their contemporaries that were still nursing calves. Early weaning also improved pregnancy rate of 2- and 3-year old females by 26 and 16 percentage units, respectively, compared to females with normal weaned (NW) calves. Lusby et al. (1981) also reported that reproductive performance was enhanced by early weaning. Primiparous dams of EW calves (50 d) had higher pregnancy rates (96.8 versus 59.4%) and shorter calving intervals (353 versus 370.5 d) than primiparous dams of NW calves (215 d). Myers et al. (1999a) reported that early weaning tended to improve pregnancy rate of dams of EW calves (168 d) over dams of NW calves (223 d) (78 versus 67%, respectively; P = .10). The breeding season had ended before early weaning, therefore early weaning had no influence on conception rate. If this treatment difference was biologically real, embryonic death was reduced in dams of EW calves relative to dams of NW calves. Myers and coworkers did not report age of dams. In contrast, Purvis et al. (1995) reported similar pregnancy rates for dams of EW (65 d) or NW (210 d) calves. Age of these dams was not reported, but they were in good condition at parturition (BCS = 5).

Impact of early weaning on dam body weight and condition

Early weaning eliminates energy demands of lactation, resulting in body weight gain (Lusby et al., 1981; Peterson et al., 1987; Knabel et al., 1989; Purvis et al., 1995) and increased body condition relative to lactating females (Purvis et al., 1995; Myers et al., 1999a and 1999b). Neville and M^{c}Cormick (1981) reported that dams of EW calves (67 d) experienced greater ADG from time of early weaning to normal weaning relative to those females with suckling NW calves (228 d) (.63 versus .29 kg/d, respectively). The advantage in ADG due to early weaning was 44 % greater for primiparous females than for mature females (≥3 parities). This suggests that early weaning has more influence on postpartum weight gain of young females than mature cows. Purvis et al. (1995) reported that dams of EW calves (70 d) had higher condition scores than dams of NW calves at time of normal weaning (BCS = 6.1 versus 5.5, respectively). Myers et al. (1999b) reported a linear increase in BCS of dams as weaning age decreased. At 215 d postpartum, BCS was 4.2, 4.5, and 4.9 for dams whose calves were weaned at 215 d, 152 d and 90 d, respectively. Body weight of dams also increased linearly as weaning age decreased (432, 439, and 459 kg for weaning ages of 215, 152, and 90 d, respectively). In contrast, Grimes and Turner (1991a) reported similar BCS at time of normal weaning for dams of EW (110 d) and NW (220 d) calves (3.20 versus 3.09). Dams of NW calves consumed 4.5 kg/d more DM from time of early weaning to normal weaning than dams of EW calves. Therefore, energy required for continued lactation may have been obtained by greater DM consumption by dams of NW calves rather than mobilization of body energy reserves.

Quicker recovery of body condition will reduce energy required during the winter feeding period to attain an acceptable BCS by the subsequent parturition. According to the 1996 NRC for beef cattle, 186 Mcal of additional energy is required to increase the BCS of a 450 kg female from 4 to 5 (NRC, 1996). If cows receive bromegrass hay (mid-bloom; NE_g = .61 Mcal/kg), 305 additional kg (DM) of hay would be required to meet energy demands for increasing BCS from 4 to 5.

Impact of postweaning management strategies on growth performance and feed efficiency

When animal growth is regressed against time, the resulting curve is sigmoidal in shape. Relatively slow fetal and neonatal growth is followed by a period of rapid growth which is represented by the steep portion of the sigmoidal curve. During this period of rapid growth, rate of muscle accretion is faster than that of fat accretion. Efficiency of gain is also maximized during this period because lean tissue gain is four times more efficient than that of adipose tissue (Owens et al., 1995). As an animal nears maturity, rate of weight gain declines while muscle growth slows and fat accretion increases resulting in decreased efficiency of gain. Economic return is highly influenced by rate and efficiency of gain (Melton, 1995).

Several postweaning management strategies exist that affect growth and feed efficiency. Backgrounding[1] is one strategy that is often utilized to increase weight with a low cost of gain. Growth during the backgrounding period allows for protein accretion while restricting fat accretion (Byers, 1980; Carstens et al., 1991; Coleman et al., 1993). Backgrounding results in heavier carcasses at a constant 12th rib fat thickness (Rompala and Jones, 1984; Lewis et al., 1990; Gill et al., 1993b) or leaner carcasses at a constant weight (Lancaster et al., 1973; Danner et al., 1980) relative to carcasses from non-backgrounded cattle. Gill et al. (1993c) compared carcass composition of

[1] For the purposes of this thesis, backgrounding refers to either a grazing period or a growing period in the feedlot during which cattle receive a high roughage diet. This period immediately follows weaning and is prior to a finishing period during which cattle receive a high concentrate diet.

backgrounded and non-backgrounded cattle that were harvested at a constant fat thickness (1.1 cm). When compared to carcasses of non-backgrounded cattle, those of backgrounded cattle had less fat (32.1 versus 25.7%, respectively) and more protein (14.3 versus 15.4%, respectively) as a percentage of empty body weight. Carstens et al. (1991) also reported that carcasses of backgrounded cattle contained less fat than those of non-backgrounded cattle (27.2 versus 34.3%, respectively, as a percentage of carcass weight). Ridenour et al. (1982) and Dubeski et al. (1997) reported less kidney, pelvic, and heart fat (**KPH**) in carcasses of backgrounded cattle relative to those of non-backgrounded cattle.

Although ADG of backgrounded cattle is limited by dietary energy during the backgrounding period, they generally have greater ADG during the finishing period than non-backgrounded cattle. Average daily gain of backgrounded cattle during the finishing period has been reported to be 10 to 37% greater than that of non-backgrounded cattle (Dikeman et al., 1985a and 1985b; Lewis et al., 1990; Carstens et al., 1991). Following a period of energy restricted gain, cattle often have accelerated gain (Carstens et al., 1991; Owens, 1993).

Enhanced ADG of backgrounded cattle during the finishing period may or may not compensate for lower ADG during the backgrounding period. Ridenour et al. (1982), Dikeman et al. (1985b), and Carstens et al. (1991) reported lower ADG for the entire postweaning period (weaning through harvest) of backgrounded cattle relative to those not backgrounded (.99 verus 1.22 kg/d; 1.08 versus 1.30 kg/d; .83 versus 1.23 kg/d, respectively for each trial). In contrast, Dikeman et al. (1985a) reported no difference in postweaning ADG between backgrounded and non-backgrounded cattle (1.14 versus 1.21 kg/d, respectively).

Backgrounded cattle have increased daily DMI during the finishing period relative to non-backgrounded cattle. Lewis et al. (1990) and Gill et al. (1993a) reported increased daily DMI of backgrounded cattle during the finishing period when compared to non-backgrounded cattle (12.39 versus 8.53 kg/d; 11.17 versus 8.26 kg/d, respectively for each trial). Differences in DMI still existed in both studies when daily DMI was expressed as a percentage of body weight. In contrast, others have reported that backgrounded and non-backgrounded cattle have similar daily DMI (Carstens et al., 1991) or similar energy intake (Dikeman et al., 1985b) during the finishing period.

Backgrounded cattle are less feed efficient during the finishing period than non-backgrounded cattle. Backgrounded cattle have a heavier average body weight during the finishing period relative to non-backgrounded cattle and therefore, would be expected to have higher maintenance requirements. Lewis et al. (1990) reported that backgrounded cattle were 11% less efficient during the finishing period than non-backgrounded cattle. Gill et al. (1993a) reported a 24% decrease in efficiency during the finishing period for backgrounded cattle relative to those not backgrounded.

The relative difference in feed efficiency between backgrounded and non-backgrounded cattle appears to be dependent upon length of the backgrounding period. Length of the backgrounding period is positively related to average body weight during the finishing period and therefore is also positively related to maintenance requirements. Ridenour et al. (1982) reported that non-backgrounded cattle were more feed efficient during the finishing period than cattle that were backgrounded for 173 or 201 d (.129 versus .108 and .104, respectively). However, feed efficiency was similar between non-backgrounded cattle and those that were backgrounded for only 79 or 133 d (.129 versus .130 and .125, respectively). Gill et al. (1993a) also observed that feed efficiency during finishing decreased as length of the backgrounding period increased. Dikeman et al. (1985a) examined feed efficiency of backgrounded and non-backgrounded cattle independent of body weight. Feed efficiency of backgrounded cattle during the entire finishing period (d 0 through d 174 of the finishing period; average weight = 476 kg) was compared to that of non-backgrounded cattle over approximately the last one-third of the finishing period (d 139 through d 242 of the finishing period; average weight = 495 kg). Feed efficiency was similar between backgrounded and non-backgrounded cattle (.137 versus .145, respectively). This suggests that differences in feed efficiency between backgrounded and non-backgrounded cattle is at least partially body weight dependent.

Impact of postweaning management strategies on carcass characteristics and meat palatability

Carcass characteristics and meat palatability attributes (tenderness, juiciness, and flavor) may also be affected by postweaning management schemes. As stated previously, restricted fat accretion during the backgrounding period allows for heavier carcasses at a constant 12th rib fat thickness (Rompala and Jones, 1984; Lewis et al., 1990; Gill et al., 1993b) or leaner carcasses at a constant weight (Lancaster et al., 1973; Danner et al., 1980). The effect of backgrounding on carcass quality (marbling) is difficult to assess because harvest endpoints vary among studies. Ideally, carcass quality differences should be compared at a constant 12th rib subcutaneous fat thicknesses because 12th rib subcutaneous fat thickness and marbling are positively correlated (Marshall, 1994). Previously, 12th rib fat thickness was selected as the common harvest endpoint in only a few studies. In these instances, it was usually determined by a subjective visual estimation that was not always accurate. In studies by Aberle et al. (1981) and Gill et al. (1993b), 12th rib fat thickness at harvest was similar for backgrounded and non-backgrounded cattle (1.07 versus .97 cm and 1.41 versus 1.42 cm, respectively for each trial). Marbling scores and quality grades were not different between treatments in either study. These studies suggest that implementation of a backgrounding period does not affect marbling scores or quality grades.

Implementation of a backgrounding period increases chronological age at which cattle are harvested and may have detrimental effects on meat tenderness. Decreased beef tenderness associated with increased harvest age is due to changing physical properties of connective tissue within muscle. The amount and state of collagen are major determining factors of meat tenderness (Locker, 1960; Cover et al., 1962; Ritchey et al., 1963). The amount of collagen in bovine muscle varies among muscles. Generally, muscles that are more tender, such as the longissimus dorsi and psoas major, have lower collagen content relative to less tender muscles, such as the sternomandibularis in the neck (Ritchey et al., 1963; Dutson et al., 1976). Even though the amount of collagen varies from muscle to muscle, the amount remains relatively unchanged within a specific muscle, especially after cattle are one year of age (Goll et al., 1963; Carmichael and Lawrie, 1967; Kim et al., 1967; Cross et al., 1973). However, the state of collagen within a specific muscle changes over time (Bailey, 1969). Solubility of collagen decreases as cattle age (Carmichael and Lawrie, 1967; Cross et al., 1973) due to an increase in intermolecular crosslinking (Hill, 1966; Bailey, 1969; Shimokomaki et al., 1972). Cross et al. (1973) reported that age was negatively correlated to collagen solubility in bovine muscle (-.57). Herring et al. (1967) reported that collagen solubility decreased as USDA carcass maturity increased from A (9 to 30 months of age) to B (31 to 42 months of age) (10.48 versus 9.40%, respectively) and from B to E (> 96 months of age) (9.40 versus 4.21%, respectively). Husaini (1950) reported a high negative correlation (-.87) between insoluble connective tissue and beef tenderness.

Relatively few studies have reported effects of increased harvest age due to postweaning management strategies on meat palatability. Simone et al. (1959) examined effects of increased harvest age due to backgrounding on meat palatability attributes. Steers were either backgrounded for 365 d after weaning and then were finished as yearlings, or they received a finishing diet immediately after weaning. This resulted in average harvest ages of 30 and 18 months. Harvest endpoint was determined by visual estimation of fat thickness. Taste panel scores for tenderness were less desirable for steaks from backgrounded cattle relative to those from non-backgrounded cattle. There was no difference in taste panel scores for juiciness or flavor due to treatment. Dikeman et al. (1985b) reported that when compared to non-backgrounded cattle, the longissimus dorsi and semimembranosus of backgrounded cattle had higher Warner-Bratzler shear force (WBS) values (2.69 versus 3.11 kg and 3.63 versus 4.08 kg, respectively for each muscle). Backgrounded cattle were 140 d older at harvest than non-backgrounded cattle in that trial. Dikeman et al. (1985a) also reported that backgrounding had detrimental effects on palatability and tenderness even when backgrounded cattle were only 42 d older at harvest than non-backgrounded cattle. When compared to non-backgrounded cattle, the semimembranosus from backgrounded cattle had higher WBS values (4.6 versus 5.2 kg, respectively) and less desirable taste panel scores for overall tenderness. Collagen solubility was not analyzed in these studies by Dikeman and coworkers. However, it has been reported that backgrounding results in decreased collagen solubility (Rompala and Jones, 1984).

In disagreement with the aforementioned studies, others have reported that increased harvest age due to backgrounding does not affect meat palatability. Aberle et al. (1981) reported that longissimus dorsi muscles from backgrounded and non-backgrounded cattle had similar WBS values (3.44 versus 3.31 kg, respectively), collagen solubility (19.2 versus 19.3%, respectively) and taste panel scores. Berry et al. (1974) examined effects of carcass maturity (USDA maturity grade ranging from A to E) on meat palatability. Palatability and WBS values of A and B maturity carcasses were superior to those with advanced maturity (E). However, within A and B maturity classes, WBS values and taste panel scores were similar.

Following backgrounding, length of the finishing period affects meat tenderness and palatability. Dolezal et al. (1982) examined effects of varying the length of the finishing period of previously backgrounded steers on meat palatability. Length of the finishing period for backgrounded steers ranged from 30 to 160 d. Following harvest, rib steaks were removed and aged 14 to 16 d postmortem before WBS values and taste panel scores were obtained. Taste panel scores and WBS values were similar between steaks from non-backgrounded and backgrounded cattle that had been finished for at least 100 d (3.70 versus 4.28 kg, respectively, for WBS values). However, when the finishing period of previously backgrounded steers was < 100 d, steaks from backgrounded cattle had higher WBS values (6.58 versus 3.70 kg) and less desirable taste panel scores for tenderness and overall palatability relative to those for steaks from non-backgrounded cattle. Marbling scores for carcasses of backgrounded cattle that were finished < 100 d were significantly lower than those from non-backgrounded cattle. This may have resulted in poorer taste panel scores for overall palatability of steaks from backgrounded cattle, but would not be expected to significantly contribute to less desirable WBS values. Taste panel scores for palatability may be influenced by marbling, but tenderness at 14 d postmortem as determined by WBS in not highly correlated with marbling (Shackelford et al., 1991).

Impact of early weaning on postweaning performance and efficiency

Performance of EW calves and the relative difference in performance between EW and NW calves is highly dependent upon the plane of nutrition of both groups after the time of early weaning. Early weaned calves may receive a high concentrate finishing diet immediately following weaning, or they may be backgrounded prior to finishing. Grazing conditions and availability of supplemental feed offered to suckling NW calves affect their performance from time of early weaning to that of normal weaning. In a two year study, Myers et al. (1999a) compared the growth performance of EW calves (177 and 158 d of age for year 1 and 2, respectively) and NW calves (231 and 213 d of age for year 1 and 2, respectively) that were or were not offered creep feed from time of early weaning to time of normal weaning. After early weaning, EW calves received a high concentrate diet. In both years, EW calves experienced greater ADG over both creep-fed and non-creep-fed NW calves (yr 1 = 1.44 versus .82 and .62 kg/d, respectively; yr 2 = 1.04 versus .80 and .61 kg/d, respectively) from time of early weaning to that of normal weaning. This suggests that EW calves receiving a finishing diet will outperform suckling NW calves from time early weaning to normal weaning, regardless of supplementation of NW calves.

When EW calves are grazed after weaning, the relative difference in ADG from time of early weaning to normal weaning between grazing EW calves and suckling NW calves is highly dependent on forage quality and availability, and supplementation of both EW and NW calves. Neville and M[c]Cormick (1981) compared growth performance of EW (67 d) and NW (230 d) calves from early weaning to normal weaning. Immediately after early weaning, half of the EW calves were backgrounded, while the other half received a high concentrate diet. The backgrounded EW calves were grazed and offered supplemental feed primarily consisting of rolled corn. The suckling NW calves were not offered supplemental feed. The EW calves that received a high concentrate diet had greater ADG than backgrounded EW calves (1.04 versus .96 kg/d, respectively), and backgrounded EW calves had greater ADG than suckling NW calves (.96 versus .85 kg/d, respectively). In agreement with Neville and M^{c}Cormick (1981), Harvey et al. (1975) reported that EW calves (150 d) with access to supplemental grain while grazing experienced greater ADG over non-supplemented, suckling NW calves (234 d) (1.86 versus 1.23 kg/d, respectively) from the time of early weaning to that of normal weaning.

In the previously mentioned studies, additional energy was provided to grazing EW calves through grain supplementation that likely enhanced their ADG. Early weaned calves that are grazed require energy supplementation at least equivalent to the energy supplied by milk to suckling NW calves from time of early weaning to normal weaning in order to achieve the same performance level of their suckling NW contemporaries. Purvis et al. (1995) early weaned calves (65 d) and allowed them to graze native range with only protein supplementation. Suckling NW calves (185 d) did not have access to supplemental feed. Grazing EW calves had lower ADG from time of early weaning to normal weaning when compared to that of suckling NW calves (.97 versus 1.16 kg/d, respectively). This resulted in NW calves being 28 kg heavier than EW calves at normal weaning.

It has been reported that by nine weeks of age energy from milk only meets maintenance requirements of calves (Bartle et al., 1984). Calf growth may be limited if other energy resources are not available. Therefore, if growth of suckling NW calves is limited from the time early weaning to that of normal weaning, NW calves may experience accelerated gain immediately after weaning. Although NW calves may experience accelerated gain following weaning, ADG of NW calves for the entire finishing period (weaning to harvest) will not likely exceed that of EW calves. Lusby et al. (1990) reported that NW calves (225 d) had greater ADG than EW calves (120 d) from time of normal weaning to harvest (1.42 versus 1.11 kg/d, respectively), however ADG for the entire finishing period (time of early weaning to harvest for EW calves; time of normal weaning to harvest for NW calves) was numerically similar for NW and EW calves (1.42 versus 1.32 kg/d, respectively). Myers et al. (1999a) also reported greater ADG of NW calves (231) than EW calves (177 d) from normal weaning to harvest (1.38 versus 1.28 kg/d, respectively), but ADG for the finishing period was numerically similar for NW and EW calves (1.38 versus 1.31 kg/d, respectively). Myers et al. (1999b) reported no difference in ADG between NW (215 d) and EW (90 d) calves for the finishing period. In contrast, Gill et al. (1993a) reported that EW calves had lower ADG for the finishing period than NW calves (1.33 versus 1.46 kg/d, respectively).

When EW calves outperform NW calves from time of early weaning to normal weaning, they will also likely have greater ADG from time of early weaning to harvest. It has been reported that ADG of EW calves from time of early weaning to harvest is 10-15% greater than that of NW calves (Myers et al., 1999b; Schoonmaker et al., 1999a; Lusby et al., 1990).

Early weaned calves have decreased daily DMI and increased feed efficiency during the finishing period relative to NW calves. The advantage in feed efficiency is largely due to lower maintenance requirements of EW calves because they have lighter average body weights during the finishing period. Myers et al. (1999b) reported daily DMI was lower for EW calves (90 d) relative to NW calves (215 d) (5.90 versus 7.19 kg/d, respectively), and EW calves were 22% more feed efficient than NW calves.

Average body weights of EW calves during the feeding period was 283 kg compared to 324 kg for NW calves. Schoonmaker et al. (1999a) reported that EW calves had lower daily DMI and improved feed efficiency during the finishing period relative to NW calves (daily DMI, 7.49 versus 8.44 kg/d, respectively; gain:feed, .219 versus .209, respectively). Others have also reported that early weaning decreased daily DMI and improved feed efficiency of EW calves during the finishing period relative to NW calves (Gill et al., 1993a; Myers et al., 1999a). In contrast, Pritchard et al. (1988) reported that although EW calves (164 d) had decreased daily DMI relative to NW calves (203 d) (8.56 versus 8.95 kg/d, respectively), feed efficiency was similar for EW and NW calves. In their study, there was only 39 days between time of early and normal weaning resulting in relatively similar average body weights for EW and NW calves during the feeding period (381 versus 402 kg, respectively). Therefore, maintenance requirements were similar and potential differences in feed efficiency were mitigated.

Even though EW calves may have lower daily DMI than NW calves, their total DMI for the finishing period is often greater than that of NW calves because EW calves have longer finishing periods. Myers et al. (1999b) reported that EW calves (90 d) consumed more DM during the finishing period than NW calves (215 d) (1984 versus 1758 kg, respectively). The finishing period of EW calves was 93 d longer than that of NW calves. Schoonmaker et al. (1999a) reported that EW calves (113 d) consumed 341.3 more kg of DM during the finishing period relative to NW calves (205 d). The finishing period of EW calves was 67 d longer than that of NW calves.

Relatively few researchers that have studied early weaning production systems have reported effects of early weaning on postweaning morbidity and mortality. Myers et al. (1999b) reported that incidence of respiratory morbidity of EW (90 d) and NW calves (215 d) was similar (25 versus 22%, respectively). In contrast, Myers et al. (1999a) reported decreased respiratory morbidity of EW calves (177 d) relative to NW calves (231 d) (1.2 versus 15.2%, respectively). There was no difference in digestive morbidity or mortality between EW and NW calves in either study.

Impact of of early weaning on carcass characteristics

Feeding EW calves a high concentrate diet will promote fat accretion at lighter weights. Therefore, EW calves may have lighter weight carcasses than NW calves when harvested at a constant fat thickness or have fatter carcasses than NW calves when harvested at a constant weight. Gill et al. (1993c) compared composition of EW (105 d) and NW calves (235 d) when harvested at a constant fat thickness (1.1 cm). The calves utilized in that study were sired by Angus bulls, and their dams were Angus crossbred females. There was no difference in composition of EW and NW calves (34.8 versus 32.1% fat and 34.8 versus 32.1% protein as a percentage of empty body weight, respectively), however EW calves had lighter carcass weights relative to NW calves (335 versus 342 kg, respectively). This is in contrast with Lusby et al. (1990) and Myers et al. (1999a). They reported that EW and NW calves had similar carcass weights when harvested at a constant fat thickness. Angus × Hereford crossbred calves were utilized in both studies. Myers et al. (1999b), and Schoonmaker et al. (1999b) also reported no difference in carcass weight due to age of weaning when British × Continental crossbred cattle were harvested at a constant fat thickness. It appears that hybrid vigor and influence of Continental genetics may affect the difference in carcass weight between EW and NW calves.

The effect of early weaning on carcass quality varies among studies. Myers et al. (1999a) reported that carcasses from EW calves (165 d) had higher marbling scores than those from NW calves (222 d) when harvested at the same fat thickness (yr 1 = Mt^{98} versus Mt^{32}, respectively; yr 2 = Mt^{68} versus Mt^{23}, respectively). In both years, a greater percentage of carcasses from EW calves graded Mid-Choice or greater than those from NW calves (yr 1 = 93 versus 68%, respectively; yr 2 = 81 versus 58%, respectively). In contrast, Grimes and Turner (1991b) reported that EW calves (110 d) had lower quality grades than NW calves (220 d) when harvested at a constant fat thickness (.90 cm). Lusby et al. (1990), Gill et al. (1993b), Myers et al. (1999b), and Schoonmaker et al. (1999b) found that EW and NW calves had similar marbling scores or quality grades when harvested at a constant fat thickness.

Meat palatability may be improved by early weaning. Schoonmaker et al. (1999b) reported that rib steaks from EW calves (113 d) tended to have lower WBS values than rib steaks from NW calves (204 d) (5.02 versus 5.39 kg, respectively). Taste panel scores for juiciness (1 to 10 scale; 1 = dry, 10 = juicy) also tended to be higher for rib steaks from EW calves when compared to those from NW calves. Taste panel scores for flavor and tenderness were similar between steaks from EW and NW calves.

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CHAPTER 2

Feedlot performance, carcass characteristics, and economic return of early weaned beef steers

Abstract

Over two years, forty-five Angus-sired steer offspring of Angus and Angus crossbred females were used to determine the effects of early weaning on feedlot performance, carcass characteristics, and economic return to the cow-calf enterprise. Steers were assigned by birth date to one of two weaning treatments: 1) weaned at an average age of 100 d (**EW**), or 2) weaned at an average age of 200 d (**NW**). Within 36 d of weaning, steers were given ad libitum access to a high concentrate diet (90% dry, whole-shelled corn). Steers were harvested when 12th rib fat thickness averaged 1.27 cm within treatment as estimated by ultrasound. Carcass measurements were taken 48 h postmortem. In year 1, rib steak tenderness was determined at 14 d postmortem by Warner-Bratzler shear force and myofibril fragmentation index (**MFI**). The EW steers had greater ADG from time of early weaning to normal weaning than suckling NW steers (1.27 vs .86 kg/d, respectively; $P < .001$). However, EW steers tended to have lower ADG for the entire finishing period than NW steers (1.33 vs 1.39 kg/d, respectively; $P = .08$). When compared to NW steers, EW steers had lower daily DMI (7.40 vs 5.95 kg/d, respectively; $P < .001$) and lower total DMI for the finishing period (1618 vs 1537 kg, respectively; $P = .04$). The EW steers had better feed efficiency for the finishing period than NW steers (.223 vs .189, respectively; $P < .001$). Carcass weights were lighter for EW steers relative to NW steers (277.9 vs 311.2 kg, respectively; $P < .001$). There was

no difference in yield grade (2.9 vs 3.0; P = .54) between treatments. All carcasses graded Low-Choice or greater and there was no difference in percentage of carcasses grading Mid-Choice or greater (94.5 vs 83.9% for EW and NW, respectively; P = .30). Warner-Bratzler shear force and MFI values were not different between treatments (P > .10). The EW steers had a lower cost of gain than NW steers (.905 vs 1.01 $/kg, respectively; P < .001), however due to lighter carcass weights, EW steers generated less return to the cow-calf enterprise than NW steers (358.56 vs 455.90 $/steer; P < .001). Early weaning steers at 100 d of age decreased total DMI, improved feed efficiency, and lowered cost of gain, however return to the cow-calf enterprise was decreased due to lighter carcass weights.

Introduction

Traditionally, beef calves are weaned at approximately seven months of age to maximize gross return to cow-calf enterprises which market calves at weaning. As the beef industry progresses toward coordinated production systems, ownership of calves may be retained by cow-calf enterprises through harvest. If ownership is retained, weaning calves at younger ages may increase production efficiency and therefore, increase return to cow-calf enterprises.

Recent reports have shown that early weaned calves have comparable ADG (Myers et al., 1999a and 1999b; Schoonmaker et al., 1999a) and improved feed efficiency during the finishing period relative to calves weaned at traditional ages (Gill et al., 1993a; Myers et al., 1999a and 1999b). Early weaned calves have lighter average body weights during the finishing period and therefore, have lower maintenance requirements relative to normal weaned calves. Daily dry matter intake of early weaned calves is also lower than that of normal weaned calves (Gill et al., 1993a; Myers et al., 1999a and 1999b).

The National Beef Quality Audit (NCBA, 1995) stated that decreasing harvest age and improving marbling will enhance product palatability and better meet demand of consumers. If early weaned calves are placed on a finishing diet immediately following weaning, they will be younger at harvest relative to calves weaned at traditional ages. It has been reported that early weaning increases marbling and quality grades (Myers, et al., 1999a). Implementation of management schemes that increase carcass quality, without sacrificing carcass weight or yield grade, may result in more economic return in value-based carcass pricing structures.

Therefore, the objectives of this research were to determine effects of early weaning beef steers with high marbling potential on feedlot performance and carcass characteristics and secondly, to determine economic return to the cow-calf enterprise.

Materials and Methods

Over two years, forty-five, spring-born, Angus-sired steer offspring of Angus and Angus crossbred 2- and 3- year-old cows were allotted by birth date and randomly assigned to one of two weaning treatments: 1) weaned at an average age of 100 ± 14 d (EW); 2) weaned at an average age of 200 ± 15 d (NW). Steers were sired by six different bulls in year 1, and five bulls in year 2. One bull was represented in both years. Therefore, ten sires were represented in the data set. In general, sires of these steers had high marbling and moderate birth weight, weaning weight, and yearling weight expected progeny differences. The dams of these steers were maintained at the Michigan State University Upper Peninsula Experiment Station, Chatham, Michigan.

Calves were weighed at birth and knife-castrated. Approximately, two weeks prior to time of weaning, steers were vaccinated against Clostridial infections (UltraBac 7, Pfizer, New York, NY or Vision 7, Bayer, Pittsburgh, PA) and common respiratory diseases (CattleMaster 4 plus L5 or Bovashield 4 plus L5, Pfizer, New York, NY). At weaning (June for EW steers and September for NW steers), steers were weighed and transported 650 km to the Beef Cattle Teaching and Research Center, Michigan State University. Upon arrival, steers received booster vaccinations, were treated for internal and external parasites (IvomecPlus, Merial, Whitehouse Station, NJ), and were treated with an antibiotic (Micotil, Elanco, Indianapolis, IN). Steers with rectal temperatures over 40°C (103.5°F) during the trial were considered morbid and were treated with Micotil or Nuflor (Schering-Plough, Union, NJ) per label instructions.

Steers were initially pen-fed for 21 d before they were housed individually in 2.1 × 1.8 m stalls with slatted floors. Steers were adapted to a finishing diet (diet B; Table 2-1) consisting of whole-shelled corn and a pelleted protein supplement within 36 d of weaning. Steers were switched from a diet containing 12.6% CP (diet B) to one containing 10.6% CP (diet C) when they weighed approximately 340 kg. Steers were given ad libitum access to diets. Orts were removed, and fresh feed was offered daily to each steer. One EW steer in yr 1 and two EW steers in yr 2 had chronic bloat, therefore 20 g of Poloxalene (BloatGuard, Pfizer, New York, NY) was added to their diet daily.

Feedstuffs were sampled approximately every 28 d for determination of CP, NDF, and ADF. Samples were ground through a Wiley mill (Arthur H. Thomas, Philadelphia, PA) fitted with a 5 mm screen and then ground with a Cyclotec sample mill (Model 1093, Tecator, Inc., Herndon, VA) fitted with a 1 mm screen. Dry matter was determined by drying samples in a forced air oven for 24 hr at 102°C. Combustion method 990.03 (AOAC, 1995; Leco FP-2000, Leco Corp., St. Joseph, MI) was used to determine CP. The Van Soest et al. (1991) method was performed to determine NDF and ADF on an organic matter basis.

The weight of both EW and NW calves at the time of early weaning and the weight of NW calves at the time of normal weaning was a single weight. The weight of EW calves at the time of normal weaning and live weight at harvest were calculated by averaging two weights taken on consecutive days. Interim weights were taken approximately every 28 d throughout the finishing period. Twelfth-rib subcutaneous fat accretion was monitored by real-time ultrasound (Pie 200 SLC, Pie Medical, Tequesta, FL). Steers were harvested when 12th rib fat thickness averaged 1.27 cm within treatment. None of the steers received anabolic implants during their lifetime. Experimental procedures were conducted according to those approved by the Michigan State University All University Committee on Animal Use and Care.

Early weaned steers were harvested in February, and NW steers were harvested in April. In year 1 cattle were harvested at Ada Beef, Ada, Michigan, and in year 2, they were harvested at Packerland, Plainwell, Michigan. Carcass data were collected 48 h postmortem. Carcass measurements collected were pre- and post-trim hot carcass weight

(**HCW**), longissimus muscle area (**LMA**), adjusted 12th rib subcutaneous fat thickness, marbling score, quality grade, and bone maturity. Post-trim HCW was taken after hot-fat trimming kidney, pelvic, and heart fat (**KPH**) from the carcass. The percentage of KPH was calculated as the difference in pre- and post-trim HCW divided by pre-trim HCW. Dressing percentage was calculated as pre-trim HCW divided by live weight at harvest less a 4% shrink.

In year 1, the entire rib section (IMPS-107; IMPS, 1988) and in year 2, only the section corresponding to the 11th and 12th rib were removed from the left side of each carcass and transported to Michigan State University Meats Laboratory for further analysis. A 2.5 cm thick steak was removed from the posterior end of the rib section (Steak #1). The remainder of the rib section was aged at 2°C for 14 d and then frozen. After Steak #1 was removed, colorimeter (Minolta Chroma Meter CR-310, Minolta Corp., Ramsey, NJ) readings were taken on the rib-face in the L*b*a* (luminance, L*; redness, a*; yellowness, b*) colorspace (Wulf et al., 1997). The measuring area was 50 mm in diameter. The face of the rib was allowed to bloom for 15 minutes before muscle color was measured. This process (blooming) allows for oxygenation of myoglobin causing the bright red color of beef. Only the longissimus muscle was scanned for color; intermuscular fat and spinalis dorsi muscle area were excluded.

After colorimeter readings were taken, Steak #1 was aged for 14 d at 2°C and myofibril fragmentation index (**MFI**) analysis was performed according to Culler et al. (1978) in year 1. In contrast to Culler et al. (1978), the procedure was performed on fresh meat samples, not frozen samples.

The frozen rib section was fabricated into 2.5 cm thick steaks. Each steak was numbered sequentially starting from the posterior end of the remaining rib section (Steak #2, Steak #3, etc.). In year 1, Steak #2 was used for Warner-Bratzler shear force (WBS) determination (Wheeler et al., 1995). Six 1.27 cm (diameter) cores were removed the longissimus dorsi muscle of each steak and sheared perpendicular to the longitudinal axis of muscle fibers with a Salter shearing device (G-R Electric, Manhattan, KS). The WBS value for each steak was the average value of the six cores. In year 1, moisture, CP, and lipid were determined in duplicate from powdered samples of Steak #3. Powdered samples were prepared by denuding frozen Steak #3 of the spinalis dorsi muscle, external fat and connective tissue, so that only the longissimus dorsi muscle remained. Then, the frozen longissimus dorsi was sliced (.5 cm thick) and chopped with a knife into small pieces. Pieces of chopped muscle, along with dry ice, were powdered using a Tecmar grinder (Tecmar Company, Cincinnati, OH). Dry ice was allowed to evaporate before powdered samples were stored at -20°C. Moisture was determined by drying powdered muscle samples in a forced air oven for 18 h at 102°C (method 950.46; AOAC, 1995). Combustion method 992.15 (AOAC, 1995; Leco FP-2000, Leco Corp., St. Joseph, MI) was used to determine crude protein. Lipid was determined by solvent extraction method 991.36 (AOAC, 1995; Tecator Soxtec System HT 1046 service unit and Tecator Soxtec System HT 1043 extraction unit, Tecator, Inc., Herndon, VA).

Performance data were used to calculate and compare the cost of gain of EW and NW steers. When the steers were pen-fed (initial 21 d of the finishing period), individual feed intake was considered the mean DMI for the pen. Feed and other operating costs (medication, chute charge, yardage, transportation, and interest; Appendix A-2) were determined. Cost of gain was calculated by summing feed and operating costs and dividing by total gain during the finishing period. Total gain was calculated by subtracting live weight at harvest from weaning weight (both weights were shrunk 4%).

Carcass data and four different carcass pricing schemes were used to calculate gross return to the cow-calf enterprise. Average monthly base carcass prices (yield grade 1 to 3, choice quality grade, 250 to 340 kg) from 1986 through 1998 were calculated from weekly carcass prices obtained from the U.S.D.A. Agricultural Marketing Service (U.S.D.A., 1999). The period of 1986 to 1998 was chosen because it was representative of an entire cattle price cycle (Figure 2-1). Depending upon the pricing scheme, base carcass price was adjusted by adding a premium of $6.61/100 kg for carcasses with Prime quality grades or meeting specifications of a generic branded beef program (≥ Mid-Choice quality grade, yield grade 1 to 3, and > 275 kg HCW). Yield grade 4 carcasses or those weighing < 250 kg were discounted $26.43/100 kg, as required by the pricing scheme. Total carcass revenue was calculated by multiplying the adjusted carcass price by HCW. Gross return to the cow-calf enterprise was the difference between total carcass revenue and total input cost from time of weaning to harvest. Feeder calf breakeven price was calculated as gross return to the cow-calf enterprise divided by weaning weight (shrunk 4%).

In pricing scheme-1 (**PS-1**), base carcass prices in February and April were used for EW and NW steers, respectively, which is representative of the trial. Carcasses having quality grades of Prime received a premium and those having yield grades of 4 or weighing < 250 kg were discounted. Pricing scheme-2 (**PS-2**) simulated selling carcasses into a generic branded beef program. February and April base carcass prices were used for EW and NW steers, respectively. Carcasses that met program specifications did not receive an additional quality grade premium if they graded Prime. Carcasses that graded Prime but did not meet other program specifications received a quality grade premium. Carcasses with yield grades of 4 and those weighing < 250 kg were discounted. Pricing scheme-3 (**PS-3**) was similar to PS-1, except carcasses weighing < 250 kg were not discounted. The cattle used in this trial may have been predisposed to light carcass weights due to their genotype. Therefore, the weaning system was not penalized for underweight carcasses in PS-3. May and July base carcass prices are used for EW and NW steers, respectively, in pricing scheme 4 (**PS-4**). These would be approximate selling dates if the calving season was 90 d later than in this trial. With a later calving season, EW cattle would have been sold at the peak base carcass price in the seasonal price cycle (Figure 2-2).

The GLM procedures of SAS (1990) were used to analyze feedlot performance, carcass data, meat characteristics, cost of gain and economic return. Steer served as the experimental unit. The model included weaning treatment, year, sire, and the weaning treatment × year interaction as independent variables in the statistical analysis of all data with the exception of morbidity rate. The GLM procedure over-adjusted for the effect of sire on morbidity rate resulting in negative least squares means. Therefore, sire was removed from the model when analyzing binomial morbidity rate data. The level of probability at which effects were considered significant was $P < .05$. In year 2, one EW steer was removed from the trial due to chronic morbidity. In year 2, one NW steer died due to bloat 16 d after weaning.

Results and Discussion

The EW steers had greater ADG from time of early weaning to normal weaning and were 18% heavier at time of normal weaning than NW calves (Table 2-2). There was a significant treatment × year interaction ($P < .10$) for ADG from time of early to normal weaning and weight at normal weaning. The difference in weight between EW and NW calves at normal weaning was 52.7 kg in year 1 and 24.3 kg in year 2 (Table 2-6). The smaller weight difference at normal weaning in year 2 can be attributed to increased ADG from time of early to normal weaning of NW steers in year 2 relative to year 1 (.94 versus .78 kg/d, respectively) and decreased ADG during the same period for EW steers in year 2 relative to year 1 (1.19 versus 1.34 kg/d, respectively). Increased ADG of NW steers in year 2 from early to normal weaning was likely due to increased milk production of their dams. In year 1, all dams were first-calf heifers. In year 2, only one quarter of the dams were first-calf females and the remainder were in their second parity. These results agree with those of Neville and McCormick (1981), Myers et al. (1999a), and Schoonmaker et al. (1999a) in which EW calves receiving a high concentrate diet had greater ADG than NW calves from time of early weaning to normal weaning.

The NW steers tended to have greater ADG for the finishing period (weaning to harvest) than EW calves ($P = .08$). The tendency for NW steers to have higher ADG for the finishing period resulted from accelerated gain early in the finishing period. The NW steers gained .14 kg/d more than EW steers during the initial 100 d of the finishing period. Growth of NW calves had been limited prior to weaning, therefore they experienced compensatory growth when dietary energy increased after weaning. Daily gain for the final 60 d of the finishing period was not different between EW and NW calves. Gill et al. (1993a) reported that finishing period ADG of NW calves was 10% greater than that of EW calves.

The EW steers had 19.6 % lower daily DMI during the finishing period than NW steers. Even though the finishing period of EW steers was 40 d longer than that of NW steers, EW steers consumed 81.5 less kg of DM than NW steers. It has been reported that EW calves have lower daily DMI than NW calves (Gill et al., 1993a; Myers et al., 1999a and 1999b; Schoonmaker et al., 1999a). However, in contrast to this study, others have observed that total DMI for the finishing period was greater for EW calves due to their longer finishing period (Schoonmaker et al., 1999a; Myers et al., 1999b).

Early weaning improved feed efficiency by 18% for the finishing period. The EW steers had lower maintenance requirements due to a lower average body weight during the finishing period compared to NW steers. There was a 69 kg difference in the average body weights of EW and NW steers during the finishing period. The largest difference in feed efficiency between EW and NW steers was during the initial 100 d of the finishing period. From d 0 through d 100 of the finishing period, EW steers were 27.7% more efficient than NW steers. The advantage in feed efficiency of EW calves over NW calves has ranged from 5 to 22% in previous research (Gill et al., 1993a; Myers et al., 1999a and 1999b; Schoonmaker et al., 1999a). In contrast, Pritchard et al. (1988) reported that EW and NW calves had similar feed efficiency. Their EW calves were weaned at 165 d, and NW calves were only 39 d older at time of normal weaning.

There was a significant treatment × year interaction for morbidity rate (Table 2-6). In year 1, EW steers had a higher morbidity rate than EW steers in year 2 and NW steers in either year. When averaged over both years, a greater percentage of EW steers had at least one incidence of morbidity than NW steers. There was no difference in the percentage of EW and NW steers having two or more incidences of morbidity. These results are in contrast with Myers et al. (1999a). They reported that EW calves (165 d of age) had a lower incidence of respiratory morbidity than NW calves (222 d of age). The EW calves in their study were 65 d older at weaning than the EW calves in this study which may have affected morbidity rate.

Carcass characteristics of EW and NW steers are displayed in Table 2-3. Hot carcass weight of EW steers was 33.3 kg lighter than that of NW steers when harvested at a constant fat thickness. Placing EW calves on a high concentrate diet likely promoted fat accretion at lighter weights relative to NW steers. The genotype (predominately Angus) of steers utilized in this study may have predisposed them to light carcass weights. Gill et al. (1993b) also reported that early weaning predominately Angus calves resulted in lighter weight carcasses than those of NW calves. However, others have reported similar carcass weights for EW and NW crossbred calves when harvested at a constant fat thickness (Lusby, et al., 1990; Myers et al., 1999a and 1999b; Schoonmaker et al., 1999b). The crossbred calves likely had more growth potential than Angus calves due to hybrid vigor and influence of Continental genetics. Marbling scores were similar for carcasses from EW and NW steers when averaged over both years, however, the treatment × year interaction was significant. In year 1, carcasses from EW steers had numerically higher marbling scores, and in year 2, they had numerically lower marbling scores than those from NW steers (Table 2-6). All carcasses graded Low-Choice or greater and there were no differences in the percentage of carcasses grading at least Mid-Choice or those grading at least High-Choice when averaged over both years. High quality grades can be attributed to the genotype of the steers; the average marbling expected progeny difference for the sires of these steers ranked in the top 20% of the Angus breed (American Angus Association, 1999). Yield grade and bone maturity were similar for carcasses from both treatments.

Rib steak color, tenderness, and composition are shown in Table 2-4. Steaks from NW steers had higher L* (whiter; greater reflectance) color values than those from EW steers. There was no difference in a* and b* values between steaks from EW and NW steers. Wulf et al. (1997) reported that L* value was negatively correlated (-.36) to WBS value. Although L* values were significantly higher for steaks from NW steers than for EW steers in this study, WBS values were similar for rib steaks from EW and NW steers. Schoonmaker et al. (1999b) reported that steaks from EW calves (113 d of age) tended to have lower WBS values than steaks from NW calves (204 d of age). Steaks from NW steers had a higher protein content than those from EW steers. Percentage of moisture and lipid were similar between treatments.

Economic return to the cow-calf enterprise of EW steers is compared to that of NW steers in Table 2-5. The treatment × year interaction was significant for feed cost, total input cost, and cost of gain (Table 2-6). The interaction resulted from numerically higher feed costs for EW steers relative to NW steers in year 1, but in year 2, EW steers had numerically lower feed costs than NW steers. Even though EW steers consumed less total feed than NW steers, feed costs were similar for EW and NW steers when averaged over both years. The pelleted protein supplement, which was the most expensive component of the diet, accounted for a larger proportion of total feed consumed by EW steers relative to NW steers (7.2 versus 5.7%, respectively). Operating costs were higher for EW steers than NW steers. This can be primarily attributed to greater yardage fees charged to EW steers because they had a 40 d longer finishing period than NW steers. Even though total input costs were similar for EW and NW steers when averaged over both years, cost of gain was lower for EW steers than for NW steers. The EW steers had more total gain over the finishing period than did NW steers, therefore total cost was divided over more kg of gain, resulting in a lower cost of gain. Under PS-1, adjusted carcass price was lower for EW steers relative to NW steers. This was primarily due to the seasonal cattle price cycle (Figure 2-2). Also two EW steers were discounted for underweight carcasses (< 250 kg) which decreased the average adjusted carcass price paid for EW steers. Pricing scheme-2 simulated carcasses being sold into a generic branded beef program. A greater number of carcasses from NW steers met program specifications, therefore, average adjusted carcass price for NW steers was greater than that for EW steers. In general, carcasses from EW steers were too light to meet program specifications. When the early weaning management system was not penalized for light weight carcasses in PS-3, adjusted carcass prices were similar for EW and NW steers. If the calving season had been 90 d later, EW steers would have been sold at peak base carcass prices due to the seasonal price cycle. Under this assumption in PS-4, adjusted carcass price was higher for EW steers than for NW steers. Under all four pricing schemes, early weaning resulted in less return to the cow-calf enterprise because carcasses from EW steers were lighter weight than those from NW steers.

Implications

Early weaning beef steers at 100 d of age resulted in lower daily DMI and lower total feed consumption for the finishing period relative to normal weaning at 200 d of age. Early weaning improved feed efficiency and lowered cost of gain. However, EW steers had lighter carcass weights than NW steers. This would result in less return to the cow-calf enterprise if ownership of calves was retained through harvest.

Table 2-1. Composition of finishing diets fed to steers

	Diet[a]		
Ingredient	A	B	C
	% of diet (DM basis)		
Hay, %[b]	60	0	0
Whole-shelled corn, %	30	90.4	95.1
Pelleted supplement, %[c]	10	9.6	4.9
CP, %	16.2	12.6	10.6
NDF, %	39.9	14.2	14.5
ADF, %	23.7	4.0	3.9
NE_m, Mcal/kg	1.48	2.08	2.13
NE_g, Mcal/kg	.90	1.43	1.47

[a] Steers were progressively stepped up from diet A to diet B within 36 d of weaning; cattle were switched from diet B to diet C when they weighed approximately 340 kg.

[b] NRC (1996) table composition.

[c] Soybean meal, 45.8%; wheat middlings, 12.0%; salt, 4.25%; urea, 9.1%; calcium carbonate, 18.9%; potassium chloride, 7.8%; selenium, .011%; Vitamin A, 25,000 IU/lb; Vitamin D, 2500 IU/lb; Vitamin E, 180 IU/lb; cobalt carbonate, .033%; copper sulfate, 2.9%; ferrous sulfate, 8.9%; magnesium sulfate, 9.8%; calcium iodate, .11%; zinc sulfate, 8.0%; fat 1.0%; Bovatec 68, .53 %.

Table 2-2. Performance, feed efficiency, and dry matter consumption of early weaned (EW; 100 d) and normal weaned (NW; 200 d) steers

	Treatment			
Item	EW	NW	SEM[a]	P-value
Number of steers	22	23	-	-
Days on feed	258	218	0	-
Weight at early weaning, kg	122.7	124.6	3.6	.65
Weight at normal weaning, kg[b]	249.4	211.0	5.0	.01
Live weight at harvest, kg	465.8	514.6	7.9	.01
ADG, kg/d				
Early to normal weaning[b]	1.27	.86	.03	.01
Initial 100 d of finishing period	1.31	1.45	.04	.01
Final 60 d of finishing period	1.28	1.16	.07	.13
Entire finishing period	1.33	1.39	.03	.08
Early weaning through harvest	1.33	1.23	.03	.01
Feed efficiency, gain:feed				
Initial 100 d of finishing period	.281	.220	.006	.01
Final 60 d of finishing period	.177	.144	.008	.01
Entire finishing period	.223	.189	.005	.01
Daily DMI, kg				
Initial 100 d of finishing period	4.68	6.60	.13	.01
Final 60 d of finishing period	7.15	8.02	.22	.01
Entire finishing period	5.95	7.40	.14	.01
Total DMI for the finishing period, kg	1536.8	1618.3	34.0	.04
Morbidity rate, %				
≥ 1 incidence of morbidity[b]	55.3	27.3	9.5	.04
≥ 2 incidences of morbidity[b]	27.3	9.1	7.2	.12

[a] Standard error of the LS means.
[b] Treatment × year interaction ($P < .10$).

Table 2-3. Carcass characteristics of early weaned (EW; 100 d) and normal weaned (NW; 200 d) steers

	Treatment			
Item	EW	NW	SEM[a]	P-value
Number of carcasses	22	23	-	-
Hot carcass weight, kg	277.9	311.2	4.8	.01
Post-trim hot carcass weight, kg[b]	269.2	300.5	4.5	.01
Dressing percentage[c]	62.1	63.0	.4	.03
Longissimus muscle area, cm^2	76.3	79.4	2.0	.19
Adjusted subcutaneous fat thickness, cm	1.4	1.4	.1	.81
Kidney, pelvic, and heart fat, %[de]	3.2	3.5	.2	.16
Yield grade	3.1	3.2	.2	.36
Marbling score[ef]	711	722	23	.68
≥ Low-Choice, %	100.0	100.0	0	1.0
≥ Mid-Choice, %[e]	94.5	83.9	8.7	.30
≥ High-Choice, %[e]	57.1	73.3	12.6	.27
≥ Prime, %	32.8	26.7	11.6	.65
Bone maturity[g]	129	132	3	.46

[a] Standard error of the LS means.
[b] Hot carcass weight after hot-fat-trimming kidney, pelvic, and heart area.
[c] Calculated as pre-trim hot carcass weight divided by shrunk live weight at harvest (4% shrink).
[d] Calculated as the difference between pre- and post-trim hot carcass weight divided by pre-trim hot carcass weight.
[e] Treatment × year interaction ($P < .10$).
[f] $Small^{00} = 500$, $Modest^{00} = 600$, $Moderate^{00} = 700$, Slightly $Abundant^{00} = 800$.
[g] $A^{00} = 100$, $B^{00} = 200$.

Table 2-4. Color, tenderness, and composition of rib steaks from early weaned (EW; 100 d) and normal weaned (NW; 200 d) steers

	Treatment			
Item	EW	NW	SEM[a]	P-value
Color				
Number of steaks	22	23	-	-
L*[b]	41.5	43.0	.5	.01
a*[c]	24.0	23.9	.3	.96
b*[d]	11.4	11.6	.3	.61
Tenderness				
Number of steaks	11	12	-	-
Warner-Bratzler shear force, kg[e]	2.9	2.8	.2	.77
Myofibril Fragmentation Index[e]	87.4	95.3	5.6	.32
Composition				
Number of steaks	11	12	-	-
Moisture, %	71.6	70.8	.4	.14
Ether extract, %[f]	6.1	6.6	.6	.47
Protein, %[f]	20.9	21.6	.3	.05

[a] Standard error of the LS means.
[b] 0 = black; 100 = white.
[c] Negative numbers = green; positive numbers = red.
[d] Negative numbers = blue; positive numbers = yellow.
[e] Measured 14 d postmortem.
[f] Wet basis.

Table 2-5. Input costs, adjusted carcass price, total carcass revenue, return to the cow-calf enterprise, and feeder calf breakeven price of early weaned (EW; 100 d) and normal weaned (NW; 200 d) steers using four different carcass pricing schemes

Item	Treatment EW	NW	SEM[a]	P-value
Number of steers	22	23	-	
Weaning wt, kg[b]	118.9	202.4	3.8	.01
Total input costs, \$/steer[cd]	280.89	275.60	1.65	.24
Feed cost, \$/steer[e]	184.74	187.87	4.07	.51
Operating cost, \$/steer[cf]	96.15	87.74	1.43	.01
Cost of gain, \$/kg[cg]	.855	.952	.021	.01
Carcass weight, kg	277.9	311.2	4.8	.01
Pricing scheme 1 - priced as per trial with premiums for quality grade and discounts for weight and yield grade[h]				
Adjusted carcass price, \$/100 kg	237.71	242.73	2.13	.05
Total carcass revenue, \$/steer	661.78	755.69	14.57	.01
Return to cow-calf enterprise, \$/steer	380.89	480.08	13.21	.01
Feeder calf breakeven price, \$/100 kg	321.51	220.82	11.36	.01
Pricing scheme 2 - priced as per trial with premiums for certified program, and discounts for weight and yield grade[i]				
Adjusted carcass price, \$/100 kg	238.39	245.71	2.43	.01
Total carcass revenue, \$/steer	663.37	764.80	15.60	.01
Return to cow-calf enterprise, \$/steer	382.49	489.20	14.16	.01
Feeder calf breakeven price, \$/100 kg	324.48	245.42	12.11	.01

Table 2-5 (cont'd)

Pricing scheme 3 - priced as per trial with premiums for quality grade and discounts for yield grade[j]				
Adjusted carcass price, \$/100 kg	239.31	241.97	1.71	.18
Total carcass revenue, \$/steer	665.64	753.84	12.66	.01
Return to cow-calf enterprise, \$/steer	384.74	478.24	11.53	.01
Feeder calf breakeven price, \$/100 kg	325.40	238.96	10.50	.01
Pricing scheme 4 - priced 90d later than trial with premiums for quality grade and discounts for weight and yield grade[k]				
Adjusted carcass price, \$/100 kg	244.25	236.25	2.13	.01
Total carcass revenue, \$/steer	679.22	735.60	14.65	.01
Return to cow-calf enterprise, \$/steer	378.66	435.53	12.54	.01
Feeder calf breakeven price, \$/100 kg	320.61	218.77	10.93	.01

[a] Standard error of the LS means.
[b] 4% shrunk weaning wt.
[c] Treatment × year interaction.
[d] Sum of feed and operating cost.
[e] Feed cost plus interest accrued on feed.
[f] Sum of health, transportation, yardage, and chute charges and the interest accrued on said costs.
[g] Calculated by dividing total cost by the difference in shrunk live wt at harvest and shrunk weaning wt (4% shrink).
[h] Feb. and Apr. base carcass price for EW and NW, respectively; premium for Prime quality grade = \$6.61/100 kg; discount for < 250 kg = \$26.43/100 kg; discount for yield grade 4 = \$26.43/100 kg.
[i] Feb. and Apr. base carcass price for EW and NW, respectively; premium for meeting certified program specifications of ≥Mid-Choice, > 275 kg, and yield grade 1 to 3 = \$6.61/100 kg; discount for < 250 kg = \$26.43/100 kg; discount for yield grade 4 = \$26.43/100 kg.
[j] Feb. and Apr. base carcass prices for EW and NW, respectively; premium for Prime quality grade = \$6.61/100 kg; discount for yield grade 4 = \$26.43/100 kg.
[k] May and July base carcass price for EW and NW, respectively; premium for Prime quality grade = \$6.61/100 kg; discount for < 250 kg = \$26.43/100 kg; discount for yield grade 4 = \$26.43/100 kg.

Table 2-6. Least squares means for significant treatment×year interactions

	Treatment				
	Year 1		Year 2		
Item	EW	NW	EW	NW	SEM[a]
Weight at normal weaning, kg	237.8[y]	185.1[x]	261.1[z]	236.9[y]	7.1
ADG, early to normal weaning, kg/d	1.34[x]	.78[w]	1.19[y]	.94[z]	.04
Kidney, pelvic, heart fat, %[b]	3.9[y]	4.7[x]	2.4[z]	2.2[z]	.28
Marbling score[c]	731	681	692	763	33
≥ Mid-Choice, %	97.4[y]	60.8[x]	91.5[xy]	107.0[y]	12.4
≥ High-Choice, %	73.2[xy]	37.1[x]	41.0[x]	109.6[y]	18.0
Total Input Cost, $/steer[d]	273.31[y]	254.15[x]	288.47[yz]	297.05[z]	5.46
Operating cost, $/steer[e]	96.11[y]	80.99[x]	96.20[y]	94.49[y]	2.34
Cost of gain, $/kg[f]	.807[x]	.849[xy]	.904[y]	1.06[z]	.02

[a] Standard error of the LS means.

[b] Calculated as the difference in pre- and post-trim hot carcass weight divided by pre-trim hot carcass weight.

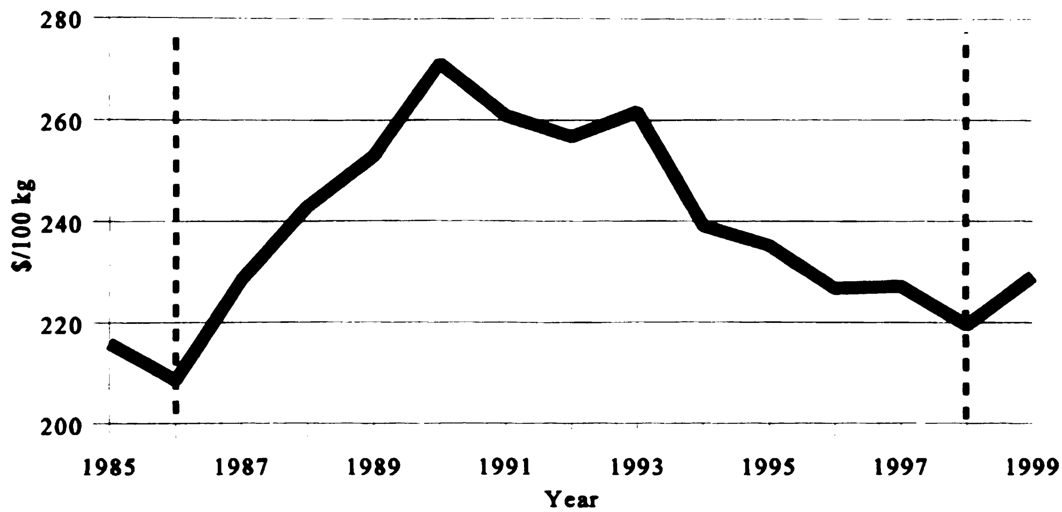
[c] $Small^{00}$ = 500, $Modest^{00}$ = 600, $Moderate^{00}$ = 700, Slightly $Abundant^{00}$ = 800.

[d] Sum of feed cost, interest on feed cost and operating costs.

[e] Sum of health, transportation, yardage, and chute charges and the interest accrued on said costs.

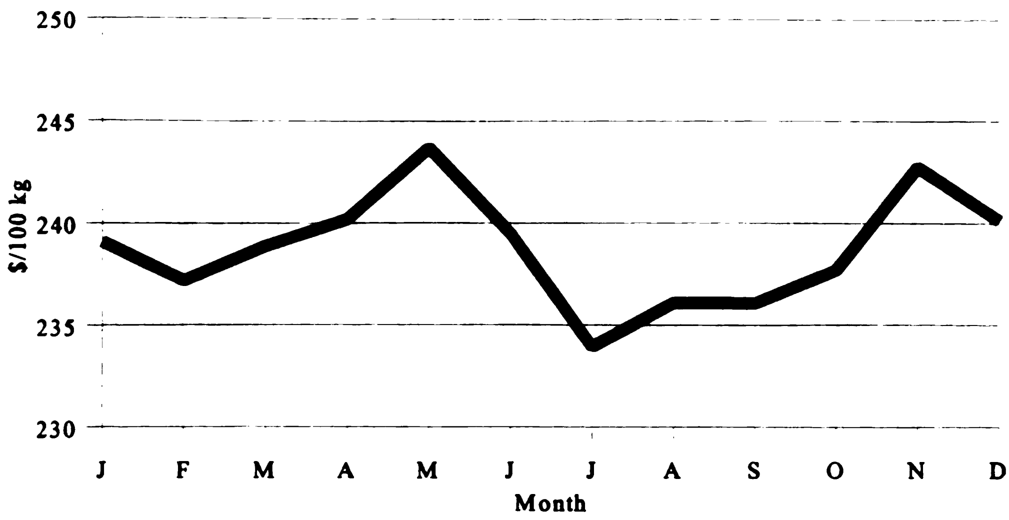
[f] Calculated by dividing total cost by the difference in shrunk live weight at harvest and shrunk weaning weight (4% shrink).

[w,x,y,z] Within a row, means lacking a common superscript letter differ ($P < .05$).



Year	Price, $/100 kg	Year	Price, $/100 kg
1985	215.81	1993	261.75
1986	208.49	1994	239.08
1987	228.58	1995	235.25
1988	243.05	1996	226.76
1989	253.03	1997	227.15
1990	271.33	1998	219.44
1991	260.86	1999	229.11
1992	256.79		

Figure 2-1. Average annual base carcass prices from 1985 to 1999 (U.S.D.A., Agricultural Marketing Service).



Month	Price, $/100 kg	Month	Price, $/100 kg
January	239.10	July	233.94
February	237.19	August	236.10
March	238.90	September	236.07
April	240.20	October	237.70
May	243.72	November	242.78
June	239.50	December	240.14

Figure 2-2. Average seasonal base carcass price from 1985 to 1998 (U.S.D.A., Agricultural Marketing Service).

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CHAPTER 3

Performance of beef cows after early weaning calves

Abstract

Over two years, fifty-six Angus and Angus crossbred 2- and 3-year-old cows were used to determine the effect of early weaning calves at 100 d on body weight, body condition, and reproductive performance. Cows were allotted by date of parturition and assigned to one of two treatments: 1) calves weaned at an average age of 100 d (**EW**); 2) calves weaned at an average age of 200 d (**NW**). Cow weight and body condition score (**BCS**; 1 to 9 scale; 1 = extremely thin, 9 = obese) were taken at parturition, time of early weaning, time of normal weaning, and at the subsequent parturition. The breeding season began 14 d prior to time of early weaning and extended for 58 d. Calving dates were used to estimate calving rates to artificial insemination (283 ± 8 d). From time of early weaning to normal weaning, dams of EW calves had greater ADG than dams of NW calves (.45 vs .19 kg/d, respectively; $P < .001$). This resulted in dams of EW calves being 21.4 kg heavier than dams of NW calves at time of normal weaning. Body condition of dams with EW calves also improved by .7 BCS from time of early weaning to normal weaning, whereas BCS of dams with NW calves was unchanged during the same period. From time of normal weaning to the subsequent parturition, dams of NW calves gained more condition than dams of EW calves (1.27 vs .80 change in BCS, respectively; $P < .01$). This resulted in similar body condition scores for dams with EW and NW calves at the subsequent parturition. Calving rate to artificial insemination and overall pregnancy

rate were similar for dams with EW and NW calves (P >.10). Early weaning resulted in greater weight gain from time of early weaning to that of normal weaning and quicker recovery of body energy reserves. Reproductive performance was unaffected by early weaning calves at 100 d of age.

Introduction

Failure to become pregnant within 80 d postpartum is the primary reason that females fail to wean a calf annually. Weaning eliminates energy demands of lactation and allows for reallocation of energy to reproductive functions. As well, the inhibitory effect of the suckling stimulus on estrus is removed at weaning. Removal of the suckling stimulus results in shortened postpartum anestrus periods (Short et al., 1972; Carter et al., 1980; Faltys et al., 1987). If calves are weaned prior to the breeding season, reproductive performance may be improved (Laster et al., 1973; Lusby et al., 1981).

Feed costs account for at least 50% of all costs incurred by cow-calf enterprises (Strohbehn, 1997). Early weaning allows for quicker recovery of body energy reserves that are lost due to large energy demands during early lactation. If energy reserves are recovered prior to the winter feeding season, less harvested feed may be required for females to reach optimum body condition by the subsequent parturition. Therefore, winter feed costs may be reduced by early weaning.

The objectives of this research were to determine the effect of early weaning beef calves at 100 d of age on cow weight, body condition, and reproductive performance.

Materials and Methods

Over 2 years, fifty-six Angus and Angus crossbred 2- and 3-year-old cows were used to determine the effect of early weaning calves on body weight, body condition and reproductive performance. Cows were allotted by date of parturition and assigned to one of two treatments: 1) calves weaned at an average age of 100 d (**EW**); 2) calves weaned at an average age of 200 d (**NW**). Cows were maintained at the Michigan State University Upper Peninsula Experiment Station, Chatham, MI.

Cows were weighed and body condition scores (**BCS**; 1 to 9 scale; 1 = extremely thin, 9 = obese) were recorded at parturition, at time of early weaning, at time of normal weaning, and at the subsequent parturition. Body condition scores were assigned by two experienced evaluators and then averaged. Estrus was synchronized with gonadotropin releasing hormone and prostaglandin so that ovulation occurred approximately two weeks prior to time of early weaning. Cows were artificially inseminated at a timed breeding 14 d prior to time of early weaning. Artificial insemination (**AI**) was performed by one of three experienced inseminators. Inseminator and service sire were randomly assigned at the AI. Cows were then exposed to fertile bulls for the remainder of the 58 d breeding season. Cows were palpated at the time of normal weaning for determination of pregnancy. Open cows were culled and removed from the study at time of normal weaning. Calving dates were used to estimate calving rates to the timed AI (283 ± 8 d).

Winter feeding consisted of ad libitum access to mixed grass hay. In year 1, cows were supplemented with approximately 2.6 kg/d (DM) of barley for 146 d and in year 2 they were supplemented with 5.6 kg/d (DM) of either alfalfa silage or corn silage.

Experimental procedures were conducted according to those approved by the Michigan State University All University Committee on Animal Use and Care.

The GLM procedures of SAS (1990) were used to analyze body weight, BCS, and reproductive performance. Cow served as the experimental unit. The model included weaning treatment and year as independent variables. The treatment × year interaction did not account for significant variation in the model, therefore it was removed. Any female that was not pregnant at time of normal weaning was culled and removed from the study. For the 2 year study, four females with EW calves and eight females with NW calves were culled because they were not pregnant at time of normal weaning. The level of probability at which effects were considered significant was $P < .05$.

Results and Discussion

Weight and BCS of dams did not differ at time of early weaning. From time of early weaning to normal weaning, dams of EW calves had greater ADG than dams of NW calves (Table 3-1). This resulted in dams of EW calves being 21.4 kg heavier than dams of NW calves at time of normal weaning. Also, dams with EW calves gained body condition from time of early weaning to normal weaning whereas BCS of dams with NW calves was unchanged. This resulted in dams of EW calves having a greater BCS than dams of NW calves prior to the winter feeding period. It has been well-documented that early weaning results in weight gain and quicker recovery of body energy reserves (Purvis et al., 1995; Myers et al., 1999a and 1999b). From time of normal weaning to the subsequent parturition, dams of NW calves experienced greater improvement in BCS than dams of EW calves. This resulted in similar condition scores for dams of EW and NW calves by the subsequent parturition. According to NRC (1996) equations, dams of NW calves would have required 45% more energy above maintenance (317.4 versus 219.4 Mcal of NE_g) than dams of EW calves from normal weaning to achieve the change BCS that was observed.

Early weaning did not improve calving rate to artificial insemination and there was also no difference in overall pregnancy rate between dams of EW and NW calves. However, early weaning tended to improve calving rate to natural service. It was not expected that early weaning would improve calving rate to artificial insemination in this study because initial insemination occurred prior to time of early weaning. Laster et al. (1973) and Lusby et al. (1981) reported that early weaning improved reproductive performance of young females ($\leq$ 2 parities). In both studies, early weaning occurred prior to the breeding season. Therefore, energy requirements for lactation were eliminated and the suckling stimulus had been removed before the breeding season. The potential positive impact of early weaning on reproductive performance in the present study may have been diminished because dams of EW and NW calves were in good condition (average BCS > 5) prior to the breeding season and were not in negative energy balance. Richards et al. (1986) reported that reproductive performance of females in good condition (BCS $\geq$ 5) is unaffected when body weight is gained.

Implications

The cessation of lactation by early weaning allowed for body weight gain and recovery of body condition. Increased body condition of dams of EW calves relative to dams of NW calves prior to the winter feeding period may result in less energy required over the winter feeding period.

Table 3-1. Weight, body condition scores, and reproductive performance of dams having calves early weaned (EW; 100 d) or normal weaned (NW; 200 d)

	Treatment					
Item	n	EW	n	NW	SEM[a]	P-value
Postpartum weight, kg	44	464.4	42	466.9	7.9	.82
Postpartum BCS[b]	44	4.7	42	4.7	.1	.78
Weight at early weaning, kg	44	455.2	42	457.4	5.7	.79
BCS at early weaning[b]	44	5.2	42	5.1	.1	.62
Weight at normal weaning, kg	44	499.3	41	477.9	6.1	.01
BCS at normal weaning[b]	44	5.8	41	5.1	.1	.01
ADG from early weaning to normal weaning, kg	44	.45	41	.19	.02	.01
BCS change from early weaning to normal weaning[b]	44	.69	41	.00	.09	.01
Overall pregnancy rate, %[c]	44	91.4	42	81.5	5.3	.41
Calving rate to AI, %[d]	44	41.0	42	50.1	7.8	.18
Calving rate to natural service, %[e]	44	50.5	42	31.4	7.5	.07
Weight at subsequent calving, kg	40	588.1	33	563.7	8.5	.03
BCS at subsequent parturition[b]	40	6.6	34	6.4	.1	.23
ADG from normal weaning to subsequent parturition, kg	40	.48	32	.44	.02	.15
BCS change from normal weaning to subsequent parturition[b]	40	.80	33	1.27	.11	.01

[a] Standard error of the LS means.
[b] Body condition score (1 to 9 scale; 1 = extemely thin, 9 = obese).
[c] Percentage of cows palpated as pregnant of those that were bred.
[d] Percentage of cows that calved 283 ± 8 d following artificial insemination.
[e] Percentage of cows that calved > 283 ± 8 d following artificial insemination.

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CHAPTER 4

Interpretive Summary

Traditionally, calves are weaned at approximately seven months of age to maximize gross economic return to cow-calf enterprises which market calves at weaning. As the beef industry evolves from a segmented to a vertically coordinated industry, early weaning calves may be a viable management strategy for cow-calf enterprises that retain ownership of calves through harvest. Over two years, the effect of early weaning (100 d of age) beef steers with high marbling potential on feedlot performance, carcass characteristics, cow performance, and economic return to cow-calf enterprises was compared to that of steers normal weaned at a traditional age of 200 d.

Although EW steers experienced greater ADG than NW steers from time of early weaning to harvest, they tended to have lower ADG for the entire finishing period relative to NW steers. Early weaned steers had 20% lower daily dry matter intake. This resulted in less total feed consumption for the finishing period even though the finishing period of EW steers was 40 d longer than that of NW steers. Early weaned steers were also 23% more feed efficient than NW steers. The EW steers had lighter average body weights during the finishing period which resulted in lower maintenance requirements.

When harvested at a constant fat thickness, EW steers had lighter carcass weights than NW steers. Two carcasses from EW steers weighed less than 250 kg. There were no differences in longissimus muscle area, percentage of kidney, pelvic, and heart fat, yield grade, or bone maturity between carcasses from EW and NW steers. All carcasses graded low Choice or greater, and there were no differences in the percentage of carcasses grading at least Mid-Choice or grading at least High-Choice.

Due to a longer finishing period, yardage cost was greater for EW steers relative to NW steers. However, EW steers gained more total weight and consumed less feed than NW steers. This advantage in feed efficiency offset greater yardage cost resulting in lower cost of gain for EW steers relative to NW steers. Even though EW steers had a lower cost of gain than NW steers, they generated less economic return to the cow-calf enterprise due to lighter weight carcasses than NW steers.

Early weaning resulted in body weight gain and body condition score improvement of dams from time of early weaning to that of normal weaning. Dams of EW calves were in better condition prior to the winter feeding period than dams of NW calves. In order to achieve the change in BCS observed at the subsequent parturition, it would be expected that dams of EW calves consumed less energy during the winter feeding period than dams of NW calves

This study indicates that early weaning results in less economic return to the cow-calf enterprise because EW steers had lighter carcass weights than NW steers. The cattle used in this study may have been predisposed to light carcass weights due to their genotype. Steers were sired by Angus bulls and their dams were Angus-based females. If the steers had been sired by Continental bulls, carcass weight would have likely increased due to the influence of growth oriented, Continental sires and hybrid vigor. Also, in year 1, steers were sired by calving ease bulls. In general, yearling weight may be sacrificed when sires with a low birth weigh expected progeny difference are utilized because birth weight and yearling weight expected progeny differences are positively correlated. Other studies have shown that carcass weights of EW crossbred calves are comparable to NW crossbred calves, however in those studies economic return was not determined. Further research is needed to quantify the economic impact of early weaning calves with more growth potential.

The steers utilized in this study did not receive anabolic implants. The use of anabolic implants is a common management strategy that improves ADG and feed efficiency, however, some implants have been shown to decrease carcass quality grades. Further research is needed to determine the effects of an implant strategy on feedlot performance and carcass characteristics of EW calves and the resulting impact on economic return.

The effect of early weaning on health status and morbidity rate of calves needs to be determined. This study also indicated that EW steers had higher morbidity rates than NW steers, however, the sample size was small. Research is needed in order to establish vaccination and medication programs that are appropriate for EW calves.

Further research and(or) additional economic analyses are required to thoroughly compare the economic consequence of an early weaning production system to that of a traditional production system with retained ownership in the Eastern Cornbelt. In this study, input costs and economic return were calculated for only the postweaning period. Pasture cost from time of early weaning to that of normal weaning was not charged to NW steers. Winter feed costs and health costs for the cow herd were not included. National average base carcass prices used in this study may not be representative of carcass prices in the Eastern Cornbelt. As well, the seasonal cattle price cycle in the Eastern Cornbelt may differ from the national average due to the number of farmer-feeders in the Eastern Cornbelt. Demand for carcasses grading Mid-Choice or higher may be greater in the Eastern Cornbelt than the national average due to the large proportion of export beef trade from the East Coast. This may also affect base carcass price, premiums paid for carcasses grading at least Mid-Choice, and the seasonal cattle price.

As the beef industry progresses toward coordinated production systems and value-based marketing, it is of upmost importance that management strategies implemented at one point in the system do not adversely affect economic return to the entire system. Production systems and management strategies that efficiently produce beef which is demanded in the marketplace need to be identified.

APPENDIX

Table A-1. Vaccination and medication schedule and product listing for early weaned and normal weaned steers

Item	Date	Booster date	Product
Respiratory disease vaccination			
Year 1			
Early weaned steers	5-29-97	6-10-97	CattleMaster 4+5L; Pfizer, New York, NY
Normal weaned steers	8-21-97	9-18-97	BovaShield 4+5L; Pfizer, New York, NY
Year 2			
Early weaned steers	5-28-98	6-12-98	CattleMaster 4+5L; Pfizer, New York, NY
Normal weaned steers	8-26-98	9-17-98	CattleMaster 4+5L; Pfizer, New York, NY
Clostridial vaccination			
Year 1			
Early weaned steers	5-29-97	6-10-97	UltraBac 7; Pfizer, New York, NY
Normal weaned steers	5-29-97 and 8-21-97	6-9-97 and 9-18-97	UltraBac 7; Pfizer, New York, NY
Year 2			
Early weaned steers	5-28-98	6-12-98	Vision 7; Bayer, Pittsburgh, PA
Normal weaned steers	5-28-98 and 8-26-98	6-11-98 and 9-17-98	Vision 7; Bayer, Pittsburgh, PA
Parasite treatment			
Year 1			
Early weaned steers	6-10-97	--	IvomecPlus; Merial, Whitehouse Station, NJ
Normal weaned steers	9-18-97	--	IvomecPlus; Merial, Whitehouse Station, NJ
Year 2			
Early weaned steers	6-12-98	--	IvomecPlus; Merial, Whitehouse Station, NJ
Normal weaned steers	9-17-98	--	IvomecPlus; Merial, Whitehouse Station, NJ
Mass antibiotic treatment			
Year 1			
Early weaned steers	6-10-97	--	Micotil; Elanco, Indianapolis, IN
Normal weaned steers	9-18-97	--	Micotil; Elanco, Indianapolis, IN
Year 2			
Early weaned steers	6-12-98	--	Micotil; Elanco, Indianapolis, IN
Normal weaned steers	9-17-98	--	Micotil; Elanco, Indianapolis, IN

Table A-2. Description of costs used to calculate feed and operating costs during the finishing period

Item	Cost	Source	Notes
Feed			
Corn	$.101/kg DM	ADM-Countrymark, Toledo, OH, 1986-1998	Averaged for only months that were included in the finishing period (June-Feb. for EW; Sept-Apr. for NW)
Pellets	$.315/kg DM	Purina Mills, Lansing, MI	Converted from $320/ton (wet); 89.5% DM
Hay	$.084/kg DM	Morgan's Weekly Hay Price	Mixed hay from Northern IL; converted from $65/ton (wet); 85% DM
Interest on feed	5%	--	Calculated on total cost of feed for half of the finishing period (109 d for EW; 129 d for NW)
Operating costs			
Medication			
IvomecPlus	$.62/ml	Valley Vet Supply, Marysville, KS	Merial, Whitehouse Station, NJ
Micotil	$.97/ml	Stoneman's Cattle Company, Brekenridge, MI	Elanco, Indianapolis, IN
Nuflor	$.40/ml	Stoneman's Cattle Company, Brekenridge, MI	Schering-Plough, Union, NJ
Yardage	$.28/d		Estimated industry charge
Chute charge	$1.00/animal	Stoneman's Cattle Company, Brekenridge, MI	Each time a steer went through the chute, $1.00 fee was charged
Transportation	$.0000546/kg per loaded km		Chatham to East Lansing = 645 km; East Lansing to packing plant = 130 km
Interest on operating costs	5%		Calculated on total operating costs for the entire finishing period

Table A-3. Description of four pricing schemes used to calculate revenue generated by early weaned (EW; 100 d) and normal weaned (NW 200 d) steers

Item	Value	Notes
Pricing scheme 1		
Carcass base price	\$239.40/100 kg for EW; \$242.86/100 kg for NW	Average price in February and April for EW and NW, respectively; U.S.D.A. Agric. Marketing Service, Des Moines, IA
Premium	\$6.61/100 kg for Prime quality grade	
Discount	\$26.43/100 kg for yield grade 4 or < 250 kg	
Pricing scheme 2		
Carcass base price	\$239.40/100 kg for EW; \$242.86/100 kg for NW	Average price in February and April for EW and NW, respectively; U.S.D.A. Agric. Marketing Service, Des Moines, IA
Premium	\$6.61/100 kg for Prime quality grade; \$6.61/100 kg for carcasses grading at least Mid-Choice, yield grade 1-3, and weighing > 275 kg	Prime carcasses that also qualified for the branded program received only one premium; they did not receive two premiums for being Prime and meeting program specifications
Discount	\$26.43/100 kg for yield grade 4 and < 250 kg	
Pricing scheme 3		
Carcass base price	\$239.40/100 kg for EW; \$242.86/100 kg for NW	Average price in February and April for EW and NW, respectively; U.S.D.A. Agric. Marketing Service, Des Moines, IA
Premium	\$6.61/100 kg for Prime quality grade	
Discount	\$26.43/100 kg for yield grade 4	The cattle used in the trial may have been predisposed to underweight carcasses due to their genotype, therefore under pricing scheme 3, the management system is not liable for underweight carcass
Pricing scheme 4		
Carcass base price	\$245.94/100 kg for EW; \$236.38/100 kg for NW	Average price in May and July for EW and NW, respectively; U.S.D.A. Agric. Marketing Service, Des Moines, IA
Premium	\$6.61/100 kg for Prime quality grade	
Discount	\$26.43/100 kg for yield grade 4 and < 250 kg	

Table A-4. Sires of early weaned (100 d) and normal weaned (200 d) steers

Name	Expected Progeny Differences[a]							
	Birth wt (acc)	Weaning wt (acc)	Yearling wt (acc)	Carcass wt (acc)	Marbling (acc)	Longissimus muscle area (acc)	Fat thickness (acc)	% Retail product (acc)
Emulation N Bar 5522	-1.0 (.99)	33 (.99)	59 (.99)	3 (.95)	.10 (.96)	-.01 (.94)	.03 (.94)	-.04 (.94)
B/R New Design 036	1.4 (.99)	35 (.99)	78 (.97)	13 (.95)	.59 (.96)	.51 (.94)	-.04 (.93)	.8 (.93)
GAR Traveler 1489	-.7 (.99)	32 (.99)	59 (.99)	13 (.91)	.25 (.93)	-.09 (.90)	.01 (.89)	-.4 (.89)
RR Scotchcap 9440	3.8 (.99)	40 (.99)	81 (.99)	14 (.85)	-.04 (.88)	-.16 (.84)	.06 (.82)	-1.0 (.82)
N Bar Emulation EXT	2.2 (.99)	44 (.99)	83 (.99)	24 (.98)	.10 (.98)	.25 (.98)	.03 (.98)	-.03 (.98)
Finks 5522-6148	2.6 (.99)	42 (.99)	79 (.97)	13 (.91)	.49 (.93)	.35 (.90)	-.01 (.89)	.40 (.89)
B/R New Design 323	.50 (.97)	36 (.97)	72 (.80)	-13 (.69)	.75 (.73)	.32 (.67)	-.03 (.64)	.90 (.64)
TC Stockman 365	4.9 (.99)	41 (.99)	74 (.97)	32 (.67)	.45 (.72)	1.19 (.65)	-.08 (.62)	1.8 (.62)
Hoff Triumph S C 108	-1.3 (.99)	52 (.86)	77 (.98)	7 (.82)	.02 (.85)	.36 (.80)	-.03 (.78)	.70 (.78)
Rito 3Q7 of 9M47 Rito 1B	4.4 (.38)	29 (.38)	55 (.32)	8 (.36)	.27 (.40)	.29 (.34)	0 (.33)	.30 (.32)
Breed Averages	2.9	30	56	7.9	.08	.15	0	.10

[a] American Angus Association Sire Evaluation Report, Spring 1999

Table A-5. Performance data of cows with early weaned (EW; 100 d) or normal weaned (NW; 200 d) calves

Item	Eartag								
	75	118	124	155	221	264	284	402	429
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	EW	NW	NW	EW	EW	EW	NW	NW	EW
Age of dam, years	2	2	2	2	2	2	2	2	2
Weight at parturition, kg	392.7	429.0	425.9	400.0	404.1	414.0	370.0	408.6	363.2
BCS at parturition[a]	3.25	4.00	4.25	4.50	4.25	4.00	4.00	4.00	4.00
Weight at early weaning, kg	420.9	421.8	416.8	400.0	420.0	407.7	394.1	390.4	370.0
BCS at early weaning[a]	4.25	4.25	4.50	4.50	5.00	4.75	4.50	4.50	4.00
ADG from time of early to normal weaning, kg/d	0.33	0.10	-0.08	0.31	0.34	0.33	0.26	0.18	0.52
BCS change from time of early to normal weaning[a]	0.00	-0.75	-1.50	0.25	1.00	-0.50	0.00	-1.00	0.75
Weight at normal weaning, kg	454.0	431.3	408.6	431.3	454.0	440.4	420.0	408.6	421.8
BCS at normal weaning[a]	4.25	3.50	3.00	4.75	6.00	4.25	4.50	3.50	4.75
Calved to AI	1	0	0	0	1	1	0	1	0
Pregnant at NW	1	1	0	1	1	1	1	1	1
Weight at subsequent parturition, kg	548.4	544.8	.	562.5	523.5	531.6	528.0	476.7	510.8
BCS at subsequent parturition[a]	6.00	5.50	.	6.00	6.00	5.50	5.00	5.75	5.50
ADG from time of normal weaning to subsequent parturition, kg/d	0.61	0.53	.	0.62	0.40	0.54	0.58	0.39	0.48
BCS change from time of normal weaning to subsequent parturition[a]	1.75	2.00	.	1.25	0.00	1.25	0.50	2.25	0.75

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	402	429	432	741	751	770	782	968	974
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	NW	EW	EW	EW	EW	NW	NW	NW	EW
Age of dam, years	2	2	2	2	2	2	2	2	2
Weight at parturition, kg	408.6	363.2	363.2	419.0	438.1	431.8	428.1	383.2	413.1
BCS at parturition[a]	4.00	4.00	3.75	4.25	4.25	4.25	4.00	3.25	5.00
Weight at early weaning, kg	390.4	370.0	373.2	435.8	417.7	426.8	430.4	394.5	417.7
BCS at early weaning[a]	4.50	4.00	4.75	5.00	4.50	4.50	4.50	4.00	4.75
ADG from time of early to normal weaning, kg/d	0.18	0.52	0.40	0.35	0.34	0.23	0.22	0.27	0.50
BCS change from time of early to normal weaning[a]	-1.00	0.75	-0.50	0.00	-0.25	-1.00	-0.25	0.00	0.25
Weight at normal weaning, kg	408.6	421.8	413.1	470.8	451.7	449.5	452.2	421.8	467.6
BCS at normal weaning[a]	3.50	4.75	4.25	5.00	4.25	3.50	4.25	4.00	5.00
Calved to AI	1	0	1	0	1	1	1	0	0
Pregnant at NW	1	1	1	1	1	1	1	1	1
Weight at subsequent parturition, kg	476.7	510.8	479.0	553.9	544.3	542.5	559.8	494.9	549.3
BCS at subsequent parturition[a]	5.75	5.50	5.25	5.75	4.75	5.50	5.50	5.75	5.50
ADG from time of normal weaning to subsequent parturition, kg/d	0.39	0.48	0.37	0.42	0.56	0.52	0.61	0.33	0.44
BCS change from time of normal weaning to subsequent parturition[a]	2.25	0.75	1.00	0.75	0.50	2.00	1.25	1.75	0.50

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	976	978	992	1015	1090	1105	1110	1170	1187
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	NW	NW	EW	EW	EW	EW	NW	EW	NW
Age of dam, years	2	2	2	2	2	2	2	2	2
Weight at parturition, kg	396.8	414.0	390.4	408.6	378.2	408.6	370.0	446.7	406.8
BCS at parturition[a]	3.50	3.75	4.00	4.75	3.50	4.00	3.25	5.25	4.50
Weight at early weaning, kg	370.5	432.7	414.5	415.4	405.0	400.0	370.9	434.5	448.1
BCS at early weaning[a]	4.50	4.75	4.50	5.25	5.00	4.25	4.00	4.75	5.25
ADG from time of early to normal weaning, kg/d	-0.04	0.33	0.55	0.74	0.38	0.35	0.23	0.69	0.34
BCS change from time of early to normal weaning[a]	-1.00	-0.50	0.50	0.25	0.00	-0.75	-0.25	1.25	0.25
Weight at normal weaning, kg	366.8	465.8	469.9	489.4	443.1	434.5	394.1	503.9	481.7
BCS at normal weaning[a]	3.50	4.25	5.00	5.50	5.00	3.50	3.75	6.00	5.50
Calved to AI	0	1	0	0	1	0	1	1	0
Pregnant at NW	1	1	1	1	1	1	1	1	0
Weight at subsequent parturition, kg	454.9	540.3	518.0	542.5	507.6	563.0	474.0	605.2	.
BCS at subsequent parturition[a]	4.75	5.75	5.00	5.75	6.25	5.50	5.00	5.75	.
ADG from time of normal weaning to subsequent parturition, kg/d	0.44	0.44	0.24	0.26	0.38	0.62	0.46	0.59	.
BCS change from time of normal weaning to subsequent parturition[a]	1.25	1.50	0.00	0.25	1.25	2.00	1.25	-0.25	.

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	1195	1197	1213	1221	1228	1235	1254	1262	1302
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	NW	NW	EW	NW	EW	EW	NW	EW	EW
Age of dam, years	2	2	2	2	2	2	2	2	2
Weight at parturition, kg	411.3	424.5	420.0	394.5	394.5	424.5	454.0	408.6	429.5
BCS at parturition[a]	3.50	3.75	4.25	4.25	4.00	4.00	4.50	3.50	4.00
Weight at early weaning, kg	417.7	475.8	419.5	395.4	415.4	424.0	447.2	410.0	412.2
BCS at early weaning[a]	4.75	4.75	5.00	4.75	4.75	5.00	4.75	4.75	4.50
ADG from time of early to normal weaning, kg/d	0.00	-0.20	0.35	0.26	0.16	0.24	0.11	0.57	0.43
BCS change from time of early to normal weaning[a]	-1.00	-0.75	0.25	-0.75	0.25	-0.25	-0.50	0.25	1.00
Weight at normal weaning, kg	417.7	455.8	454.0	421.3	431.3	448.1	458.5	466.7	454.9
BCS at normal weaning[a]	3.75	4.00	5.25	4.00	5.00	4.75	4.25	5.00	5.50
Calved to AI	1	0	0	1	0	0	0	1	1
Pregnant at NW	1	1	1	1	0	1	1	1	1
Weight at subsequent parturition, kg	481.2	603.8	569.8	479.9	.	551.6	538.0	558.9	555.2
BCS at subsequent parturition[a]	5.50	5.25	5.50	4.50	.	5.50	5.50	5.00	5.00
ADG from time of normal weaning to subsequent parturition, kg/d	0.38	0.78	0.62	0.35	.	0.54	0.40	0.55	0.56
BCS change from time of normal weaning to subsequent parturition[a]	1.75	1.25	0.25	0.50	.	0.75	1.25	0.00	-0.50

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	1304	1372	1406	1435	1445	4	14	15	30
Year	1	1	1	1	1	2	2	2	2
Weaning treatment	NW	EW	NW	NW	NW	EW	EW	EW	NW
Age of dam, years	2	2	2	2	2	2	2	2	2
Weight at parturition, kg	464.9	441.7	497.1	432.2	375.0	388.6	444.0	438.1	406.3
BCS at parturition[a]	4.75	4.50	5.75	5.00	5.00	4.25	4.25	5.00	4.75
Weight at early weaning, kg	457.6	423.1	464.4	429.0	390.4	422.2	471.7	447.2	441.7
BCS at early weaning[a]	5.00	4.75	6.50	5.00	4.50	5.00	5.25	5.00	5.00
ADG from time of early to normal weaning, kg/d	0.35	0.44	-0.10	0.02	0.29	0.63	0.27	0.37	0.21
BCS change from time of early to normal weaning[a]	-0.75	0.25	-1.50	-0.75	0.50	0.50	0.75	1.00	0.25
Weight at normal weaning, kg	492.6	466.7	454.0	430.8	419.0	484.0	498.5	483.5	462.2
BCS at normal weaning[a]	4.25	5.00	5.00	4.25	5.00	5.50	6.00	6.00	5.25
Calved to AI	0	0	1	1	0	1	1	1	0
Pregnant at NW	1	1	1	1	1	1	1	1	0
Weight at subsequent parturition, kg	601.6	587.9	557.5	535.3	488.1	551.6	562.1	567.5	.
BCS at subsequent parturition[a]	5.50	5.50	6.50	6.25	5.00	7.00	7.50	7.50	.
ADG from time of normal weaning to subsequent parturition, kg/d	0.55	0.63	0.59	0.61	0.37	0.40	0.37	0.48	.
BCS change from time of normal weaning to subsequent parturition[a]	1.25	0.50	1.50	2.00	0.00	1.50	1.50	1.50	.

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	33	46	73	78	82	221	251	259	264
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	NW	EW	NW	NW	EW	EW	NW	NW	NW
Age of dam, years	2	2	2	3	2	3	3	3	3
Weight at parturition, kg	392.7	406.3	404.5	535.3	390.4	523.5	544.8	565.7	531.6
BCS at parturition[a]	4.25	4.75	4.25	4.50	4.25	6.00	6.00	5.00	5.50
Weight at early weaning, kg	401.8	447.6	423.6	510.3	388.2	503.9	521.2	543.4	498.9
BCS at early weaning[a]	4.25	4.75	4.50	5.50	4.25	6.00	6.50	5.75	5.00
ADG from time of early to normal weaning, kg/d	.	0.30	0.04	0.44	0.35	0.32	0.05	0.50	0.37
BCS change from time of early to normal weaning[a]	.	0.75	0.50	0.75	0.75	1.25	0.25	1.50	1.25
Weight at normal weaning, kg	.	477.2	427.7	553.0	422.2	535.7	526.2	592.5	534.8
BCS at normal weaning[a]	.	5.50	5.00	6.25	5.00	7.25	6.75	7.25	6.25
Calved to AI	1	0	0	1	0	0	0	0	1
Pregnant at NW	1	1	0	1	1	1	1	1	1
Weight at subsequent parturition, kg	513.0	606.1	.	631.1	520.7	594.3	615.2	681.0	643.3
BCS at subsequent parturition[a]	6.00	7.25	.	7.25	6.50	8.00	7.50	7.50	7.75
ADG from time of normal weaning to subsequent parturition, kg/d	.	0.60	.	0.45	0.52	0.27	0.39	0.47	0.63
BCS change from time of normal weaning to subsequent parturition[a]	.	1.75	.	1.00	1.50	0.75	0.75	0.25	1.50

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	284	302	402	429	432	469	477	741	748
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	NW	EW	NW	EW	NW	EW	EW	EW	NW
Age of dam, years	3	3	3	3	3	3	3	3	3
Weight at parturition, kg	528.0	554.3	476.7	510.8	479.0	553.9	583.4	553.9	606.1
BCS at parturition[a]	5.00	6.00	5.75	5.50	5.25	4.50	6.75	5.75	5.00
Weight at early weaning, kg	479.0	519.4	453.1	460.8	463.5	525.3	559.3	533.5	568.9
BCS at early weaning[a]	5.25	5.25	5.00	5.00	5.50	6.00	7.50	5.25	5.75
ADG from time of early to normal weaning, kg/d	0.32	0.72	0.19	0.76	0.05	0.45	0.32	0.41	0.20
BCS change from time of early to normal weaning[a]	1.00	2.00	1.00	1.50	-0.50	1.25	0.50	1.00	1.00
Weight at normal weaning, kg	510.8	589.7	471.3	535.3	468.1	569.8	590.2	573.4	588.8
BCS at normal weaning[a]	6.25	7.25	6.00	6.50	5.00	7.25	8.00	6.25	6.75
Calved to AI	1	0	0	0	0	0	0	1	1
Pregnant at NW	1	1	0	1	0	0	1	1	1
Weight at subsequent parturition, kg	556.2	692.4	.	641.5	.	.	696.9	657.8	681.0
BCS at subsequent parturition[a]	8.00	7.75	.	7.75	.	.	8.50	7.50	7.00
ADG from time of normal weaning to subsequent parturition, kg/d	0.27	0.52	.	0.50	.	.	0.45	0.49	0.52
BCS change from time of normal weaning to subsequent parturition[a]	1.75	0.50	.	1.25	.	.	0.50	1.25	0.25

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	751	770	782	968	974	976	978	980	992
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	NW	EW	NW	EW	EW	NW	EW	NW
Age of dam, years	3	3	3	3	3	3	3	3	3
Weight at parturition, kg	544.3	542.5	559.8	494.9	549.3	454.9	540.3	661.9	518.0
BCS at parturition[a]	4.75	5.50	5.50	5.75	5.50	4.75	5.75	6.00	5.00
Weight at early weaning, kg	522.6	508.0	481.2	521.6	523.0	426.8	537.5	607.5	505.8
BCS at early weaning[a]	5.50	5.25	5.00	5.75	6.00	5.00	5.75	7.00	5.00
ADG from time of early to normal weaning, kg/d	0.46	0.17	0.50	0.18	0.54	0.44	0.19	0.26	0.65
BCS change from time of early to normal weaning[a]	1.25	1.00	0.50	-0.25	0.75	1.75	1.25	0.25	1.25
Weight at normal weaning, kg	568.0	524.8	530.7	538.9	576.1	469.9	556.2	633.3	569.3
BCS at normal weaning[a]	6.75	6.25	5.50	5.50	6.75	6.75	7.00	7.25	6.25
Calved to AI	0	1	0	1	0	1	0	1	1
Pregnant at NW	1	1	1	1	0	1	1	1	1
Weight at subsequent parturition, kg	686.9	615.2	643.8	.	.	560.7	632.4	730.9	673.7
BCS at subsequent parturition[a]	8.00	7.00	7.75	7.00	.	7.25	7.75	8.00	8.50
ADG from time of normal weaning to subsequent parturition, kg/d	0.51	0.51	0.53	.	.	0.50	0.35	0.56	0.60
BCS change from time of normal weaning to subsequent parturition[a]	1.25	0.75	2.25	1.50	.	0.50	0.75	0.75	2.25

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag								
	1015	1090	1110	1170	1195	1197	1213	1235	1254
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	EW	EW	EW	EW	EW	EW	NW	NW
Age of dam, years	3	3	3	3	3	3	3	3	3
Weight at parturition, kg	542.5	507.6	474.0	605.2	481.2	603.8	569.8	551.6	538.0
BCS at parturition[a]	5.75	6.25	5.00	5.75	5.50	5.25	5.50	5.50	5.50
Weight at early weaning, kg	516.7	512.6	459.4	551.6	478.5	543.9	521.2	517.1	514.4
BCS at early weaning[a]	6.00	6.50	5.00	6.00	6.00	5.00	6.00	6.25	5.75
ADG from time of early to normal weaning, kg/d	0.82	0.38	0.36	0.61	0.56	0.46	0.59	0.13	0.29
BCS change from time of early to normal weaning[a]	2.00	1.75	0.50	2.00	1.25	1.50	2.00	0.50	0.25
Weight at normal weaning, kg	597.0	550.2	494.9	611.1	533.5	588.8	578.9	530.3	542.5
BCS at normal weaning[a]	8.00	8.25	5.50	8.00	7.25	6.50	8.00	6.75	6.00
Calved to AI	0	0	0	1	1	1	0	1	0
Pregnant at NW	0	1	1	1	1	1	1	1	1
Weight at subsequent parturition, kg	.	623.8	560.7	694.6	628.8	701.4	650.1	603.4	572.9
BCS at subsequent parturition[a]	.	8.25	7.50	8.00	8.00	7.50	7.75	8.00	7.00
ADG from time of normal weaning to subsequent parturition, kg/d	.	0.34	0.29	0.49	0.53	0.67	0.38	0.40	0.14
BCS change from time of normal weaning to subsequent parturition[a]	.	0.00	2.00	0.00	0.75	1.00	-0.25	1.25	1.00

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-5 (cont'd)

Item	Eartag						
	1262	1293	1302	1372	1406	1435	1445
Year	2	2	2	2	2	2	2
Weaning treatment	NW	NW	NW	EW	NW	NW	NW
Age of dam, years	3	3	3	3	3	3	3
Weight at parturition, kg	558.9	553.9	555.2	587.9	557.5	535.3	488.1
BCS at parturition[a]	5.00	4.75	5.00	5.50	6.50	6.25	5.00
Weight at early weaning, kg	501.7	512.1	500.8	532.5	498.9	499.4	476.2
BCS at early weaning[a]	5.00	5.00	5.50	6.25	7.00	6.00	6.00
ADG from time of early to normal weaning, kg/d	0.17	0.06	0.05	0.59	0.37	0.10	0.19
BCS change from time of early to normal weaning[a]	0.25	0.00	1.50	1.75	-0.50	0.50	0.25
Weight at normal weaning, kg	518.5	518.0	505.3	590.2	534.8	509.4	494.9
BCS at normal weaning[a]	5.25	5.00	7.00	8.00	6.50	6.50	6.25
Calved to AI	0	1	1	0	1	0	0
Pregnant at NW	0	1	1	1	1	0	1
Weight at subsequent parturition, kg	.	508.5	531.2	671.9	612.9	.	587.9
BCS at subsequent parturition[a]	.	6.50	8.00	7.75	7.75	.	8.25
ADG from time of normal weaning to subsequent parturition, kg/d	.	-0.06	0.15	0.39	0.44	.	0.43
BCS change from time of normal weaning to subsequent parturition[a]	.	1.50	1.00	-0.25	1.25	.	2.00

[a] BCS (1 to 9 scale; 1 = extremely thin, 9 = obese).

Table A-6. Feedlot performance of early weaned (EW: 100 d) or normal weaned (NW: 200 d) steers

Item	Eartag								
	G507	G509	G513	G515	G516	G518	G521	G523	G525
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	NW	EW	NW	EW	NW	EW	NW	EW	NW
Sire[a]	5	4	4	6	1	4	6	5	5
Weight at early weaning, kg	100.33	125.76	129.84	110.32	136.20	130.75	119.40	108.05	108.96
Weight at normal weaning, kg	172.97	290.11	207.93	263.77	229.27	269.22	200.67	251.97	191.59
Weight at harvest, kg	483.96	518.92	530.73	460.36	480.79	473.07	486.23	454.00	529.82
Days on feed	209	252	209	252	209	252	209	252	209
Harvest age, d	416	359	414	356	412	355	411	353	408
ADG from early to normal weaning, kg/d	0.73	1.64	0.78	1.53	0.93	1.38	0.81	1.44	0.83
ADG for initial 100 d of finishing period, kg/d	1.70	1.64	1.77	1.53	1.47	1.38	1.36	1.44	1.66
ADG for final 60 d of finishing, kg/d	0.97	1.67	1.06	0.99	0.68	1.13	1.11	1.11	1.53
ADG for entire finishing period, kg/d	1.49	1.56	1.54	1.39	1.20	1.36	1.37	1.37	1.62
ADG from early weaning to harvest, kg/d	1.24	1.56	1.30	1.39	1.12	1.36	1.19	1.37	1.36
DM consumption for initial 100 d of finishing period, kg	6.45	5.00	7.06	5.04	6.57	5.35	5.93	4.87	6.15
DM consumption for final 60 d of finishing period, kg	7.87	7.57	7.75	7.03	6.57	7.68	6.94	7.11	7.92
DM consumption for entire finishing period, kg	1518.77	1569.49	1602.19	1558.55	1440.36	1718.14	1376.35	1549.63	1479.37
Daily DM consumption, kg/d	7.27	6.23	7.67	6.18	6.89	6.82	6.59	6.15	7.08
Feed efficiency for initial 100 d of finishing period, gain:feed	0.264	0.329	0.250	0.304	0.223	0.259	0.229	0.296	0.270
Feed efficiency for final 60 d of finishing period, gain:feed	0.124	0.221	0.137	0.141	0.103	0.147	0.160	0.156	0.193
Feed efficiency for entire finishing period, gain:feed	0.205	0.251	0.201	0.225	0.175	0.199	0.208	0.223	0.229
≥ 1 antibiotic treatment	0	1	0	1	0	1	1	1	0
≥ 2 antibiotic treatments	0	0	0	1	0	0	0	1	0
≥ 3 antibiotic treatments	0	0	0	0	0	0	0	0	0

[a] Sire code (1 = Emulation N Bar 5522, 2 = B/R New Design 036, 3 = GAR Traveler 1489, 4 = RR Scotchcap 9440, 5 = N Bar Emulation EXT, 6 = N Bar Emulation EXT, 7 = Finks 5522-6148, 8 = TC Stockman 365, 9 = Hoff Triumph S C 108, 10 = natural service sire, Rito 3Q7 of 9M47 Rito 1B).

Table A-6. (cont'd)

Item	Eartag								
	G526	G529	G530	G531	G532	G534	G535	G536	G537
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	EW	EW	NW	NW	EW	NW	EW	EW	NW
Sire[a]	5	6	3	5	1	6	6	3	6
Weight at early weaning, kg	31.78	36.32	30.42	31.78	37.23	37.23	32.23	38.59	36.77
Weight at normal weaning, kg	93.98	94.89	91.71	87.17	96.70	101.70	113.05	137.11	118.95
Weight at harvest, kg	221.10	225.64	175.70	161.62	214.29	185.69	241.98	274.67	187.96
Days on feed	439.02	428.12	493.50	516.65	433.57	493.04	432.21	519.38	474.43
Harvest age, d	252	252	209	209	252	209	252	252	209
ADG from early to normal weaning, kg/d	352	351	407	407	351	407	351	351	407
ADG for initial 100 d of finishing period, kg/d	1.27	1.31	0.84	0.74	1.18	0.84	1.29	1.38	0.69
ADG for final 60 d of finishing, kg/d	1.27	1.31	1.63	1.50	1.18	1.66	1.29	1.38	1.34
ADG for entire finishing period, kg/d	1.42	1.18	1.21	1.71	1.34	1.35	1.34	1.49	1.34
ADG from early weaning to harvest, kg/d	1.37	1.32	1.52	1.70	1.34	1.47	1.27	1.52	1.37
DM consumption for initial 100 d of finishing period, kg	1.37	1.32	1.30	1.39	1.34	1.27	1.27	1.52	1.15
DM consumption for final 60 d of finishing period, kg	4.33	4.03	6.69	5.76	4.04	6.93	4.22	4.60	6.46
DM consumption for entire finishing period, kg	7.78	6.77	7.24	8.40	7.37	7.41	6.94	7.87	8.15
Daily DM consumption, kg/d	1482.79	1332.32	1486.71	1476.04	1421.66	1493.34	1355.40	1598.09	1536.84
Feed efficiency for initial 100 d of finishing period, gain:feed	5.88	5.29	7.11	7.06	5.64	7.15	5.38	6.34	7.35
Feed efficiency for final 60 d of finishing period, gain:feed	0.293	0.324	0.244	0.261	0.291	0.239	0.306	0.299	0.207
Feed efficiency for entire finishing period, gain:feed	0.183	0.175	0.168	0.203	0.182	0.183	0.194	0.188	0.164
≥ 1 antibiotic treatment	0.233	0.250	0.214	0.241	0.237	0.206	0.235	0.239	0.187
≥ 2 antibiotic treatments	1	1	1	1	1	0	1	1	0
≥ 3 antibiotic treatments	1	1	0	0	0	0	1	0	0

[a] Sire code (1 = Emulation N Bar 5522, 2 = B/R New Design 036, 3 = GAR Traveler 1489, 4 = RR Scotchcap 9440, 5 = N Bar Emulation EXT, 6 = N Bar Emulation EXT, 7 = Finks 5522-6148, 8 = TC Stockman 365, 9 = Hoff Triumph S C 108, 10 = natural service sire, Rito 3Q7 of 9M47 Rito 1B).

Table A-6. (cont'd)

Item	Eartag								
	G541	G543	G544	G545	G546	H610	H611	H613	H614
Year	1	1	1	1	1	2	2	2	2
Weaning treatment	NW	EW	EW	NW	EW	EW	EW	NW	NW
Sire[a]	3	6	3	3	3	3	3	3	3
Weight at early weaning, kg	38.59	38.14	33.60	31.33	32.69	24.97	29.51	25.88	26.33
Weight at normal weaning, kg	118.04	101.24	123.49	107.60	88.98	139.38	161.17	158.45	151.64
Weight at harvest, kg	191.59	242.44	238.80	177.97	213.38	262.41	291.92	253.33	237.90
Days on feed	487.60	481.69	413.14	482.60	408.60	461.26	469.89	563.41	510.75
Harvest age, d	209	252	252	209	252	264	264	228	228
ADG from early to normal weaning, kg/d	405	348	347	402	346	393	392	452	452
ADG for initial 100 d of finishing period, kg/d	0.74	1.41	1.15	0.70	1.24	1.23	1.31	0.95	0.86
ADG for final 60 d of finishing, kg/d	1.58	1.41	1.15	1.48	1.24	1.23	1.31	1.41	0.93
ADG for entire finishing period, kg/d	1.11	1.54	0.83	0.71	1.28	1.06	1.16	1.29	1.02
ADG from early weaning to harvest, kg/d	1.42	1.51	1.15	1.46	1.27	1.22	1.17	1.36	1.20
DM consumption for initial 100 d of finishing period, kg	1.20	1.51	1.15	1.21	1.27	1.22	1.17	1.23	1.09
DM consumption for final 60 d of finishing period, kg	6.91	4.35	4.00	6.54	4.59	4.49	5.43	7.15	5.63
DM consumption for entire finishing period, kg	8.30	7.61	6.52	8.24	6.47	6.70	7.26	8.40	8.36
Daily DM consumption, kg/d	1592.31	1488.79	1500.50	1559.13	1315.73	1499.58	1639.50	1797.02	1644.79
Feed efficiency for initial 100 d of finishing period, gain:feed	7.62	5.91	5.95	7.46	5.22	5.68	6.21	7.88	7.21
Feed efficiency for final 60 d of finishing period, gain:feed	0.229	0.324	0.289	0.226	0.271	0.274	0.241	0.197	0.165
Feed efficiency for entire finishing period, gain:feed	0.134	0.202	0.127	0.086	0.197	0.158	0.159	0.153	0.122
≥ 1 antibiotic treatment	0.186	0.256	0.193	0.196	0.243	0.215	0.188	0.173	0.166
≥ 2 antibiotic treatments	0	1	0	0	0	1	0	0	1
≥ 3 antibiotic treatments	0	1	0	0	0	0	0	0	1

[a] Sire code (1 = Emulation N Bar 5522, 2 = B/R New Design 036, 3 = GAR Traveler 1489, 4 = RR Scotchcap 9440, 5 = N Bar Emulation EXT, 6 = N Bar Emulation EXT, 7 = Finks 5522-6148, 8 = TC Stockman 365, 9 = Hoff Triumph S C 108, 10 = natural service sire, Rito 3Q7 of 9M47 Rito 1B).

Table A-6. (cont'd)

Item	Eartag								
	H615	H616	H619	H624	H625	H631	H636	H637	H642
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	NW	EW	EW	NW	EW	NW	EW	NW
Sire[a]	3	3	3	3	7	9	9	3	8
Weight at early weaning, kg	32.69	22.70	29.51	36.32	36.32	38.59	33.14	39.04	39.95
Weight at normal weaning, kg	163.44	149.82	151.64	121.67	148.91	118.95	115.32	141.19	131.66
Weight at harvest, kg	270.58	230.63	262.87	245.16	241.07	227.00	204.75	233.81	223.82
Days on feed	459.90	519.83	463.99	440.38	572.95	446.74	492.59	438.56	499.85
Harvest age, d	264	228	264	264	228	264	228	264	228
ADG from early to normal weaning, kg/d	390	451	379	365	427	362	422	360	420
ADG for initial 100 d of finishing period, kg/d	1.07	0.81	1.11	1.23	0.92	1.08	0.89	0.93	0.92
ADG for final 60 d of finishing, kg/d	1.07	1.41	1.11	1.23	1.64	1.08	1.20	0.93	1.16
ADG for entire finishing period, kg/d	0.93	1.03	1.26	1.33	1.41	1.17	1.10	1.03	1.04
ADG from early weaning to harvest, kg/d	1.12	1.27	1.18	1.21	1.46	1.24	1.26	1.13	1.21
DM consumption for initial 100 d of finishing period, kg	1.12	1.13	1.18	1.21	1.29	1.24	1.15	1.13	1.12
DM consumption for final 60 d of finishing period, kg	5.37	7.01	4.43	4.44	6.86	4.63	6.39	3.93	7.03
DM consumption for entire finishing period, kg	8.61	9.75	6.55	6.70	8.62	7.12	7.41	6.45	8.59
Daily DM consumption, kg/d	1899.09	1871.63	1456.08	1488.57	1726.72	1597.17	1591.23	1426.45	1762.66
Feed efficiency for initial 100 d of finishing period, gain:feed	7.19	8.21	5.52	5.64	7.57	6.05	6.98	5.40	7.73
Feed efficiency for final 60 d of finishing period, gain:feed	0.200	0.202	0.251	0.278	0.240	0.234	0.188	0.235	0.165
Feed efficiency for entire finishing period, gain:feed	0.108	0.106	0.192	0.199	0.163	0.164	0.149	0.160	0.121
≥ 1 antibiotic treatment	0.156	0.155	0.215	0.214	0.192	0.205	0.181	0.208	0.157
≥ 2 antibiotic treatments	0	0	0	1	0	0	0	0	0
≥ 3 antibiotic treatments	0	0	0	0	0	0	0	0	0

[a] Sire code (1 = Emulation N Bar 5522, 2 = B/R New Design 036, 3 = GAR Traveler 1489, 4 = RR Scotchcap 9440, 5 = N Bar Emulation EXT, 6 = N Bar Emulation EXT, 7 = Finks 5522-6148, 8 = TC Stockman 365, 9 = Hoff Triumph S C 108, 10 = natural service sire, Rito 3Q7 of 9M47 Rito 1B).

Table A-6. (cont'd)

Item	Eartag								
	H643	H644	H645	H646	H650	H654	H655	H660	H665
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	NW	EW	NW	NW	EW	NW	EW	NW
Sire[a]	3	8	3	8	10	10	10	10	10
Weight at early weaning, kg	36.77	45.40	36.77	48.12	39.95	44.49	36.32	43.13	39.04
Weight at normal weaning, kg	138.47	142.56	147.55	139.38	122.58	139.83	126.67	124.85	118.49
Weight at harvest, kg	266.50	247.43	250.61	220.19	216.10	261.96	229.27	249.25	222.46
Days on feed	502.58	587.48	453.55	514.38	476.70	483.96	533.45	469.89	506.66
Harvest age, d	264	228	264	228	228	264	228	264	228
ADG from early to normal weaning, kg/d	357	417	354	415	407	342	402	335	394
ADG for initial 100 d of finishing period, kg/d	1.28	1.05	1.03	0.81	0.94	1.22	1.03	1.24	1.04
ADG for final 60 d of finishing, kg/d	1.28	1.50	1.03	1.37	1.00	1.22	1.30	1.24	1.25
ADG for entire finishing period, kg/d	1.26	1.49	1.05	0.96	0.87	1.32	1.17	1.32	0.92
ADG from early weaning to harvest, kg/d	1.38	1.49	1.16	1.29	1.14	1.30	1.33	1.31	1.25
DM consumption for initial 100 d of finishing period, kg	1.38	1.36	1.16	1.14	1.08	1.30	1.24	1.31	1.18
DM consumption for final 60 d of finishing period, kg	4.97	7.32	4.53	6.61	5.64	4.60	6.86	4.60	6.36
DM consumption for entire finishing period, kg	8.48	9.04	6.33	7.71	6.72	7.12	9.99	7.52	7.97
Daily DM consumption, kg/d	1794.27	1887.95	1529.82	1668.16	1537.76	1566.14	1897.67	1584.30	1686.28
Feed efficiency for initial 100 d of finishing period, gain:feed	6.80	8.28	5.79	7.32	6.74	5.93	8.32	6.00	7.40
Feed efficiency for final 60 d of finishing period, gain:feed	0.258	0.204	0.228	0.208	0.178	0.265	0.190	0.270	0.197
Feed efficiency for entire finishing period, gain:feed	0.149	0.165	0.166	0.124	0.130	0.185	0.117	0.176	0.116
≥ 1 antibiotic treatment	0.203	0.180	0.200	0.176	0.169	0.220	0.160	0.218	0.169
≥ 2 antibiotic treatments	0	0	0	1	1	1	0	0	0
≥ 3 antibiotic treatments	0	0	0	0	1	0	0	0	0

[a] Sire code (1 = Emulation N Bar 5522, 2 = B/R New Design 036, 3 = GAR Traveler 1489, 4 = RR Scotchcap 9440, 5 = N Bar Emulation EXT, 6 = N Bar Emulation EXT, 7 = Finks 5522-6148, 8 = TC Stockman 365, 9 = Hoff Triumph S C 108, 10 = natural service sire, Rito 3Q7 of 9M47 Rito 1B).

Table A-7. Carcass data for early weaned (EW: 100 d) and normal weaned (NW: 200 d) steers

Item	Eartag								
	G507	G509	G513	G515	G516	G518	G521	G523	G525
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	NW	EW	NW	EW	NW	EW	NW	EW	NW
Pre-trim hot carcass weight, kg	300.09	303.73	316.89	269.22	298.73	286.93	292.38	278.76	312.35
Post-trim hot carcass weight, kg[a]	284.66	290.56	297.82	259.69	281.03	273.31	278.30	266.50	299.64
Dressing percentage, %[b]	0.6459	0.6097	0.6220	0.6092	0.6472	0.6318	0.6264	0.6396	0.6141
Longissimus muscle area, cm^2	88.71	100.32	79.03	69.03	64.84	65.81	71.94	72.58	96.77
Adjusted 12th rib fat thickness, cm	1.27	1.02	1.14	1.40	1.78	1.78	1.27	1.65	1.02
Kidney, pelvic, and heart fat, %[c]	5.14	4.33	6.02	3.54	5.93	4.75	4.81	4.40	4.07
Yield grade	2.89	1.93	3.56	3.41	4.72	4.34	3.59	3.74	2.13
Marbling score[d]	720	720	920	740	730	710	800	720	540
≥ Mid-Choice	1	1	1	1	1	1	1	1	0
≥ High-Choice	1	1	1	1	1	1	1	1	0
≥ Prime	0	0	1	0	0	0	1	0	0
Bone maturity[e]	140	120	130	130	130	130	130	130	140

[a] Hot carcass weight after hot-fat-trimming of kidney, pelvic, and heart area.

[b] Calculated as pre-trim hot carcass weight after divided by shrunk live weight at harvest (4% shrink).

[c] Calculated as the difference between pre- and post-trim hot carcass weight divided by pre-trim hot carcass weight.

[d] Small^{00} = 500, Modest^{00} = 600, Moderate^{00} = 700, Slightly Abundant^{00} = 800.

[e] A^{00} = 100, B^{00} = 200.

Table A-7. (cont'd)

Item	Eartag								
	G526	G529	G530	G531	G532	G534	G535	G536	G537
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	EW	EW	NW	NW	EW	NW	EW	EW	NW
Pre-trim hot carcass weight, kg	261.50	251.52	301.46	310.08	255.60	285.57	261.96	315.53	278.76
Post-trim hot carcass weight, kg[a]	250.61	242.89	289.65	296.92	241.98	270.58	254.69	298.73	266.50
Dressing percentage, %[b]	0.6205	0.6120	0.6363	0.6252	0.6141	0.6033	0.6313	0.6328	0.6120
Longissimus muscle area, cm^2	70.97	78.39	80.32	82.26	71.29	75.16	73.23	85.81	78.71
Adjusted 12th rib fat thickness, cm	1.65	1.14	0.89	1.52	1.27	1.14	1.14	1.78	1.14
Kidney, pelvic, and heart fat, %[c]	4.17	3.43	3.92	4.25	5.33	5.25	2.77	5.32	4.40
Yield grade	3.63	2.53	2.70	3.36	3.42	3.34	2.74	3.70	2.93
Marbling score[d]	840	800	660	610	720	560	710	660	590
≥ Mid-Choice	1	1	1	1	1	0	1	1	0
≥ High-Choice	1	1	0	0	1	0	1	0	0
≥ Prime	1	1	0	0	0	0	0	0	0
Bone maturity[e]	130	130	120	120	120	140	130	130	130

[a] Hot carcass weight after hot-fat-trimming of kidney, pelvic, and heart area.

[b] Calculated as pre-trim hot carcass weight after divided by shrunk live weight at harvest (4% shrink).

[c] Calculated as the difference between pre- and post-trim hot carcass weight divided by pre-trim hot carcass weight.

[d] Small ^{00} = 500, Modest^{00} = 600, Moderate^{00} = 700, Slightly Abundant^{00} = 800.

[e] A^{00} = 100, B^{00} = 200.

Table A-7. (cont'd)

Item	Eartag								
	G541	G543	G544	G545	G546	H610	H611	H613	H614
Year	1	1	1	1	1	2	2	2	2
Weaning treatment	NW	EW	EW	NW	EW	EW	EW	NW	NW
Pre-trim hot carcass weight, kg	300.09	282.39	239.71	302.36	241.98	266.95	273.54	330.97	306.45
Post-trim hot carcass weight, kg[a]	286.02	273.31	232.45	289.20	231.54	259.92	266.73	320.52	298.96
Dressing percentage, %[b]	0.6411	0.6107	0.6044	0.6526	0.6169	0.6029	0.6064	0.6119	0.6250
Longissimus muscle area, cm^2	78.71	74.84.	63.55	73.87	75.16	68.39	70.97	74.19	73.55
Adjusted 12th rib fat thickness, cm	0.89	1.02	1.02	1.40	1.52	0.89	1.27	1.27	1.40
Kidney, pelvic, and heart fat, %[c]	4.69	3.22	3.03	4.35	4.32	2.64	2.49	3.16	2.44
Yield grade	2.92	2.79	2.96	3.61	3.16	2.74	3.02	3.47	3.28
Marbling score[d]	590	680	700	730	800	660	610	750	710
≥ Mid-Choice	0	1	1	1	1	1	1	1	1
≥ High-Choice	0	0	1	1	1	0	0	1	1
≥ Prime	0	0	0	0	1	0	0	0	0
Bone maturity[e]	120	120	130	130	150	140	140	120	130

[a] Hot carcass weight after hot-fat-trimming of kidney, pelvic, and heart area.
[b] Calculated as pre-trim hot carcass weight after divided by shrunk live weight at harvest (4% shrink).
[c] Calculated as the difference between pre- and post-trim hot carcass weight divided by pre-trim hot carcass weight.
[d] Small^{00} = 500, Modest^{00} = 600, Moderate^{00} = 700, Slightly Abundant^{00} = 800.
[e] A^{00} = 100, B^{00} = 200.

Table A-7. (cont'd)

Item	Eartag								
	H615	H616	H619	H624	H625	H631	H636	H637	H642
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	NW	EW	EW	NW	EW	NW	EW	NW
Pre-trim hot carcass weight, kg	276.49	309.63	266.27	259.01	350.94	264.91	301.23	259.01	298.73
Post-trim hot carcass weight, kg[a]	270.58	309.40	259.23	252.65	346.18	260.82	295.55	253.79	291.70
Dressing percentage, %[b]	0.6262	0.6205	0.5978	0.6127	0.6380	0.6177	0.6370	0.6152	0.6225
Longissimus muscle area, cm^2	72.26	73.55	71.61	73.55	88.39	78.71	81.94	74.19	70.32
Adjusted 12th rib fat thickness, cm	1.27	1.02	1.27	1.14	2.16	0.89	1.52	1.02	1.14
Kidney, pelvic, and heart fat, %[c]	2.13	0.07	2.64	2.45	1.36	1.54	1.88	2.02	2.36
Yield grade	2.91	2.46	2.96	2.64	3.45	2.00	2.83	2.39	3.11
Marbling score[d]	600	720	600	730	840	620	700	680	740
≥ Mid-Choice	1	1	1	1	1	1	1	1	1
≥ High-Choice	0	1	0	1	1	0	1	0	1
≥ Prime	0	0	0	0	1	0	0	0	0
Bone maturity[e]	130	160	130	140	140	120	130	130	130

[a] Hot carcass weight after hot-fat-trimming of kidney, pelvic, and heart area.
[b] Calculated as pre-trim hot carcass weight after divided by shrunk live weight at harvest (4% shrink).
[c] Calculated as the difference between pre- and post-trim hot carcass weight divided by pre-trim hot carcass weight.
[d] Small ^{00} = 500, Modest^{00} = 600, Moderate^{00} = 700, Slightly Abundant^{00} = 800.
[e] A^{00} = 100, B^{00} = 200.

Table A-7. (cont'd)

Item	Eartag								
	H643	H644	H645	H646	H650	H654	H655	H660	H665
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	NW	EW	NW	NW	EW	NW	EW	NW
Pre-trim hot carcass weight, kg	294.65	358.21	274.67	313.26	286.70	279.89	315.30	283.52	310.76
Post-trim hot carcass weight, kg[a]	286.70	348.90	268.31	308.72	281.71	276.03	306.45	276.03	302.59
Dressing percentage, %[b]	0.6107	0.6351	0.6308	0.6344	0.6265	0.6024	0.6157	0.6285	0.6389
Longissimus muscle area, cm^2	71.61	83.23	69.03	78.71	70.97	67.74	76.77	80.65	80.65
Adjusted 12[th] rib fat thickness, cm	1.78	1.52	1.52	1.27	1.40	1.52	1.52	1.02	1.52
Kidney, pelvic, and heart fat, %[c]	2.70	2.60	2.31	1.45	1.74	1.38	2.81	2.64	2.63
Yield grade	3.70	3.39	3.34	2.76	3.10	3.26	3.39	2.40	3.13
Marbling score[d]	820	810	770	820	760	560	700	600	640
≥ Mid-Choice	1	1	1	1	1	0	1	1	1
≥ High-Choice	1	1	1	1	1	0	1	0	0
≥ Prime	1	1	0	1	0	0	0	0	0
Bone maturity[e]	120	130	140	130	140	140	150	140	140

[a] Hot carcass weight after hot-fat-trimming of kidney, pelvic, and heart area.
[b] Calculated as pre-trim hot carcass weight after divided by shrunk live weight at harvest (4% shrink).
[c] Calculated as the difference between pre- and post-trim hot carcass weight divided by pre-trim hot carcass weight.
[d] Small ^{00} = 500, Modest^{00} = 600, Moderate^{00} = 700, Slightly Abundant^{00} = 800.
[e] A^{00} = 100, B^{00} = 200.

Table A-8. Rib steak characteristics of early weaned (EW: 100 d) and normal weaned (NW: 200 d) steers

Item	Eartag								
	G507	G509	G513	G515	G516	G518	G521	G523	G525
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	NW	EW	NW	EW	NW	EW	NW	EW	NW
Color									
L^{*a}	48.60	45.44	47.64	42.10	41.25	43.07	48.35	42.90	45.25
a^{*b}	24.57	24.22	23.11	22.96	26.27	25.04	24.23	26.75	26.92
b^{*c}	10.98	10.41	10.38	8.77	10.77	10.74	10.86	11.28	11.73
Tenderness									
Warner-Bratzler shear force, kg[d]	2.72	3.18	1.72	3.55	2.57	4.40	2.95	2.33	3.35
Myofibril Fragmentation Index[d]	93.50	70.00	78.00	65.50	97.00	70.50	80.50	87.50	110.00
Composition									
Moisture, %	71.01	72.65	68.90	71.56	71.80	71.10	69.26	71.37	73.07
Lipid[e], %	7.58	5.01	8.80	5.80	5.23	7.55	9.06	6.11	3.84
Protein[e], %	21.53	21.03	21.41	21.60	20.79	19.45	22.91	20.86	21.20

[a] 0 = black; 100 = white.
[b] negative numbers = green; positive numbers = red.
[c] negative numbers = blue; positive numbers = yellow.
[d] Measured 14 d postmortem.
[e] Wet basis.

Table A-8. (cont'd)

Item	Eartag								
	G526	G529	G530	G531	G532	G534	G535	G536	G537
Year	1	1	1	1	1	1	1	1	1
Weaning treatment	EW	EW	NW	NW	EW	NW	EW	EW	NW
Color									
L^{*a}	43.30	43.31	39.48	45.94	42.17	42.42	43.03	39.86	44.18
a^{*b}	23.67	24.45	23.47	25.45	26.03	24.46	24.77	25.06	24.54
b^{*c}	9.55	10.34	8.40	10.93	11.25	9.78	10.13	9.03	9.23
Tenderness									
Warner-Bratzler shear force, kg[d]	2.30	2.48	2.78	3.35	2.75	2.80	3.25	2.58	2.42
Myofibril Fragmentation Index[d]	104.00	78.50	86.50	105.00	107.00	98.50	122.00	124.00	87.50
Composition									
Moisture, %	70.91	70.58	71.70	69.20	70.78	72.47	71.12	72.27	70.35
Lipid[e], %	7.29	7.63	5.90	6.94	6.95	3.98	7.16	4.30	5.58
Protein[e], %	21.01	20.28	22.45	21.57	21.00	22.78	20.33	21.72	22.16

[a] 0 = black; 100 = white.
[b] negative numbers = green; positive numbers = red.
[c] negative numbers = blue; positive numbers = yellow.
[d] Measured 14 d postmortem.
[e] Wet basis.

Table A-8. (cont'd)

Item	Eartag								
	G541	G543	G544	G545	G546	H610	H611	H613	H614
Year	1	1	1	1	1	2	2	2	2
Weaning treatment	NW	EW	EW	NW	EW	EW	EW	NW	NW
Color									
L*[a]	47.07	42.10	40.57	42.41	42.00	37.59	38.83	38.92	38.20
a*[b]	26.90	23.13	21.96	25.03	24.14	22.05	24.52	23.72	22.62
b*[c]	12.41	9.23	7.75	10.10	9.54	11.92	12.96	12.34	12.12
Tenderness									
Warner-Bratzler shear force, kg[d]	3.08	3.28	2.67	3.23	2.32	.	.	.	.
Myofibril Fragmentation Index[d]	120.00	69.00	75.00	105.00	59.50	.	.	.	.
Composition									
Moisture, %	72.50	72.96	72.60	68.94	71.94	.	.	.	.
Lipid[e], %	5.41	4.12	4.68	9.19	5.70	.	.	.	.
Protein[e], %	22.30	22.20	22.36	20.23	20.71	.	.	.	.

[a] 0 = black; 100 = white.
[b] negative numbers = green; positive numbers = red.
[c] negative numbers = blue; positive numbers = yellow.
[d] Measured 14 d postmortem.
[e] Wet basis.

Table A-8. (cont'd)

Item	Eartag								
	H615	H616	H619	H624	H625	H631	H636	H637	H642
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	NW	EW	EW	NW	EW	NW	EW	NW
Color									
L*[a]	38.52	40.00	38.10	39.14	44.48	39.03	38.27	37.62	41.43
a*[b]	22.82	21.91	22.80	22.36	22.75	24.14	23.57	23.62	22.11
b*[c]	11.94	11.80	11.61	11.96	13.40	12.82	12.16	12.23	12.11
Tenderness									
Warner-Bratzler shear force, kg[d]	.	.	.	.	.	.	.	.	.
Myofibril Fragmentation Index[d]	.	.	.	.	.	.	.	.	.
Composition	.	.	.	.	.	.	.	.	.
Moisture, %									
Lipid[e], %	.	.	.	.	.	.	.	.	.
Protein[e], %	.	.	.	.	.	.	.	.	.

[a] 0 = black; 100 = white.
[b] negative numbers = green; positive numbers = red.
[c] negative numbers = blue; positive numbers = yellow.
[d] Measured 14 d postmortem.
[e] Wet basis.

Table A-8. (cont'd)

Item	Eartag								
	H643	H644	H645	H646	H650	H654	H655	H660	H665
Year	2	2	2	2	2	2	2	2	2
Weaning treatment	EW	NW	EW	NW	NW	EW	NW	EW	NW
Color									
L^{*a}	38.91	44.35	40.36	39.60	38.86	38.52	40.06	38.14	42.17
a^{*b}	23.66	23.32	24.00	21.67	21.96	22.13	21.39	23.52	23.36
b^{*c}	12.97	14.19	13.35	11.15	11.29	11.43	10.94	12.52	13.09
Tenderness									
Warner-Bratzler shear force, kg[d]	.	.	.	.	.	.	.	.	.
Myofibril Fragmentation Index[d]	.	.	.	.	.	.	.	.	.
Composition									
Moisture, %	.	.	.	.	.	.	.	.	.
Lipid[e], %	.	.	.	.	.	.	.	.	.
Protein[e], %	.	.	.	.	.	.	.	.	.

[a] 0 = black; 100 = white.
[b] negative numbers = green; positive numbers = red.
[c] negative numbers = blue; positive numbers = yellow.
[d] Measured 14 d postmortem.
[e] Wet basis.