Developmental programming of beef cattle:

Impacts of weaning age and early calf nutrition on calf growth and carcass quality

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In addition to pre-natal programming, research indicates that developmental programming can also occur post-natal. Adipocyte development occurs up until 250 d of age in cattle (Du et al., 2010). After 250 d of age, marbling increases only via growth of pre-existing adipocytes. Several management strategies coincide with this "window" of adipocyte development such as early weaning and creep feeding. These strategies have been reported to have lasting effects on progeny performance, carcass characteristics, and subsequent reproductive performance in heifers.

Age of weaning

Beef calves are traditionally weaned at around 205 d of age and then enter a grazing system or a feedlot. Oftentimes, one of the incentives for early weaning is to benefit the cow. Weaning removes the cow's nutrient requirements for lactation so she can re-partition them towards replenishing body reserves and to resume cycling. Alternate ages of weaning and effects to the cow and calf have been explored as a way to improve reproductive efficiency of the cow and performance of the calf.

Performance and carcass characteristics

There is a substantial amount of work that has been completed on age of weaning and the subsequent effects on growth performance and carcass characteristics on the calves. If calves are early-weaned and placed on a high concentrate diet while their counterparts remain on the grazing cow, early-weaned calves have improved ADG and BW by the time of normal weaning

(Neville and McCormick, 1981; Myers et al., 1999a, Shike et al., 2007; Shoup et al., 2015a). In another study where early-weaned calves were fed forage or grazed pastures, performance did not exceed that of their normal-weaned counterparts (Arthington et al., 2005).

Age of weaning on finishing ADG is very mixed. Some observed improvements (Myers et al., 1999a; Wertz et al., 2002), no difference (Arthington et al., 2005; Shike et al., 2007; Shoup et al., 2015b), or poorer ADG overall (Schoonmaker et al., 2004a) if calves were weaned early. Improved feedlot feed efficiency has been shown in early-weaned steers compared to normal-weaned steers in some studies (Myers et al. 1999a; Schoonmaker et al., 2004a) but not others (Shoup et al., 2015b). Early weaning has also resulted in fewer d to harvest compared to steers weaned later (Shike et al., 2007; Shoup et al., 2015b).

In some cases, early weaning has been associated with improved carcass quality. Shike et al. (2007) found steers weaned at 63 d to have increased HCW, marbling score, percentage grading Average Choice or greater, and percentage of steers grading Low Prime or greater compared to steers weaned at 189 d. This finding is supported elsewhere, where earlier calf age at weaning (60 to 190 d) has been associated with increased fat depth (Story et al., 2000; Shoup et al., 2015b), improved marbling scores (Myers et al., 1999a; Meteer et al., 2013), and an increased percentage grading USDA Choice or greater (Myers et al., 1999a; Meyer et al., 2005; Shoup et al., 2015b). The effects on hot carcass weights have been more mixed with early weaning associated with increased hot carcass weights (Myers et al., 1999a; Story et al., 2000; Meyer et al., 2005; Shoup et al., 2015b) whereas the opposite was found in other studies (Schoonmaker et al., 2004a). Still other studies have found no differences in carcass characteristics between early-weaned and normal-weaned cattle (Story et al., 2000; Arthington et al., 2005).

Conclusions- early weaning

In a review by Thrift and Thrift (2004), the authors concluded that, generally, early-weaned calves fed a concentrate diet had equal or improved BW by the time of traditional wean, but feedlot ADG and carcass weight tended to be less compared to traditionally-weaned calves. The same is not seen in carcass yield or quality; where early-weaned cattle have equal or improved carcass yield grade and carcasses grading Low Choice or better compared to traditionally-weaned cattle (Thrift and Thrift, 2004). Despite these generalizations, some inconsistencies occur in the literature; mainly, the definition of early weaning (60-190 d), normal weaning (180-270 d), late weaning (250+ d), and the effect on the health and carcass quality status of the calf. Time of calving (spring or fall), type of forage, and genetic variation of the cattle vary in the literature as well.

Creep feeding

Early creep feeding trials were focused on increasing weaning weights of beef calves. However, it was later realized that creep feeding had effects on carcass characteristics, post-weaning performance, fiber digestion, as well as cow performance, reproduction, and stocking rate. More recent research has also shown creep feeding has an effect on replacement heifer performance and reproduction.

Performance and carcass characteristics

It is no surprise that creep feeding results in improved ADG during the creep-feeding phase compared to non-creep fed calves (Bray, 1934; Stuedmann et al., 1968; Myers et al., 1999a) and improved weaning weights (Stricker et al., 1979; Martin et al., 1981). But creep feeding has also been shown to impact calves through the finishing phase. Over the feedlot phase, creep-fed calves have had improved gain (Scarth et al., 1968; Shike et al., 2007), reduced

days in the feedlot (Scarth et al., 1968; Anderson et al., 1978; Myers et al., 1999a, Shike et al., 2007), and increased carcass weights (Scarth et al., 1968; Deutscher and Slyter 1978; Shike et al., 2007). In several studies, differences in carcass characteristics were also observed. Greater marbling (Deutscher and Slyter, 1978), greater quality grades (Deutscher and Slyter, 1978; Faulkner et al., 1994) and greater ribeye area (Shike et al., 2007) have been found in carcasses of creep-fed calves compared to non-creep fed calves. Some studies found no effect of creep feeding on post-weaning growth performance (Stuedemann et al., 1968; Garrigus et al., 1969) or carcass quality (Tarr et al., 1994; Myers et al., 1999a). Some of these differences may be attributed to variations in type of creep feed offered, length that creep feed was offered, and calving system used for these studies.

Source of energy

An important consideration in the discussion of creep feeding and early weaning is what to feed. One study that spurred research to pursue this investigation was Smith and Crouse (1984). These authors found the majority of the lipogenic substrate units in subcutaneous adipose tissue are acetate which only accounts for 10 to 25% of the substrate units utilized in intramuscular lipogenesis (Smith and Crouse, 1984). Glucose was identified as the preferred substrate for intramuscular lipogenesis. Fermentation of starch by the rumen increases blood glucose levels suggesting the possibility that high starch diets could target intramuscular lipogenesis instead of subcutaneous fat deposition. This is possible because feeding high starch diets will shift the rumen fermentation patterns lowering the acetate: propionate ratio, increasing glucose production (May et al., 2009).

Many subsequent experiments have evaluated concentrate, by-product, fat, and forage inclusion on developmental programming of early-weaned and creep-fed calves. Generally,

marbling development has been thought to be directly related to time on concentrate diet. Indeed, cattle fed either an ad libitum concentrate diet or ad libitum forage diet during the growing phase had different slaughter weights, backfat, and marbling scores when slaughtered at the end of the growing phase (Schoonmaker et al., 2004b). However, after being fed a common finishing diet, Schoonmaker et al. (2004a) found no differences in marbling score. However, if starch inclusion differences were maintained through the finishing diet, backfat, marbling, and performance continued to differ (Retallick et al. 2010). Bedwell et al. (2008) reported improved marbling in early-weaned calves fed varying corn and distillers grains diets compared to calves that grazed pasture for 73 days prior to entering the feedlot. Evidence has also indicated that feeding various co-products have resulted in similar marbling scores to those from calves fed starch-based diets (Bedwell et al., 2008; Meteer et al., 2013; Segers et al., 2014). Increased fat inclusion (4.7% vs 3.5%) during the growing phase has resulted in greater marbling score and percentage grading Choice or better in early-weaned cattle that finished on a common diet (Segers et al., 2014).

Source of energy in creep feed has had varying effects on carcass quality. Faulkner et al. (1994) reported improved quality grades in calves creep-fed corn compared to calves that were creep-fed soyhulls. However, other studies have found no difference between types of creep feed (Shike et al., 2007; Meteer et al., 2013). The reason for these discrepancies is not clear but merits further investigation.

Conclusions

The evidence presented in the literature suggests that early weaning and creep feeding can have long-term effects on calves. Both strategies have been shown to improve pre-weaning calf growth and have potential growth and carcass advantages in the feedlot. Consideration should be given as to what to feed EW calves or as a creep feed.

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