EFFECT OF CHANGES IN WEANING AGE ON CARCASS TRAITS IN FORAGE FINISHED BEEF CATTLE.

A Thesis Presented to the Faculty of the Department of Animal Science in Partial Fulfillment of The Requirements for a Bachelor's Degree with Distinction in Research

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Abstract

An increase in percent intramuscular fat **(%IMF**) and average daily gain (**ADG**) are advantageous to the profitability and consumer palatability of forage finished beef. The effects of weaning age in beef cattle fed an all forage diet on measure of weight gain and carcass quality were analyzed over two years of calf data. Measures of gain included average daily gain, weight per day of age (**WDA**), and weight at the conclusion of trial two weaning **(CW2).** Measures of carcass quality included percent intramuscular fat, *Longissimus muscle* area (**REA**), rib fat (**BF**), finished live-weight (**FW**), rump fat (**RF**) at the conclusion of trial two weaning, empty body fat (**EBF**) and *Longissimus muscle* area as a function of finished weight (**REA/FW**). Angus x Simmental beef calves (N=50 over two years) were weaned at two distinct ages. In both trials, calves were weaned using a calf-weaner, a plastic removable nose ring used for low stress weaning. In trial one calves were weaned at the time normally practiced, approximately 157 (±13) days of age in 2004 and 182.7 (+ 9.7) days of age in 2005. In trial two the time of weaning was delayed to 338.5 (± 13.6) days of age in 2004 and 266.1 (± 8.4) days of age in 2005. Following weaning in both trails, calves were fed an all forage diet. For calves born in 2004, carcass data for both weaning groups was gathered by ultrasound at 597(± 13.6) days of age; in 2005, calves from both trails were analyzed by ultrasound at approximately 554(± 8.9) days of age. The calves in which weaning was delayed showed numerically higher values for percent intramuscular fat, rib eye area, rump fat, back fat, finished weight, weight per day of age, empty body fat (percent), and rib eye area as a function of finished weight. These differences however were generally not statistically significant using the general linear model in SAS (1998), and analyzing least square

means using The Waller-Duncan K-ratio t test. There was a statistically significant difference in WDA and CW2 for 2005 born calves. The results of this research potentially show a relationship between delaying weaning and an increase in the carcass quality of forage finished beef. As farmers producing forage finished beef seek to compete for market share in a market primarily dominated by grain finished, highly marbled, younger carcasses, a delay in weaning age may produce carcasses which are more highly competitive in the current market and capable of better suiting consumer preferences.

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Introduction

Production animal agriculture (especially beef and swine production) in recent years has been largely limited to Concentrated Animal Feeding Operations (CAFO[1]) which are generally found in centralized locations, housing between a thousand and hundreds of thousands of animals. This orientation of CAFO in central locations, generally close to sites where feedstuffs are produced, has caused massive challenges to agricultural areas removed from such systems. The location of these facilities near grain producing centers has made it difficult for farmers not located in these regions to produce marketable carcasses of similar quality at a competitive cost. While large sections of the cattle industry were moved from small farms and individual families throughout the country to concentrated areas of CAFO organization, the number of small farms dramatically decreased, and this decrease is still ongoing. The change from traditional, diversified small farms to modern commercial CAFO systems has also had effects on perceptions of animal welfare, consumer health, and the environment.

The traditional diet fed to CAFO raised beef cattle is one high in corn and simple starches, while only feeding a high enough concentration of forage and other sources of neutral detergent fiber (NDF) to prevent rumen acidosis. This has caused changes in rumen microbiology, as well as dramatically increasing the incidence of rumen acidosis. In response to growing consumer concern for their health, as well as for the welfare of animals, an alternative beef market has emerged. A side market of grass-fed and grass-finished beef has arisen. This style of agriculture is wonderfully suited to small farming given it is a slightly more labor intensive and lengthier process than CAFO finishing.

[1] Concentrated Animal Feeding Operations are defined by the EPA pursuant to 40 CFR part 122 appendix B or the discretion of the director according to 40 CFR part 122.23; A facility housing more than 1000 slaughter or feeder cattle for more than 45 days out of a 12 month period.

This system lacks the accumulations of highly concentrated manure associated with CAFO finishing, dramatically decreases the risk of rumen acidosis and human exposure to harmful microbes (such as Escherichia coli O157:H7, which requires the lower rumen pHs associated with concentrate feeding), and allows cattle to be exposed to air free of pollution by high concentrations of airborne fecal matter.

Two major drawbacks at present exist in using a grass-fed system. In the production of grass-finished beef, it has generally taken longer for cattle to reach market weight, and these cattle have traditionally had a significantly lower concentration of intramuscular fat (IMF) than cattle finished in a CAFO system. Intramuscular fat (or marbling) is integral to the meat quality grading system used in the United States. As a result of an extensive consumer education program by the United States Government, marbling is associated with beef tenderness and overall beef quality by consumers.

The effects of forage quality and genetics on intramuscular fat and growth rates have already been extensively evaluated; however, no one to date has examined the effects of weaning age on either of these traits in a strictly forage system has not been examined to date. There are significant conflicts in the literature regarding whether or not a greater consumption of milk in cattle pre-weaning results in a larger weaning weight; and whether this weaning weight results in earlier onset of puberty and higher average daily gain to market weight. This gap in knowledge is addressed in the current study in which aspects of growth in calves weaned at the normally recommended age were compared with calves weaned at a later age. Traditional beef breeds (primarily Angus, Simmental, and Angus/Simmental crosses) were separated into two groups randomized for gender and weight at introduction into the study. These groups were then weaned at either the traditional 160 days of age or at an extended length of 250 days of age. Cattle were then evaluated for characteristics of weight gain and ultrasound-determined aspects of carcass quality. Statistical analysis will be performed to determine whether or not there is a significant difference in intramuscular fat, rib eye diameter, or average daily gain between these two weaning trials.

Review of Literature

Despite the rise in consumer awareness regarding the potential health hazards associated with concentrate fed cattle raised in confinement; several issues still remain as hurdles to the production of grass-finished beef. Over the past 100 years, primarily before 1930 and after 1960, an extensive battery of literature has been compiled on the carcass traits and palatability of meat from forage-finished beef cattle in comparison to concentrate finished beef cattle.

As a result of these vast tomes of literature, conflicting data exists on whether or not there are any off flavors associated with forage-finished beef in comparison to CF beef. In a review of 15 papers (Muir et al., 1998), it was determined that when compared at a similar carcass weight or degree of fatness, the feeding system (extensive forage only v. intensive forage and concentrate) had no significant effect on meat tenderness, color, marbling, or juiciness. In eight out of ten of these experiments, flavor was assessed, and trained panelists were unable to detect any difference in flavor between feeding systems. This review concluded that in effect highly palatable high-quality beef can be produced in an all forage system without finishing on a high concentrate diet.

It has been shown that no significant difference can be detected in tenderness between beef raised in an extensive forage system or in an extensive confinement system (Simonne et al., 1996). Research also found that there is no significant difference in shear force values in beef from older or younger animals (Miller et al., 1983). Additionally, beef from cattle grazed exclusively on pasture and forage have been shown by consumers to be as tender as beef from feedlot cattle and more succulent (juicy) than comparable cattle finished on a feedlot diet (Schaake et al., 1993). With a longer time on forage than similar grain-fed cattle would need, it has also been shown that grass-finished cattle can reach similar marbling scores as those fed a high concentrate diet, (Mandell et al., 1997).

Contrastingly, it has also been suggested that cattle fed a forage only diet, even after being finished on a high concentrate diet, will produce less tender and less flavorful beef than that from cattle fed strictly high concentrate diets immediately after weaning (Mitchell et al., 1991, Coleman et al., 1995; Kerth et al., 2007). Additionally, some research suggests that an off flavor is present in forage finished beef, and due to differences in fatty acid compositions, grows more pronounced over time after butchering (Xiong et al., 1996). There is no clear answer in the literature whether or not it is possible to produce consistently high quality beef in a forage system.

Two significant difficulties have arisen for forage finished meat production. This is especially the case when these cattle will be sold to consumers who have come to expect highly marbled beef. Average daily gain and deposition rate of percent intramuscular, an analytical measure of marbling have both been shown to be lower in cattle fed forage than in cattle fed a high concentrate diet.

Lower average daily gain in forage fed cattle has been attributed to the lower amount of energy in forage compared to grain (Coleman et al., 1995). As a result of the lower energy concentrations in forage diets, the fact that forage-finished cattle are able to attain similar percentage intramuscular fat with similar depths of back fat as concentrate finished cattle suggests the role of physiological maturity on adipose deposition (Johnson and Pryor, 1974). It has been shown that cattle deposit adipose tissue most efficiently after reaching physiological maturity, though adipose tissue is deposited throughout the animal's life even prior to birth. (Johnson and Pryor, 1974; Crews et al., 2002). It may be presumed, accordingly, that the breeds of cattle which reach maturity at an earlier age would begin rapid deposition of adipose tissue at an earlier age than later maturing breeds (Owens et al., 1993).

Ultrasonic evaluation of carcasses near weaning and yearling ages have been shown to be successful indicators of carcass traits (Crews et al., 2002). While the standard error of measurement was greater when ultrasound measurements were taken at weaning compared to a year of age, the error was consistently greater in fat measurement rather than in muscle measurement. Therefore, there may or may not be a correlation between body composition at weaning and end carcass traits. At present it appears that adipose tissue development is best gauged later in life (no earlier that yearling age) while muscle size (measured as rib eye area as a function of finished weight) may be evaluated at an earlier age. By yearling age, *Longissimus muscle* area and back fat may both be used as indicators of future carcass traits (Crews et al., 2002), suggesting that early adipose tissue development is indicative of later and more rapid adipose tissue deposition.

Milk Production and Growth

The observation of continued milk production by dams until well after weaning would traditionally occur has suggested the possibility for farmers to extend the suckling period in beef cattle thereby increasing the total amount of milk calves receive prior to weaning (Wu et al., 2000). A great deal of research has been reported on the subject of maternal ability (milk production) and calf growth, however, the effect of longevity of suckling has not been studied in great depth. Given the extended lactation curve observed by cows, significantly more milk could be made available to calves if weaning were delayed as long as possible (without interfering with future maternal reproductive cycles). This scheme has great potential in forage finished operations given the higher nutritional value of milk when compared with most forage (Schmidt et al.,1988).

The effect of an extended nursing period on post-weaning growth and on carcass traits at slaughter still remain unclear in forage finished cattle. The availability of large quantities of milk prior to weaning is considered by many to be the most efficient means of increasing growth in calves prior to weaning in a forage system.. An evaluation of the literature on this subject suggests that two conflicting hypothesis exist about the effects of milk consumption on the growth of calves and their continued growth rates and finishing weights. The research suggests that calves allowed to nurse longer may have larger carcass weights from their later weaning period through slaughter (Clutter and Nielson, 1987), or may show no significant difference over earlier weaned calves (Philips et al., 1991). Calves weaned later may have higher planes of nutrition and make less efficient use of energy; their early growth advantage from having access to milk for longer may, however, require less grain to reach finished weight while producing heavier carcasses (Ferrell and Jenkins, 1985).

Cattle weaned earlier than the industry standard and put on high concentrate diets have recently been shown to have overall higher rates of gain and improved feed efficiency. It has not been shown that earlier weaning of cattle onto a high concentrate diets has any affect on percent intramuscular fat, back fat, rib eye area, or carcass weights (Myers et al., 1999; Meyer et al., 2005). The diets these cattle used, however, were much higher energy than native pasture, legume pasture, or ensiled forages.

Significant variation exists in milk production between individual dams, especially between dams of differing breeds (Beal et al., 89). Differences in these milking abilities have been exploited to examine the effect milk intake on cattle performance.

Calves from dams that produced high milk yields had higher 205-d weights than calves from lower milk producing dams. The advantage experienced by calves from dams with higher milk yields remained significant through finishing and was reflected in higher weights at slaughter when compared with carcass data from those calves from lower milk producing dams (Clutter and Nielson, 1987).

Hot carcass weight in cattle fed a larger volume of milk pre-weaning have also been shown to be no different than those fed a lower volume of milk (Miller et al., 1998). The animals fed higher quantities of milk have been shown to require larger volumes of concentrates to reach the same level of finish as those fed less milk prior to weaning. This may be a result of the high energy in concentrated feed stuffs which allows for more rapid growth of beef cattle than milk alone.

In past comparisons of early vs. normal weaning ages in beef cattle fed a pasture diet, those cattle which were weaned earlier required dietary supplementation to finish on the same level as cattle weaned at a traditional (later) age (Schultz et al., 2005).

The influence of different forages on milk production in various breeds of beef cattle have been evaluated, and forage does affect milk yield and calf growth, however, its effect is variable and dependent upon the genetic composition of the dams involved (Brown and Brown, 2002).

Milk production in various breeds of beef cattle has been evaluated, and it is obvious that significant volumes of milk are produced by lactating dams at periods greater than 150 or 180 days. Allowing dam and suckling calf to remain together for as long as possible allows for the continued supplementation of milk, an incredibly high quality feed, into the calves pre-weaning diet (Wu et al., 2000). A high milk producing cow fed a mixed legume and grass diet would still be producing upwards of 20 kg of milk per day at 38 weeks after parturition. This would contribute a substantial amount of complete protein and fat to the still rapidly growing calf's diet, and would improve the nutritional composition of the calves diet while it was still grazing on available forages. Milk is a significantly higher quality feedstuff than most forage feeds on a dry matter basis. It contains higher concentrations of fats and complete proteins than forage feeds, both of these components are essential to rapid growth and development of muscle and adipose tissue in suckling calves (Schmidt et al., 1988).

Ultrasonic Carcass Evaluation

Ultrasonic waves directed through tissue (which is primarily composed of water) are readily able to be reflected back towards their source. The interactions between these waves and the different densities in tissues allows for the creation of a density map or ultrasound image. The wave length velocities of various tissue components are well documented and the associated images well recorded (Goss et al., 1979).

The application of this technology to obtain measurements of percent intramuscular fat, back fat and rib eye area has been well explored and can be therefore be used to indicate carcass quality. The ultrasonic evaluation of carcass data to determine

Longissimus muscle area and back fat is highly accurate, therefore, ultrasound may be used to accurately estimate carcass traits in live cattle, provided these measurements are taken by well trained and unbiased technicians (Greiner et al., 2002). Additionally, it has been shown that no difference exists in ultrasonic measurements between technicians, and thus are a highly reliable depiction of carcass traits (Perkins et al., 1991). Ultrasound technology may also be used in the measurement of percent intramuscular fat in live beef cattle. As percent intramuscular fat is correlated with marbling score and USDA quality grade, it can be used to predict carcass value (Whittaker et al., 1991). A careful manipulation of ultrasonic frequency (Park et al., 1993) and multiple views (Hassen et al., 1998) are both important for accurate measurements of percent intramuscular fat by ultrasound.

Materials and Methods

Over 2 years, beginning in 2004 a total of 50 Angus cross calves were sorted for sex, cow weight, cow body condition score (BCS) and adjusted 205 weights and randomly assigned to either of two treatments. Calves on treatment one (normal weaned) were weaned by plastic nose ring (calf-weaner) at 156 (± 13.5) days of age in 2004 and at 182.7 (± 9.7) days in 2005. Calves on treatment two (late weaned) were weaned by plastic nose ring at 338.5 (± 13.6) days of age in 2004 and 266.1 (+ 8.4) days of age in 2005. Once weaned, calves on both treatments were managed as one group and fed an all forage ad lib for approximately 2 months and then the cattle were placed on pasture. Cattle in both treatments were rotationally grazed on a mixed legume native pasture comprised primarily of orchard grass (*Dactylis glomerata),* blue grass (*Poa pratensis*), white clover (*Trifolium alba*) and red clover (*Trifolium pratense*), or for a short duration on brown midrib sorghum sudangrass (*Sorghum vulgare var. sudanense*). The end of the grazing season was determined when pasture growth was deemed insufficient to sustain average daily gain greater than 1.5 lb/day. At this time the cattle were removed from pasture. In year one, after the calves were removed from pasture they were placed on a diet consisting of ensiled sorghum sudangrass for 49 days. In an effort to supply beef for a grass-finished market cattle were placed on the ensiled sorghum sudangrass to facilitate an adequate growth rate (average daily gain of >1.5 Lb/day). However, when it was determined that the market could not take all the cattle on the trial, we collected a final body weight and terminated the trial. In year two, the trial was terminated at the conclusion of the grazing season, at which time a final liveweight was collected.

At 597.4 (± 13.6) days of age in 2004 and 553.9 (± 8.9) days of age in 2005, live animal ultrasound measurements including back fat, rump fat , rib eye area, and percentage intramuscular fat were taken using a Classic Scanner-200 equipped with a 3.5-MHz, 18-cm transducer (Classic Ultrasound Equipment, Tequesta, FL). Ultrasound images were collected by an Ultrasound Guidelines Council (UGC) certified technician and interpreted by a UGC certified image analysis laboratory (Ames, Iowa).

Determination of Percentage Empty Body Fat (%EBF)

Empty body fat (EBF) was computed using ultrasound measures of carcass traits using the procedures of (Baker et al., 2006a) for the steers and (Baker et al., 2006b) for the heifers.

Statistical Analysis

Statistical design was a randomized block in each of the two years (2004 and 2005). Animals were randomly assigned to treatment by weight and sex. The statistical model included weaning group and adjusted 205 day weigh as dependent variables Production data, rib eye area, percentage intramuscular fat, finished weight, back fat, rump fat , and rib eye area as a function of finished weight, were analyzed to determine effects of weaning group using the general linear model procedure of SAS (1998). The Waller-Duncan K-ratio t test option of the least square means statement was used to determine differences among least square means, with comparisons at a confidence interval of $P \leq 0.10$.

Results

No statistically significant differences were observed in traits associated with growth in the 2004 data (CW2, finished weight, rib eye area as a function of finished weight, and weight per day of age). There were numerical trends towards higher rates of gain and finished weights in late weaned calves (Table 1, Figure 1, Figure 3, Figure 6). In 2004, CW2 weights were an average of 4.6% larger in late weaned rather than normally weaned 2004 calves. Rib eye area as a function of finished weight was on average 3.5% larger in late weaned calves rather than normal weaned calves in 2004, and weight per day of age was 6.3 percent larger on average in late weaned calves.

While differences in carcass traits (percent intramuscular fat, back fat, rump fat, percent empty body fat, and *Longissimus muscle* area) were not statistically significant (P>0.10), there does appear to be a numerically higher depth of rump fat and larger *Longissimus muscle* area associated with late weaned calves. It does not appear that late weaned (numerically) improves percent intramuscular fat, back fat, or percent empty body fat (Table 2, Figure 2, Figure 4, Figure 5) based on this year's data. On average, late weaned calves had 8.2% greater *Longissimus muscle* area and 12.4 % greater depth of rump fat.

In 2005, weight per day of age and calf weight 2 were larger in late weaned than early weaned cattle (P<0.10). There was also a numerical trend towards larger rib eye area as a function of finished weight and finished weight in late weaned calves, though these differences were not statistically significant (P>0.10; Table 3, Figure 7, Figure 8, Figure 10). On average, rib eye area as a function of finished weight was 3.06 percent larger in late weaned than normally weaned calves.

Carcass data from 2005 again shows no statistically significant differences in carcass traits (percent intramuscular fat, back fat, rump fat, percent empty body fat, and rib eye area); however, late weaned carcasses showed numerical advantages over normally weaned calves among all of these traits (Table 4, Figure 9, Figure 11, Figure 12). On average, later weaned cattle showed a 7.17 % increase in rump fat depth, a 1.1% increase in back fat, a 4.5% difference in percentage intramuscular fat, a 3.4% increase in *Longissimus muscle* area, and a .86% increase in percent empty body fat when compared with normally weaned cattle from the same year's trial.

Table 1. Comparisons of Growth Traits in 2004 calves.

Variable	NW[1] (2004)	LW[2] (2004)	LSD[3]
CW2[5]	734 (±82.8)	770.22 (±109.34)	52.388
FW[6]	1081.64 (±66.40)	1131.67 (±91.27)	57.719
REA/FW[7]	0.893 (± .088)	0.924 (± .114)	0.0809
WDA2[8]	1.91 (± 0.210)	2.032 (± .262)	0.1297

[1]Normal Age of Weaning, commonly used by industry
[2]Late Age of Weaning, after the industry standard
[3]Least Significant Difference.
[5]Calf Weight at end of late weaned period (pounds)
[6]Finished Weight, weight at age of ultrasound analysis and trial completion (pounds)
[7]*Longissimus Muscle* area as a function of finished weight (sq. centimeters/100 pounds)
[8]Weight per day of age (pounds/day)

Table 2- Comparison of Carcass Traits in 2004.

Variable	NW (2004)[1]	LW (2004)[2]	LSD[3]
%IMF[5]	3.410 (± .760)	3.028 (± .485)	0.5248
BF[6]	0.160 (± .040)	0.159 (± .025)	0.0271
%EBF[7]	24.87 (± 1.544)	24.74(± 1.611)	1.1688
REA[8]	9.645(± .976)	10.44 (± 1.47)	0.9458
RF[9]	0.185 (± .061)	0.208 (± .038)	0.0419

[1]Normal Age of Weaning, commonly used by industry
[2]Late Age of Weaning, after the industry standard
[3]Least Significant Difference
[5]Percent Intramuscular Fat
[6]Back Fat Depth (inches)
[7]Percent Empty Body Fat (percent)
[8]*Longissimus muscle* area (square inches)
[9]Rump Fat Depth (inches)

Table 3-Comparisons of Growth Traits in 2005

Variable	NW (2005)	LW (2005)	LSD
CW2	655.33(± 68.09)	686.00(± 70.01)	23.469
FW	1155.0(± 88.66)	1180.4 (±123.8)	47.229
REA/FW	0.913(± .099)	0.941 (± 0.992)	0.0618
WDA2	2.087(± .203)	2.202 (± .200)	0.0608

[1]Normal Age of Weaning, commonly used by industry.
[2]Late Age of Weaning, after the industry standard.
[3]Least Significant Difference.
[5]Calf Weight at end of late weaned period (pounds)
[6]Finished Weight, weight at age of ultrasound analysis and trial completion (in pounds).
[7]*Longissimus Muscle* area as a function of finished weight (as square inches/ 100 pounds)
[8]Weight per day of age (in pounds/day)

Table 4- Comparison of Carcass Traits in 2005

Variable	NW (2005)	LW (2005)	LSD
RF	0.209(± .060)	0.224(± .094)	0.0449
BF	0.182(± .039)	0.184(± .053)	0.0262
%IMF	2.20(± .0395)	2.30(± .05383)	0.3783
REA	10.57(± 1.424)	10.93(± 1.295)	0.6428
EBF	21.91 (± 2.20)	22.10(± 2.21)	1.2904

[1]Normal Age of Weaning, commonly used by industry.
[2]Late Age of Weaning, after the industry standard.
[3]Least Significant Difference;
[5]Percent Intramuscular Fat (as percent).
[6]Back Fat Depth (inches).
[7]Percent Empty Body Fat (as percent).
[8]Longissimus Muscle Area (square inches).
[9]Rump Fat Depth (inches).

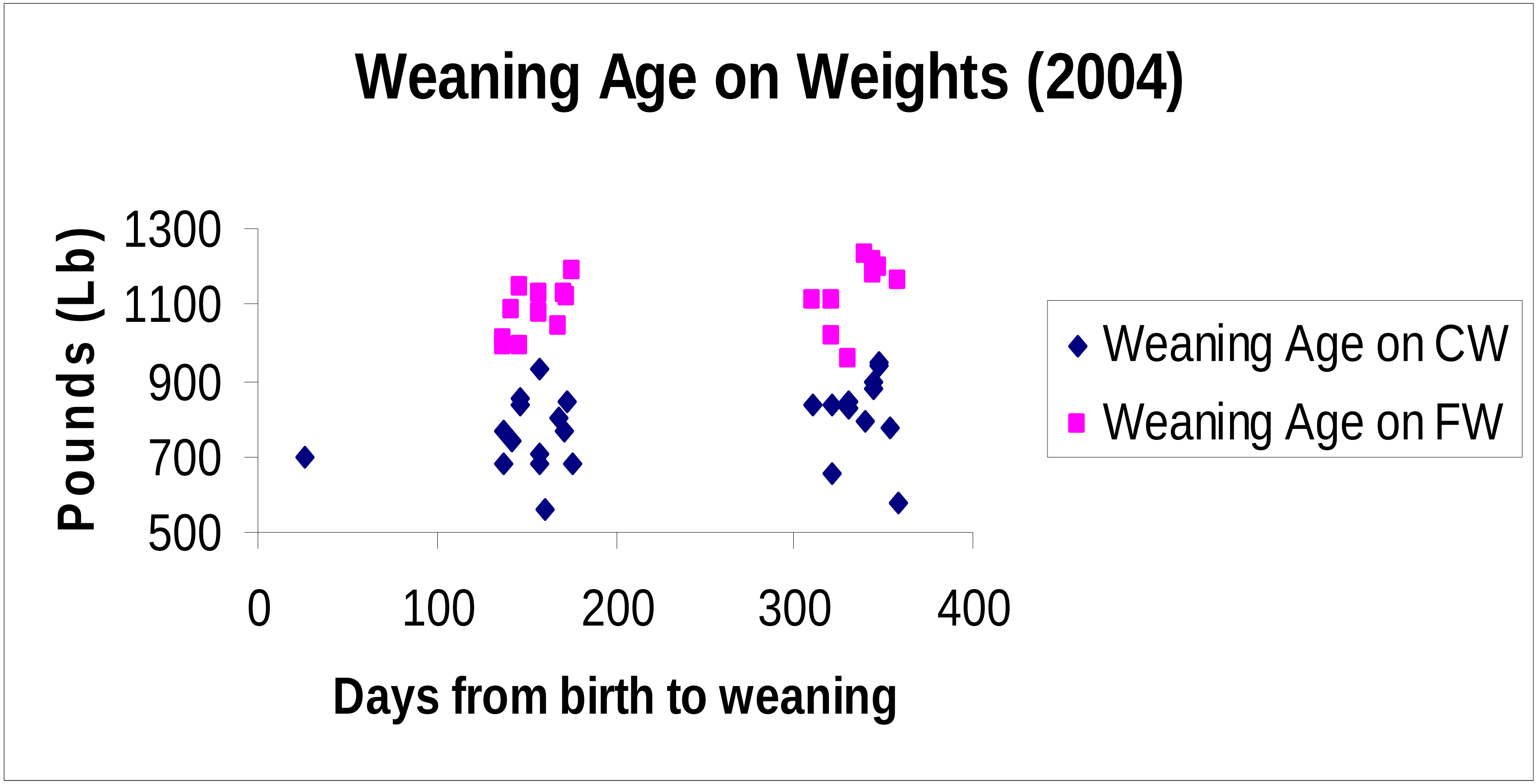

Figure 1- Weights of cattle at late weaning time (CW2) and finished weight (FW) represented by scatter plot of the actual data values in 2004 calves.

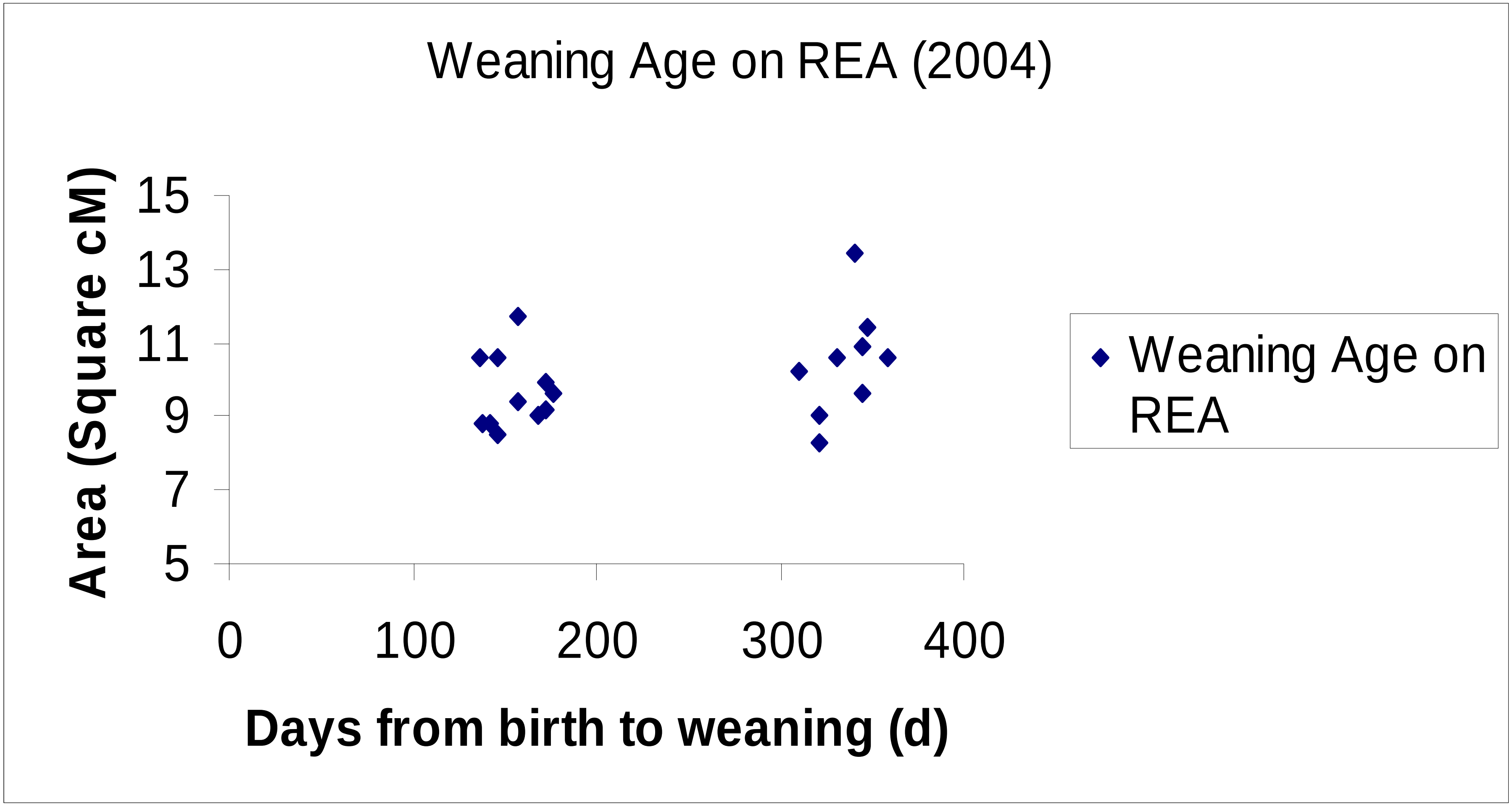

Figure 2- Scatter plot of *Longissimus muscle* area data from 2004 calves.

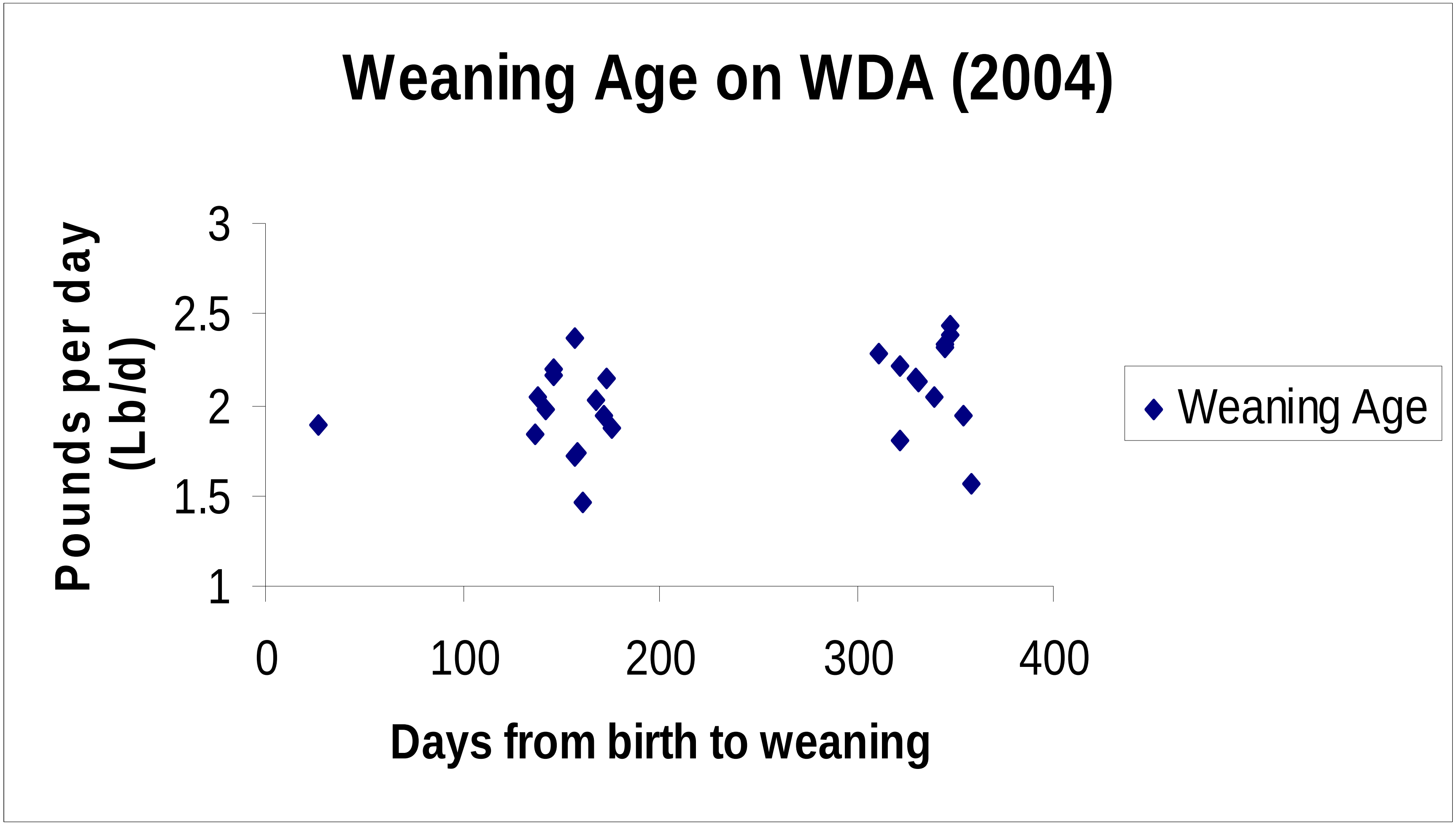

Figure 3 – Scatter plot of weight gain per day of age (WDA) in 2004 calves. WDA measured in pounds/day.

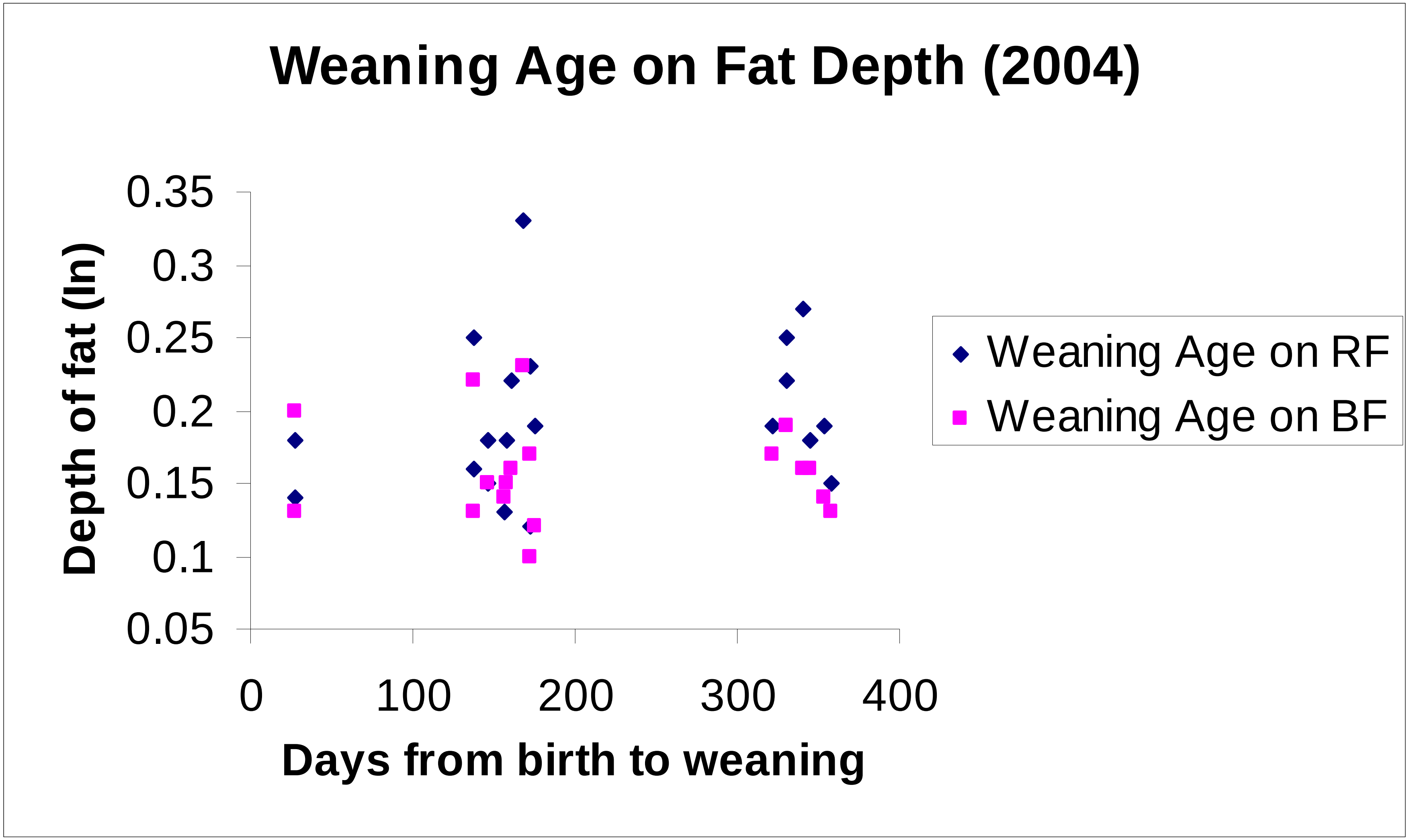

Figure 4- Scatter plot of Back Fat and rump fat data for 2004 weaned calves.

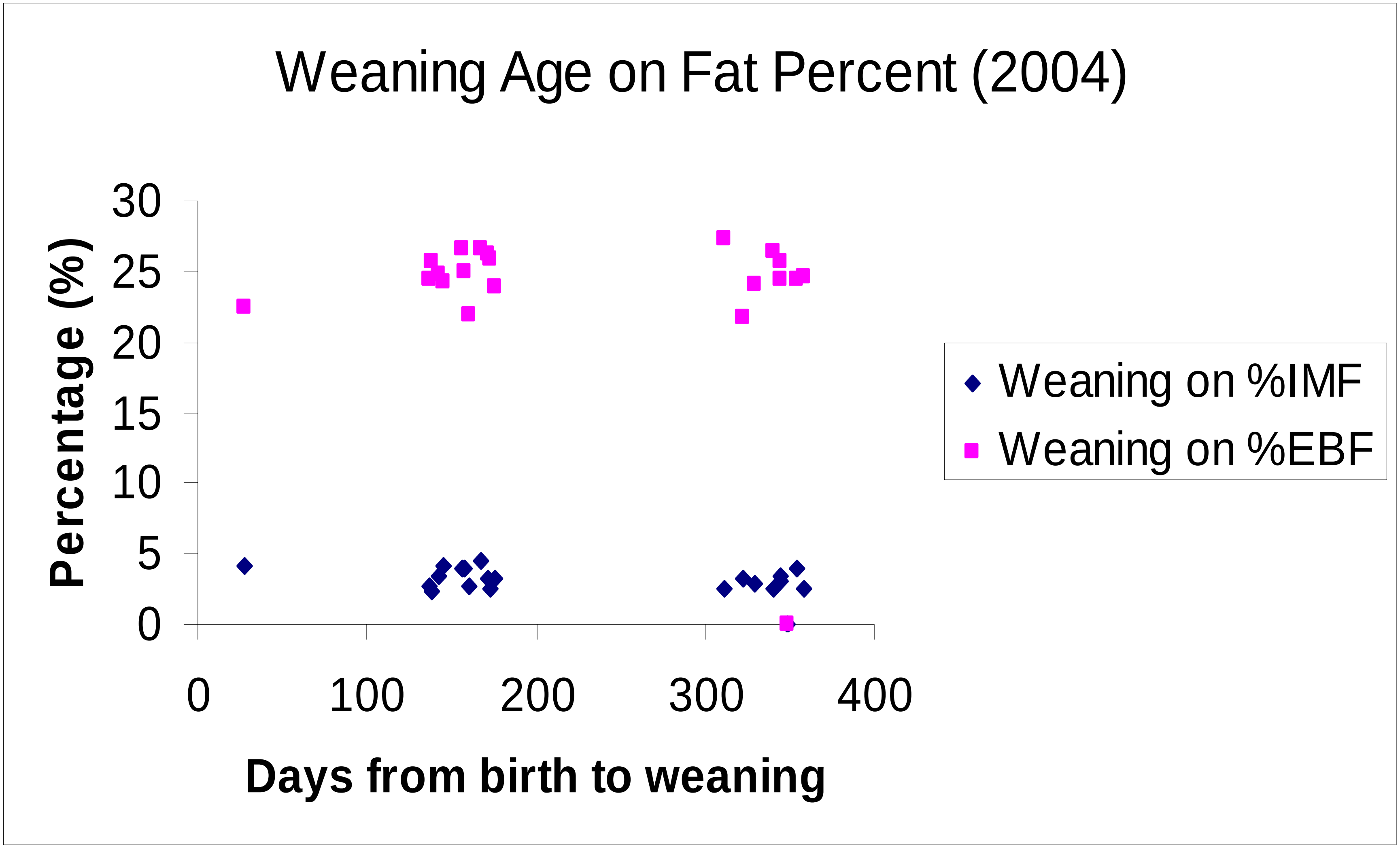

Figure 5- Scatter plot of Percentage Intramuscular Fat and Percentage Empty Body Fat in 2004 calves.

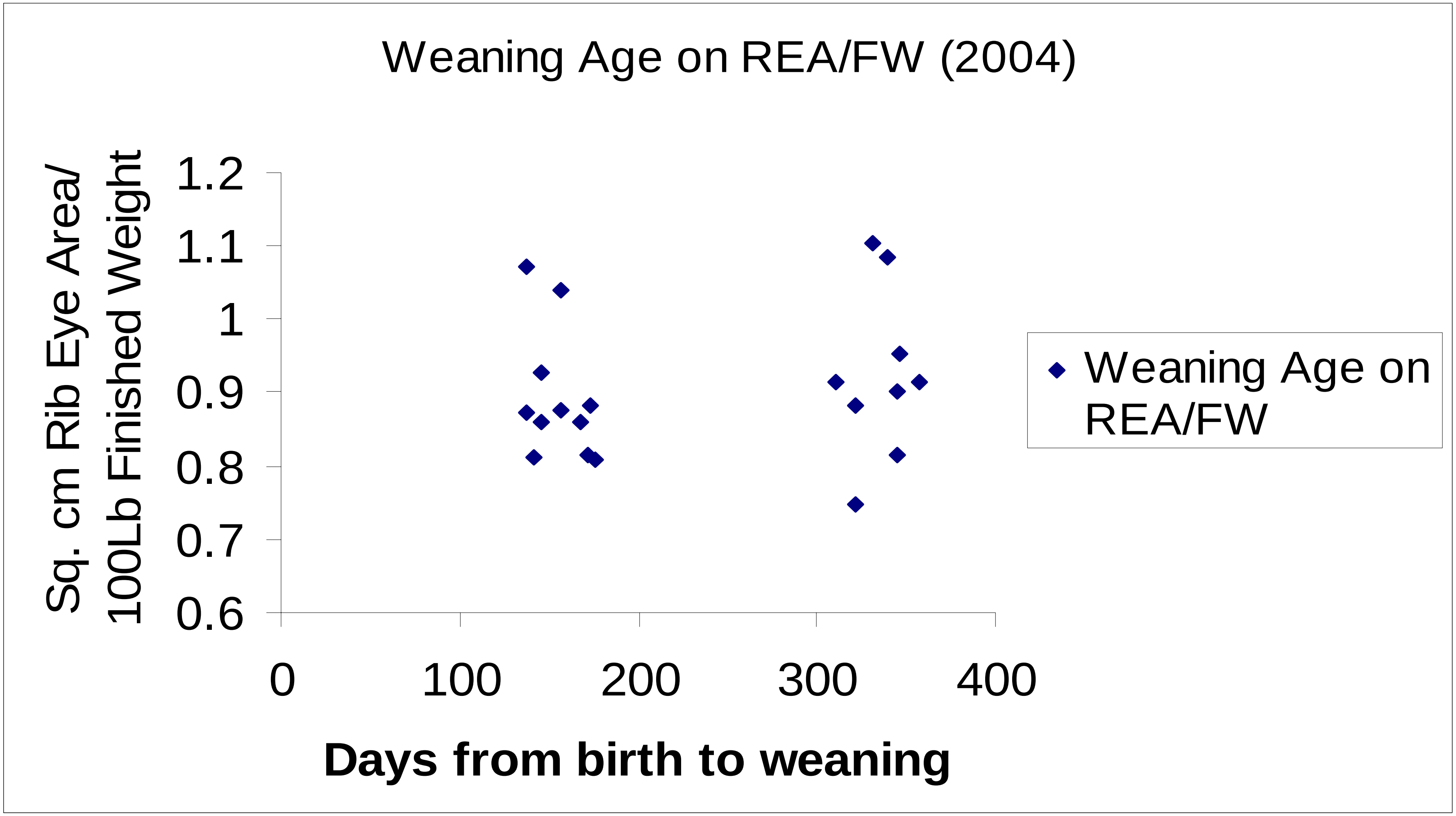

Figure 6- Scatter plot of rib eye area as a function of finished weight (measured in square centimeters/100 pounds) for 2004 calves.

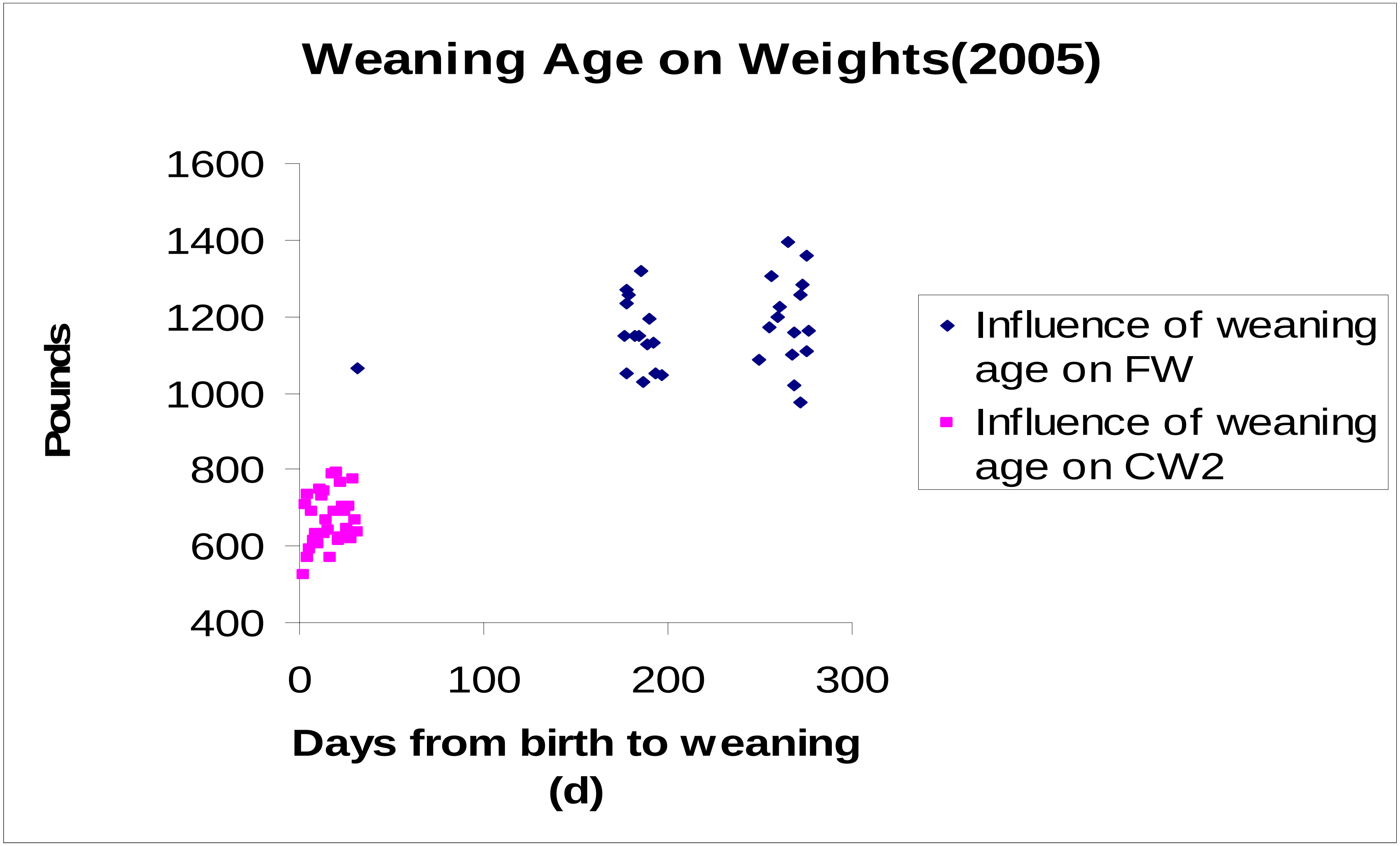

Figure 7- Weights of cattle at late weaning time (CW2) and finished weight (FW) represented by scatter plot of the actual data values in 2005 calves.

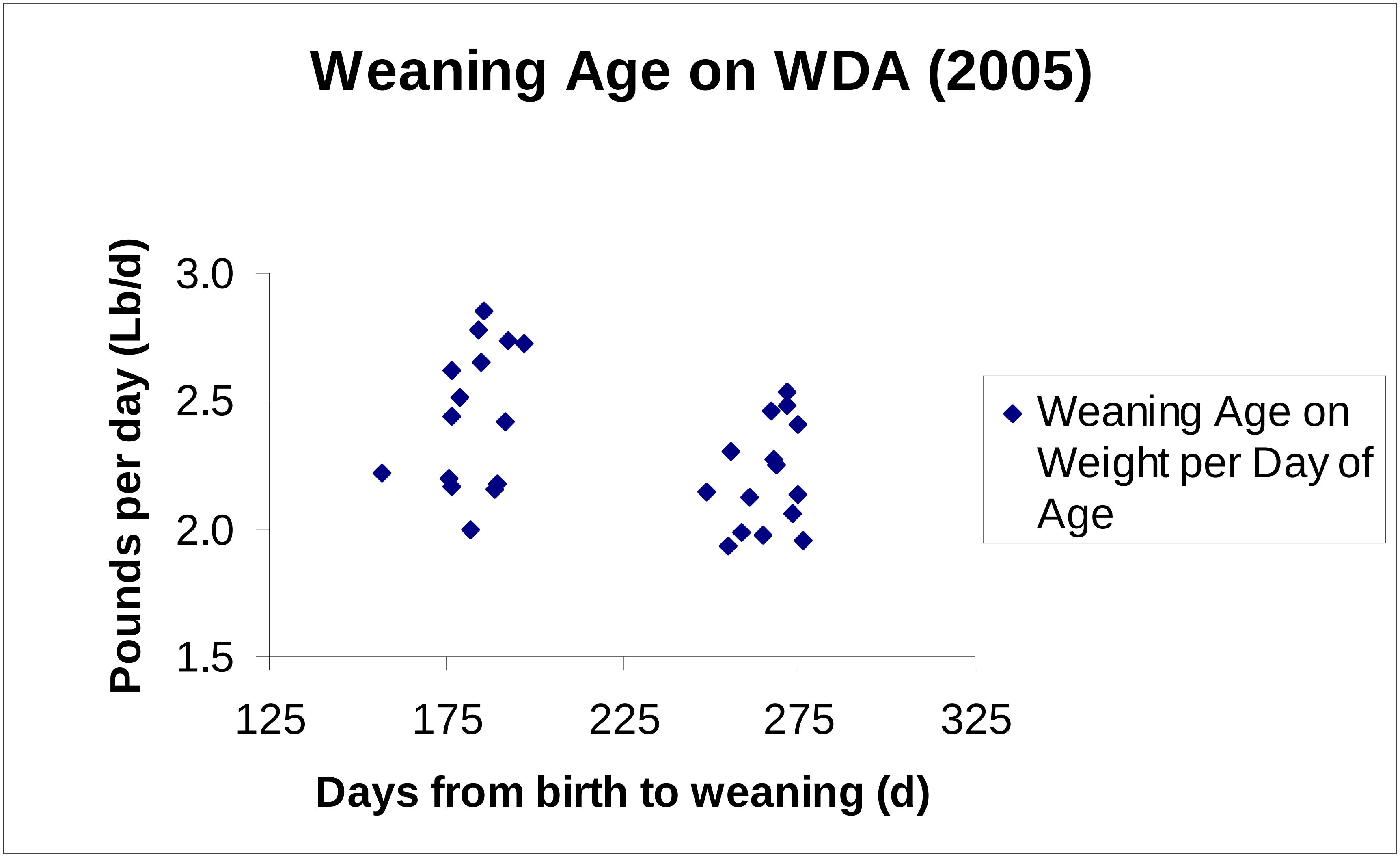

Figure 8- Scatter plot of weight gain per day of age (WDA) in 2005 calves. WDA measured in pounds/day.

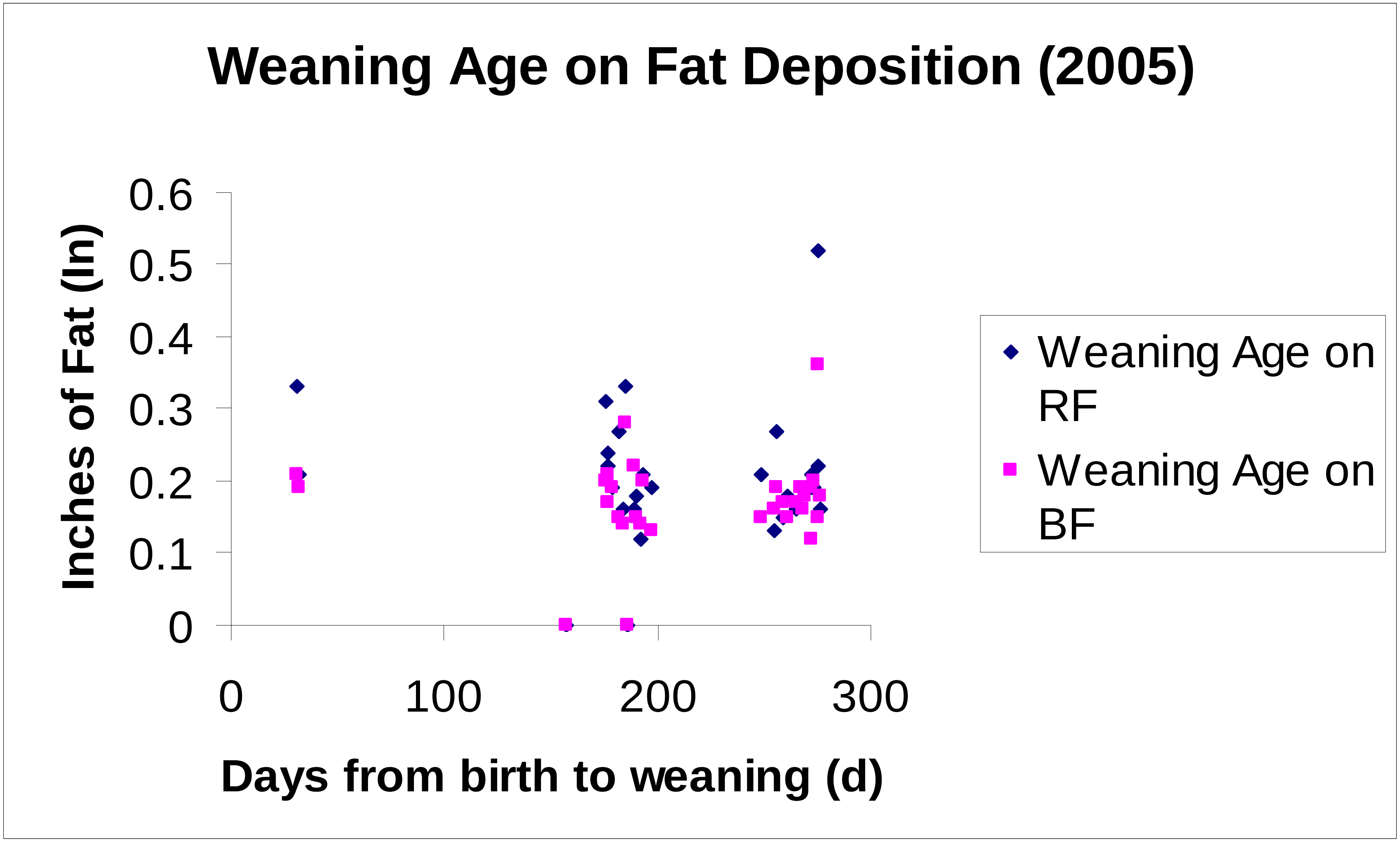

Figure 9- Scatter plot of Back Fat and rump fat data for 2005 weaned calves.

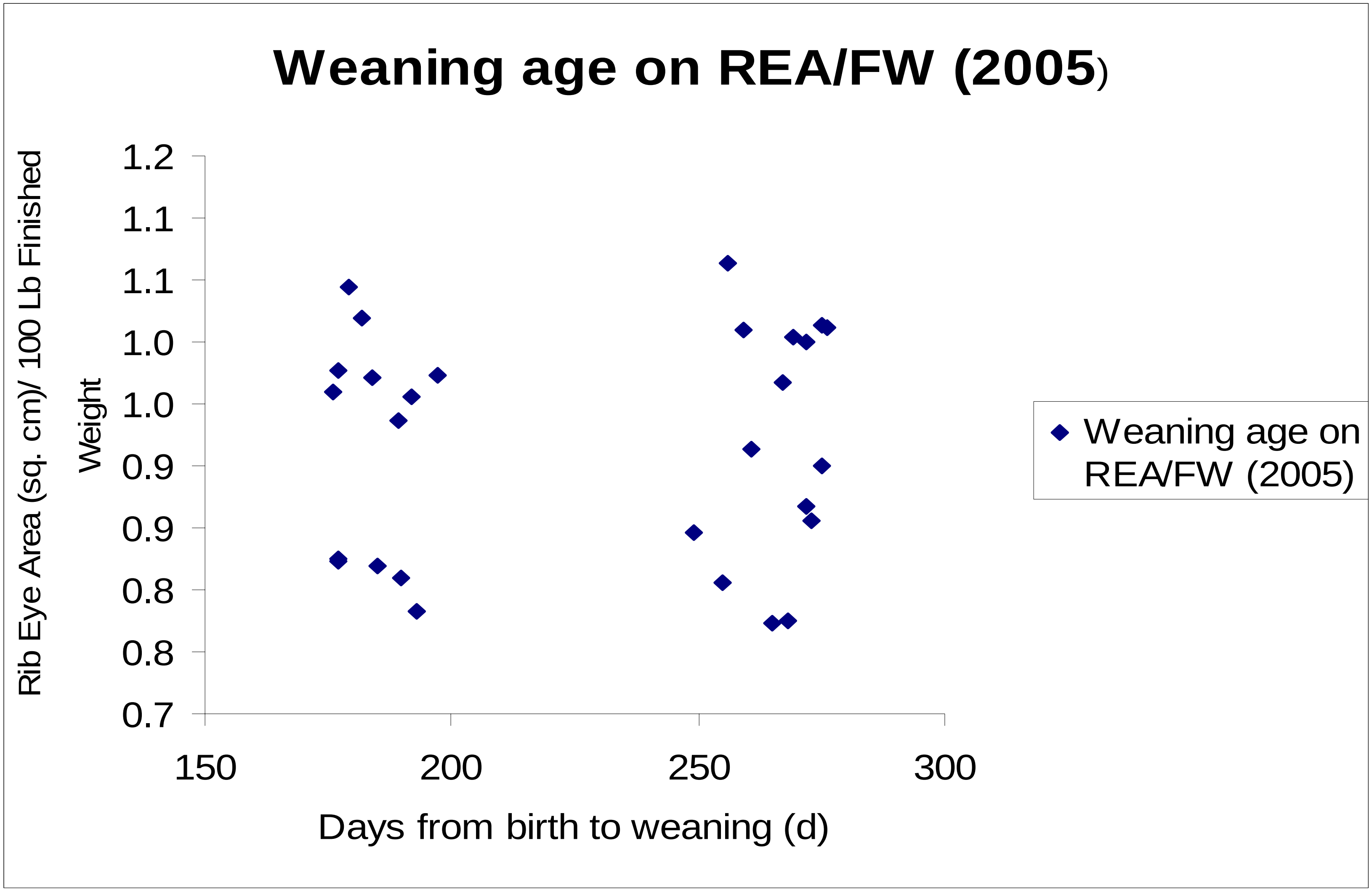

Figure 10- Scatter plot of rib eye area as a function of finished weight (measured in square centimeters/100 pounds) in 2005 calves.

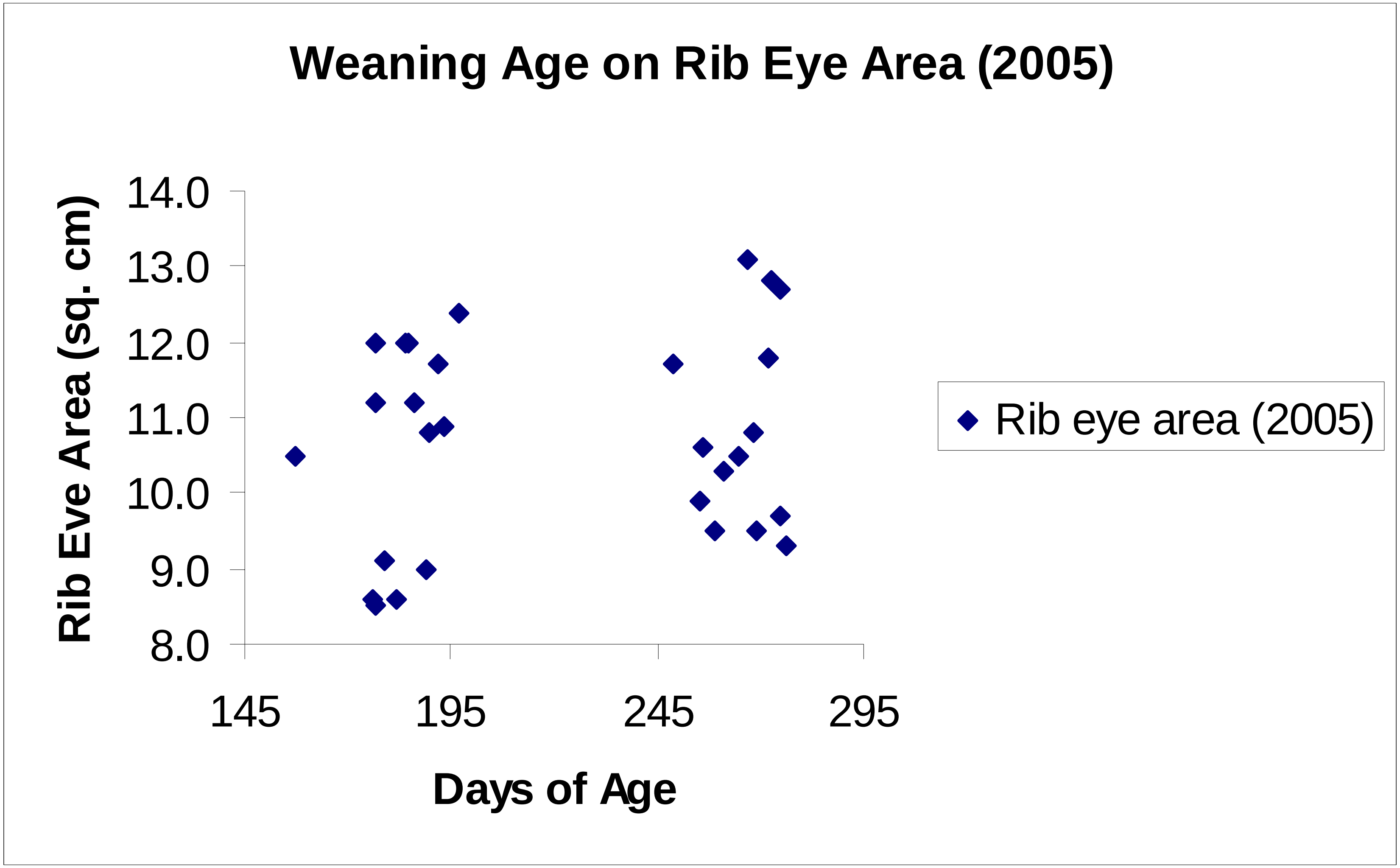

Figure 11- Scatter plot of *Longissimus muscle* area data from 2005 calves.

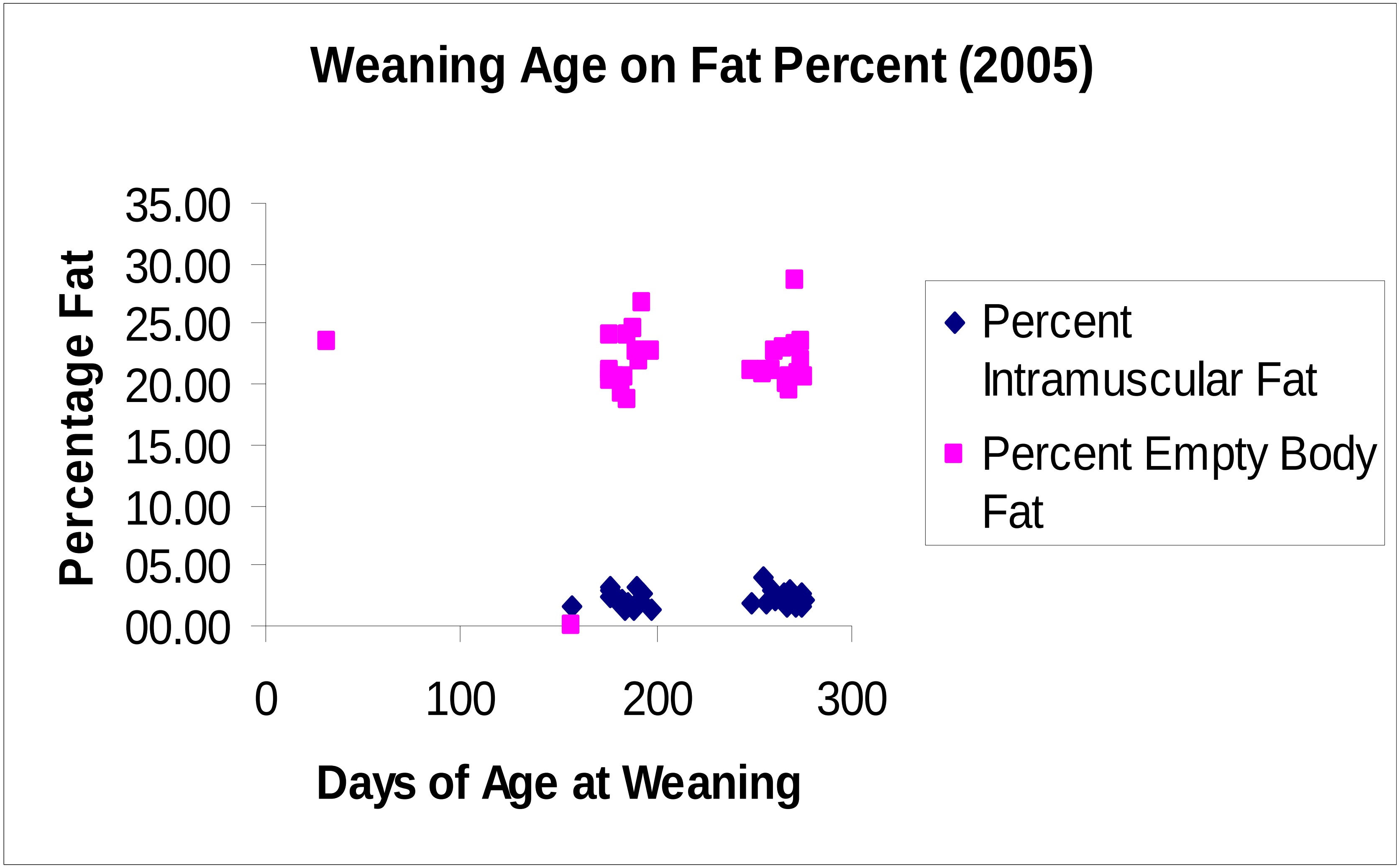

Figure 12- Scatter plot of Percentage Intramuscular Fat and Percentage Empty Body Fat in 2005 calves.

Discussion

Growth Traits

In the 2005 calf data there is a statistically significant difference in CW2 and weight day of age (Table 3, Figure 7, Figure 8) between normal weaned and late weaned calves. This is consistent with literature which has shown that increased milk consumption results in larger carcasses and increased rates of gain at weaning (Clutter and Nielson, 1987). The fact that this difference in performance is minimized over time, resulting in similar sized carcasses is also consistent with the literature, as those cattle weaned at an earlier age were able to engage in compensatory growth. This occurs as a result of the fact that animals fed a lower energy diet (or limit fed) are able to maximize the utilization of the feed they are provided and achieve a higher rate of gain than animals fed a similar feed having been fed either a higher energy feed or a high energy feed ad libitum (Philips et al., 1991). The numerically larger values exhibited for the same growth traits in 2004 data (Table 1, Figure 1, Figure 3) suggest a trend towards these growth patterns, even though the results from 2004 data are not statistically significant. Observation of both the 2004 and 2005 distributions of carcass growth rates shows a visible trend (Figure 1. Figure 3, Figure 7, Figure 8) between later age at weaning, higher CW2, and higher WDA. There is also a slight difference observed in finished weight (Table 1, Table 3, Figure 1, Figure 7), suggesting that compensatory gain was insufficient to fully overcome the difference in CW2, which also agrees with the literature (Clutter and Nielson, 1987). A significantly larger trial size would better allow for analysis of the effects of weaning age on growth traits in forage finished beef cattle. At present, there appears to be a trend towards higher rates of gain, higher weights at the end of a later weaning period, and higher carcass weights at slaughter time. The differences in rate of gain (as WDA) and weight at the conclusion of late weaning (CW2) in the 2005 data was statistically significant, it is likely however, that a larger sample size would have shown more statistically significant differences between growth traits in normally weaned and late weaned calves.

Carcass Composition

Weaning age appears to have some effect on traits indicative of carcass composition (Table 1, Table 2, Table 3, Table 4, Figure 2, Figure 10, Figure 11, Figure 16, Figure 20). While no statistical differences were observed in either the 2004 or 2005 data; there do appear to be numerical differences in REA/FW, suggesting that delaying weaning and increasing milk intake in forage finished cattle may increase muscle mass as a function of overall carcass weight at finishing. This is supported by the findings of Lewis et al. (1989), who showed that an increase in milk availability supported increased muscle mass in carcasses at slaughter age. There does not appear to be a numerical trend or statistical relationship between percent empty body fat and age at weaning. In the 2004 data (Table 2), early weaned cattle had a slightly higher %EBF, while in the 2005 data (Table 4), the later weaned cattle had slightly higher %EBF. This is consistent with research findings (Mandell et al., 1997; Johnson and Pryor, 1974) that adipose deposition depends largely on carcass maturity. While this to some extent conflicts the research of Crews et al. (2002), the cattle examined in that study were being fed high concentrate diets, such that at yearling age much of their adipose tissue deposition would be complete and they would be nearing slaughter weights quickly. The difference in fat deposition would be consistent with the findings of Schoonmaker et al. (2003) and Mandell et al.

(1998) which showed that cattle fed a limited energy diet would deposit larger amounts of lean muscle and produce larger carcasses while depositing less adipose tissue during early life.

It is highly likely that given a larger sample size there would be a statistically significant difference in REA/FW between normally weaned and late weaned calves.

Carcass Traits

There were no statistically significant differences in the carcass traits examined for in this study caused by a delay in weaning age. There are, however, trends in the data which suggest the need for further research. There appears to be no relationship between percent intramuscular fat and weaning age of calves in either 2004 or 2005 (Table 2, Table 4, Figure 5, Figure 12). In 2004, the normally weaned calves had slightly higher percent intramuscular fat, while in 2005, the late weaned calves had slightly higher percent intramuscular fat. Myers et al. (1999) reported that there is not a statistical difference between later age at weaning and increased percent intramuscular fat. These findings are also consistent with research on the subject (Mandell et al., 1998; Johnson and Pryor, 1974), which showed that percent intramuscular fat in forage finished cattle is primarily related to carcass maturity and back fat thickness and only minimally determined by plane of nutrition in early life.

The effect of weaning age on rump fat and back fat is unclear as a result of the data gathered in these experiments (Table 2, Table 4, Figure 4, Figure 9). Rump fat depth was consistently higher for late weaned calves than normally weaned calves in both 2004 and 2005; however, back fat depth was not as consistent. In 2004 back fat depth was greater for the normally weaned calves, while in 2005, back fat was thickest on the late weaned calves. This suggests that rump fat depth does have a positive relationship to later age at weaning, while there is no correlation between back fat and age at weaning in forage finished cattle. The correlation between rump fat depth and age at weaning is supported by research which shows that feeding a higher energy diet results in greater deposition of adipose tissue (Schoonmaker et al., 2004; Mandell et al., 1998). Schmidt et al. (1988) categorize milk as a high energy and high protein feed stuff, which is in contrast to the relatively low energy density of most forages. The absence of correlation between back fat and rump fat suggests that back fat deposition occurs after significant rump fat accumulation has already taken place, similar to the deposition of percent intramuscular fat only after significant depths of back fat and rump fat accumulate. The finding that weaning age has no significant difference on back fat deposition agrees with the findings of Meyer et al. (2005); who showed that there is no difference in back fat between early and late weaned beef cattle finished on the same diet.

Though not statistically significant, there is a clear numerical trend (Table 2, Table 4, Figure 2, Figure 11) towards higher rib eye area as a result of later weaning age. This is supported by the research of Lewis et al. (1989) who showed that calves fed forage diets with larger concentrations of milk in their pre-weaning diet deposit larger amounts of muscle tissue. This is likely due to the presence of higher amounts of high quality bio-available protein and energy during the period of most rapid calf growth. This disagrees with the findings of Myers et al. (1999) who showed that delaying weaning had no effect on rib eye area in concentrate fed steers. This suggests that the differences in energy available between concentrate and forage diets has an effect on the amount of impact had by extending the duration of suckling on calves.

It is likely that given a larger sample size, a statistically significant difference would exist in rump fat and *Longissimus muscle* area between normally weaned and late weaned calves. Further research will be necessary to fully understand whether or not a delay in weaning and increase in weaning age will result in significant changes to carcass traits. At present, however, there appears to be at least a numerical difference in *Longissimus muscle* area and rump fat in normally weaned versus late weaned calves.

In all three categories, calf growth, carcass composition, and carcass traits, the results of these findings disagree with the results of similar research done on variations in weaning age in concentrate finished cattle (Myers et al., 1999; Meyers et al., 2005) suggesting that the differences in available dietary energy between forage and concentrates make extending suckling and delaying weaning a more effective means of improving gain and desirable carcass traits in forage finished cattle. Continuing to explore the effects of weaning on carcass quality and growth may be an efficient way for farmers to attain higher quality carcasses from forage finished beef cattle.

Conclusion

Delaying weaning age in forage finished cattle appears to have positively affected characteristics of calf growth, carcass composition, and carcass traits which would be well received by consumers. A significantly larger trial size would be necessary to determine whether or not the numerical differences in finished weight, rib eye area as a function of finished weight, rib eye area, and rump fat are truly significant. The effects of late weaning on weight per day of age and CW2 are, however, statistically significant. Further research into the effects of delaying weaning on carcass traits is necessary to reach any definitive conclusions. At present, it seems that delaying weaning may be an effective means of increasing weight gain in younger calves on forage diets with little additional investment.

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