

THE RELATIONSHIP BETWEEN WEIGHT, AGE, AND AVERAGE DAILY GAIN,
TO PERFORMANCE IN THE SHOW RING OF GEORGIA COMMERCIAL DAIRY
HEIFERS

by

MATTHEW L. LONDON

(Under the Direction of William Graves)

ABSTRACT

In trial 1, 1,744 Commercial Dairy Heifers were evaluated to determine effects of growth on placing within Georgia Commercial Dairy Heifer Shows from 2007-2010. Mean average daily gain (ADG) for all heifers was determined to be 0.65 kg, below suggested ADG levels of 0.7 to 0.8 kg. No strong correlation ($r = -0.07$; $P = 0.0034$) was observed between ADG and placing. In the second trial, 238 heifers were evaluated for ADG, placing, weight, age, wither height, hip height, hip width, jaw width, and switch clearance. Height at withers had a moderate relationship ($r = 0.42$; $P < 0.0001$) to placing. In trial 3 1,489 Holstein heifers (from 2007-2010) were evaluated and it was determined that 63.75% did not established recommendations for weight gain. Performance and physical features associated with age indicates these commercial dairy heifers are underfed according to industry standards. Economic implications may occur from this decreased performance.

INDEX WORDS: Average Daily Gain; Georgia Commercial Dairy Heifer Program

THE RELATIONSHIP BETWEEN WEIGHT, AGE, AND AVERAGE DAILY GAIN,
TO PERFORMANCE IN THE SHOW RING OF GEORGIA COMMERCIAL DAIRY
HEIFERS

by

MATTHEW L. LONDON

B.S.A., University of Georgia, 2008

A Thesis Submitted to the Graduate Faculty of The University of Georgia in Partial

Fulfillment of the Requirements for the Degree

MASTERS OF SCIENCE

ATHENS, GEORGIA

2010

© 2010

Matthew L. London

All Rights Reserved

THE RELATIONSHIP BETWEEN WEIGHT, AGE, AND AVERAGE DAILY GAIN,
TO PERFORMANCE IN THE SHOW RING OF GEORGIA COMMERCIAL DAIRY
HEIFERS

by

MATTHEW L. LONDON

Major Professor: Dr. William Graves

Committee: Dr. John Bernard
Dr. Mark Froetschel

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
December 2010

DEDICATION

I would like to dedicate this work to all of my family and friends that have been so supportive of me throughout my school career. To my wife and best friend, Kimberly; thank you for being there for me when I needed someone to talk to. Thanks for always being supportive of my endeavors. I look forward to all the future plans that God has in store for us. Next, I would like to thank my parents, Stanley and Jennifer London. Thanks for being the best parents I could ever ask for. The two of you have always taught me that trusting in God, having a good work ethic, and always doing what was right would help me have a prosperous life. Whether at the farm, ball field, show ring, or judging contest, the two of you have always been there for me. To my sister and brother, Katie and Andrew, thanks for your love, support, and laughs that we have had together. To my Grandparents, John and Charlotte Stringer and Verner and Kathryn London, thanks for your love, advice, and inspiration that you all have given me. Nana, I miss you and know that you are smiling down from Heaven. Lastly, to my uncle, Ronnie London, and cousin, Ashley Helton, thanks for your motivation, inspiration, and memories that we have made together.

ACKNOWLEDGEMENTS

I would like to thank Dr. Bill Graves, my major professor, for his guidance and leadership through my college career. From the first day in ADSC 3400 till through the completion of my master's degree, you have helped me to appreciate and select great cows. Thank you for allowing me to participate with the UGA Dairy Judging Team, both as a contestant and coach. To my committee, thank you for taking time out of your busy schedules, for your guidance, leadership, and advice throughout my research. Next, I would like to thank the members of the 2009 and 2010 UGA Dairy Judging Teams. I feel honored to have been a part of the team and will always cherish the memories and the team's accomplishments from the judging contests. To all of my fellow Graduate Students: Jacob Segers, Matthew Sumners, Russell McKeith, and Shepherd Cronemeyer, thanks for your support while in graduate school. To the following people, thank you for directly helping with this research project. To Lewis Fortner and the employees of the University of Georgia Instrument Shop, thanks for making an instrument that was used to measure heifers in the study. It worked perfectly, and could not have asked for anything better. To Dr. Keith Bertrand and Mrs. Andra Nelson, thanks for your assistance in my statistical work. For someone like me with little experience in statistics, your help was appreciated greatly. A big thank you to the show superintendents for their assistance in providing information from the heifer shows. Thanks to Whitney Franks, Debra Sires, and Melinda Vongkunthong for your help in data collection for this research thesis.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
CHAPTER	
1 INTRODUCTION AND LITERATURE REVIEW	1
A Review of the Dairy Heifer Life Cycle.....	1
Growth Measurements and Optimal Growth Patterns	3
Growth in Pre-weaned Dairy Replacement Heifer	7
Growth in Post-weaned Dairy Replacement Heifer.....	9
Dairy Replacement Heifer Growth: Consequences of Excess Growth	11
Economics and Dairy Replacement Heifers	14
The Effects of Heifer Growth on Milk Production and Efficiency	19
Crossbreeding and its Effects.....	21
Dairy Youth Related Activities.....	22
Objectives of Studies	29
2 THE RELATIONSHIP BETWEEN WEIGHT, AGE, AND AVERAGE DAILY GAIN, TO PERFORMANCE IN THE SHOW RING OF GEORGIA COMMERCIAL DAIRY HEIFERS	31
Abstract.....	32
Introduction.....	33

Materials and Methods.....	35
Results and Discussion	43
Conclusions.....	49
3 IMPLICATIONS	52
REFERENCES	53

LIST OF TABLES

	Page
Table 1: Optimum growth patterns for Holstein heifers in ideal conditions (Hoffman, undated).....	61
Table 2: A detailed look at age, weight, and ADG from 2007-2010.....	62
Table 3: Breed comparison within the Commercial Dairy Heifer Program, 2007-2010...62	62
Table 4: County (first letter A-M) comparison within the Commercial Dairy Heifer Program, 2007-2010	63
Table 5: County (first letter N-Z) comparison within the Commercial Dairy Heifer Program, 2007-2010	64
Table 6: A detailed look at each ADG and placing rank within each class, 2007-2010 ...65	65
Table 7: Spearman correlation coefficients between ADG, placing, weight, and age, 2007-2010	65
Table 8: Spearman correlation coefficients between ADG, placing, weight, age, wither height, hip height, hip width, jaw width, switch clearance, 2010 GJNLS.....	66
Table 9: Composition of Holstein heifers below or exceeding the Pennsylvania State Holstein Growth Spreadsheet weight guidelines	67
Table 10: The Pennsylvania State Holstein Growth Spreadsheet: a view of each county's performance	68
Table 11: Differences in suggested weight from actual weight from the Pennsylvania State Holstein Growth Spreadsheet	69

LIST OF FIGURES

	Page
Figure 1: Number of entries in Georgia Junior National Livestock Show, 1997-2010.....	70
Figure 2: Custom designed heifer width measurement device, University of Georgia Instrument Shop	71
Figure 3: Holstein heifer weights compared to recommended weights, 2010 Georgia Junior National Livestock Show	72
Figure 4: Holstein heifer wither heights compared to recommended heights, 2010 Georgia Junior National Livestock Show	73
Figure 5: Holstein heifer hip heights compared to recommended heights, 2010 Georgia Junior National Livestock Show	74
Figure 6: Holstein heifer hip widths compared to recommended widths, 2010 Georgia Junior National Livestock Show	75

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

A Review of the Dairy Replacement Heifer Life Cycle

The bovine, just as any other species, begins growth and development immediately after conception. However, for the purpose of this review, the focus will begin with postnatal growth of dairy heifers. Many dairy industry leaders would argue that the greatest need in the dairy industry is to search for information about the neonate and replacement heifer (Heinrichs et al., 1994). After a gestation of approximately 280 days, the dam gives birth to her offspring. For the female offspring, it is expected that this newborn will grow and be developed adequately (equal to or greater than 575 kg) to give birth to its own progeny at 24 mo and produce adequate quantities of milk (Gardner et al., 1988, Heinrichs, 1993, Heinrichs and Swartz, 1991, Lin et al., 1988, Place et al., 1998). Depending on culling rate, the dairy heifers eventually replace cows from the milking herd, thus they are usually referred to as a dairy replacement heifers.

After birth, the dairy replacement heifer is fed colostrums within the first 24 hr of its life. On second day, the producer provides milk or milk replacer, water, and a calf-starter grain mix until weaning. During the nursery period calves are fed either a single source or a combination of whole milk, discarded, and/or milk replacer. Discarded milk is either colostrum-like milk from fresh cows or milk from cows being treated with antibiotics for mastitis that is diverted from flowing into the bulk-tank and collected in the milking parlor. The time of weaning usually occurs 4 to 8 wk of age, pending

predetermined goals including: dry feed consumption, age, BW, dry feed consumption, and health. Heifers are then placed in transition pens with other female calves of similar age and weight and fed primarily a calf-starter grain mix until the rumen becomes fully functional at 6 mo of age (Tyler and Ensminger, 2006). Although the rumen is anatomically functional at 8 wks, it requires more time for the rumen to develop and be able to effectively degrade fiber. As the rumen develops, dairy heifers gradually have their diets shift from primarily a concentrate diet to a forage-based one (Zanton and Heinrichs, 2007). Shifting to a forage ration results in delayed, but economical growth. With this shift, there is a common practice to feed lower-quality forages, resulting in decreased nutrient digestibility compared to primarily concentrate diets (Moody et al., 2007). Furthermore, as this diet is changed, the digestibility of nutrients within the forage based diet can vary more due to quality and amount of forage fed. If feeding a diet of low quality forage and minimal concentrate, it is likely that this can reduce optimum growth in the dairy heifer. Consequently, the onset of puberty and age of first parturition can be delayed (Pecsok et al., 1992, Zanton and Heinrichs, 2005).

The first most critical landmark for developing dairy replacements is the onset of puberty. Different theories have been suggested as to when this onset usually occurs. Tyler and Ensminger (2006) suggest that puberty occurs when the heifer reaches approximately 35% of mature body weight (BW). Others argue that heifers begin to cycle when they reach 43% of mature BW (Coffey et al., 2006, Van Amburgh, 1993), or at an average BW of 250 to 280 kg for large dairy breeds and between 9 to 11 mo of age (Sejrsen and Purup, 1997). Therefore, if an average Holstein calf weighs 41 kg at birth (Tyler and Ensminger, 2006), it must have an ADG of 0.77 kg to reach 250 kg at 9 mo of

age. As onset of puberty is related to growth rate, body size, and age, it is well recognized that diet and rate of growth has a direct effect on when dairy heifers becomes functional reproductively (Heinrichs, 1993). It is well recognized that heifers that states that heifers that grow faster will reach puberty at an earlier age and can enter the milking herd sooner (Hill et al., 2008). Most often the goal is set to have a dairy heifer calve at 22 to 24 mo of age, and bred at 13 to 15 mo of age at 60% of their mature body size (Tyler and Ensminger, 2006). Heifers are generally bred once they reach the management guidelines of the particular farm in which they are housed. Generally dairy replacement heifer producers observe or measure heights, weights, and/or ages of the heifers and take into account one or more of these parameters before attempting to breed heifers for the first time. After conception, producers should strive to have their heifers grow at the rate of 0.7 to 0.8 kg until parturition.

Growth Measurements and Optimal Growth Patterns

As previously mentioned, BW is the primary measurement for growth in the dairy heifer. However, evaluating dairy heifer growth solely on this measurement can be misleading, because BW alone does not describe the type of growth; whether it is due to desirable/skeletal growth or to undesirable fat deposition (Bagg et al., 1985). There are several measurements that can be taken, along with BW, to evaluate growth in dairy heifers and to provide a more complete measure of a dairy heifer's overall size (Heinrichs and Hargrove, 1991). These include: wither height, body length, hip height, hip width, heart girth, and pelvic area (Hoffman, 1997). Because BW can be affected by body condition and/or pregnancy, the skeletal measurements mentioned above may represent the correct size of the dairy heifer (Hoffman, 1997). Furthermore, it can be

argued that wither height and hip width are more accurate in determining skeletal growth as they are not influenced by body condition (Heinrichs et al., 1992, Wickersham and Schultz, 1963). The use of skeletal measurements, as previously mentioned, along with BW should be used as criterion for assessing the most correct safe calving level in heifers, instead of BW only (Wickersham and Schultz, 1963).

Although BW is the most common measurement taken on dairy farms, it is interesting to point out that many BW on dairy farms are an estimate based on a heart girth measurement rather than actually weighing the animal. This is due to the fact that most dairy farms across the U. S. do not have a scale (Hoffman, 1997). After regression equations were established, heart girth exhibited the highest correlation to BW (Heinrichs et al., 1992). However, all of the body measurements exhibited an R^2 value greater than 0.9 (Heinrichs et al., 1992). Because of this relationship, wither height in Holstein replacement heifers can be accurately predicted from BW, using the BW to wither height ratios (Heinrichs et al., 1992, Hoffman, 1997). Currently, body size measurements are only taken as means to determine how efficiently the heifer is growing. However, there is belief that an estimation of replacement heifer body size from composition selection traits could benefit dairy producers, provided the selection for these traits would help to further the efficiency and productivity of replacement heifer growth, and future milk yield (Hoffman, 1997). Genetic selection for milk yield could hypothetically result in replacement heifers with a certain body composition as determined by their frame, weight, and age (Hoffman and Funk, 1992).

Over the past century, producers and scientists alike have desired to determine the optimum growth pattern and body size in dairy heifers. Growth can be defined as

maturation of the reproductive system, as well as an increase in body size and BW (Heinrichs and Hargrove, 1987). For one to define optimum growth rates in replacement heifers, three considerations must be answered: the optimum age at first calving (Swanson, 1967), the optimum size at first calving, and the genetic variance associated with body size (Hoffman, undated). It is necessary to point out that some researchers indicate that optimum body size is misnamed, but assimilation of replacement heifer growth criteria is periodically needed so commercial dairy producers have a reference to evaluate replacement heifer management (Hoffman, 1997).

Growth can be affected by many factors including genetics, nutrition, and management (Heinrichs and Hargrove, 1987). Furthermore, there are substantial additive genetic differences between different sire groups within a dairy breed for size and growth rate of replacement heifers (Lee, 1997, Lee et al., 1988). According to Lee (1997), genetics determines the potential for an embryo to grow into a highly profitable mature bovine. Animals that have a higher capacity for genetic growth may be able to have high ADG due to greater skeletal growth without negative effects due to fattening (Bagg et al., 1985).

Genetic differences for milk yield potential also exist within different cattle populations, causing the optimal ADG rates to vary as much as 100 g/day (Sejrsen et al., 2000). Heifer growth rates are highly influenced with the implementation of a genetic selection program on a farm (Hoffman and Funk, 1992). Hoffman and Funk (1992) agree with Lee (1997), that a producer must determine a heifer's genetic potential and feed the heifer to reach her maximum frame size and BW plus some adipose tissue deposition for energy reserves needed during negative energy balance during the first lactation.

Diet and rate of growth, is mainly affected by diet and has a direct effect on age at first calving and productivity per day of herd life (Heinrichs, 1993). The main growth objective for heifers on most dairy farms today should be for their heifers to maintain desirable growth rates so that age at calving stays relatively constant around 24 mo (Heinrichs and Hargrove, 1987). The optimal growth pattern for dairy heifers has been defined by Swanson (1967) as the regimen that will develop her full lactation potential at the desired age with minimal expense (Heinrichs and Hargrove, 1994). Proper growth patterns for dairy replacement heifers, under ideal conditions, can be found in Table 1 (Hoffman, undated). Further, Swanson (1967) suggested that from an economic as well as a productive consideration, the optimal growth rate for dairy heifers can be obtained by moderate consumption level of good quality feed.

Bagg (1985) reported that when evaluating heifer growth, one should see moderate weight gains and skeletal growth occurring without excessive body condition. Proper growth rates must be achieved for the heifer to reach optimal body frame-size before first parturition (Heinrichs, 1993). Once the optimal or desired growth rates have been determined for one's dairy heifers, a dairy heifer grower should strive to maintain the protein guidelines for quantity and quality from the NRC, corresponding to the desired rate of rate growth, because any alteration may have an effect on growth parameters in dairy heifers (Hoffman and Funk, 1992). At a proper growth rate, milk production is maximized and the threat of dystocia is minimized (Heinrichs, 1993, Hoffman, 1997, Hoffman and Funk, 1992). To minimize dystocia, heifers must meet the adequate weight and frame size guidelines throughout the heifers' life. Of course, this is directly dependent on nutrition and management as well as the breed of the heifer(s) (Erb

et al., 1985, Hoffman and Funk, 1992, Lee, 1997, Meijering, 1983, Thompson et al., 1983).

To evaluate heifer growth, a starting point must be established. This is generally at birth of the dairy replacement heifer. From birth until weaning, known as the pre-weaning period, there is potential to increase body growth rates through increased energy and protein, resulting in younger ages at puberty and first calving (Brown et al., 2005b). Most dairy producers do not weigh their calves at birth. Based on research data, Tyler and Ensimerger (2006) have established birth weight averages for the Ayrshire, Brown Swiss, Guernsey, Holstein, and Jersey breeds which can be used to compare growth rates of replacement heifers. These birth weights are 34.02, 43.50, 29.96, 41.28, 24.49; for the Ayrshire, Brown Swiss, Guernsey, Holstein, and Jersey, respectively (Tyler and Ensimerger, 2006).

Growth in Pre-weaned Dairy Replacement Heifer

Adequate nutrition and environmental conditions are vital for optimum growth. After birth, the replacement heifer can be housed in many different ways including: individual pen, group pen, or with its dam. All of these can and do have an effect on growth in the heifer calf during this pre-weaning period. From the studies of Place et al. (1998), group housing or allowing the calf stay with the dam was determined to negatively affect ADG in the calf. Therefore, the most desirable form of calf housing to achieve higher ADG is individual calf pens, where the calf is removed from the dam and raised separately (Place et al., 1998). Another environmental factor in growth of the pre-weaned heifer is the season of birth. It was determined that for heifers 90d of age or less, heart girth was the largest in heifers born in the summer or early fall (Place et al., 1998).

From a growth standpoint, approximately 50% of a calf's wither height increase occurs in the first 6 mo of life (Kertz et al., 1998). The other 50% is split between two age groups, 7 to 12 mo and 12 to 24 mo (Kertz et al., 1998). This means that if a calf is weaned at around 8 wk, approximately 17% of wither growth in a heifer occurs during the pre-weaning period alone. Furthermore, Holtz et al. (1961) evaluated the four 6 mo aging intervals from birth to 24 months and found that ADG in the 0 to 6 mo interval was greatest and most critically related to fat corrected milk yield, proving the necessity of proper nutrition for the very young dairy replacement calf.

Nutrition for the pre-weaned calf can originate from various sources; the most common source is milk replacer. As a matter of convention, producers have fed approximately 0.227 kg of powder, mixed with 2 quarts warm water, twice daily, believing that this quantity would provide for proper growth and prevent scours or other illnesses. However, there is a clear opportunity to improve calf growth and energy retention by feeding more nutrient dense milk replacer at a rate higher than 0.454 kg per day (Bartlett et al., 2006, Blome et al., 2003, Hill et al., 2008). In a recent study with pre-weaned calves, Brown et al. (2005b) observed greater wither height ($P < 0.01$) and BW gain when calves were fed a milk replacer diet of 30% CP, 15.9% Fat. However Hill et al. (2008) determined that this increased growth performance of pre-weaned calves was more related to protein feeding as only increasing fat content of milk replacer did not improve growth. When comparing all of the diets used in this study, Hill et al (2008) reported that heifers fed the control diet (20 % CP, 21 % fat; fed at 441g/d) had the smallest BW, wither height, body length, hip height, and hip width when compared to the three experiment diets (28% CP, 20% fat; fed at 951 g/d, 27% CP, 28% fat; fed at 951 g/d and

1,431 g/d). Furthermore, gain to feed ratios were lower (0.36 vs. 0.44; $P < 0.05$) in the heifers fed the control milk replacer compared with the average of those fed the higher CP milk replacers (Hill et al., 2008). Intuitively, one would think feeding more to a calf would cause her to grow at a higher rate, and the data from Hill et al. (2008) solidifies the idea that producers should feed their heifers more than just the average 3.78 L of milk replacer split into two daily feedings. Other parameters that have been positively associated with growth were sex of calf, breed, and parity of dam (Place et al., 1998).

Growth in Post-weaned Dairy Replacement Heifer

At weaning, the diet for the dairy replacement heifer changes from a milk or milk replacer based to a calf starter concentrate-grain based, and eventually progressing further gradually change to a forage-based diet, as the rumen becomes functional. Providing high quality forage will encourage proper voluntary consumption levels, thus allowing for proper growth rates in dairy replacement heifers. Several studies are present in the literature that evaluates heifer growth post weaning. First, it is to be noted that the NRC (2001) recommends large breed dairy replacement heifers to have a 0.7 to 0.8 kg ADG from 10 to 67 wk of age (Kertz et al., 1987). The NRC (2001) reports that dairy heifers weighing 136 kg, with desired ADG levels of 0.77- 0.81 kg, should be fed 17% (of DM) crude protein (Hoffman, undated). However, Kertz et al. (1987) suggested that replacement heifers from 3 to 6 mo of age may gain up to 1 kg/day without excess deposition of fat. This requires a minimum of 17% CP (% DM basis), and 10 to 12 % more energy than the NRC (2001) recommendations for 0.8 kg/day gain (Kertz et al., 1987). The key component in reaching and maintain desirable growth within dairy replacement heifers is protein. Several studies in the literature, demonstrate that

increased protein levels in the diet will result in improved feed efficiency (Brown et al., 2005b, Gabler and Heinrichs, 2003b, Lammers and Heinrichs, 2000). Bagg et al. (1985), fed different protein levels (80, 100, and 120%) as a percentage of NRC requirements to heifers from approximately 6 to 10 mo of age. Results of this study indicate that increasing dietary content resulted in greater BW and ADG (879, 938, 1038 g/d; for 80, 100, 120 % CP; respectively), but no differences were observed in wither height, thus BW growth resulted from an increase in body condition (Bagg et al., 1985).

Equally important, others have discovered that increasing CP, while keeping metabolizable energy (ME) constant, results in increased wither and hip height (Gabler and Heinrichs, 2003a, Lammers and Heinrichs, 2000). Producers striving for accelerated growth rates in his dairy replacement heifers, increase the ratio of protein to energy in the ration in order to meet increased protein intake requirements (NRC, 2001; Lammers and Heinrichs, 2000). Increases in feed efficiency and structural growth was reported after Gabler and Heinrichs (2003b) studied the effects of increasing the level of CP (12.0, 15.2, 17.4, and 19.7%), all while keeping the ME constant (2.6 M cal/ kg of DM) (Gabler and Heinrichs, 2003a). Lammers and Heinrichs (2000) agree with Gabler and Heinrichs (2003a and 2003b) that increased ratios of CP: ME results in better feed efficiency, and goes a step further by proving that increased ratios of CP: ME can improve ADG by 9.5% compared to lower ratios of CP: ME. In this study of dairy replacement heifer growth from 28 to 48 wk, it was also determined that the rate of structural growth was 3.5 to 8.5% faster than ADG thus proving that increased CP:ME enhances lean-tissue growth (Lammers and Heinrichs, 2000).

Dairy Replacement Heifer Growth: Consequences of Excess Growth

In general, dairy producers strive to be effective and efficient by maximizing dry matter intake and milk production in dairy cows and maximizing growth of dairy heifers. However it is important to realize that in heifer growth and development, excessive growth may be detrimental in the productivity of a dairy heifer.

As discussed earlier, the dairy heifer from birth increases in both size and weight while developing into a mature cow. A vast majority of development in the dairy heifer hinges on attaining puberty within each heifer, especially in regards to reproduction and mammary development. This section will focus on the pre-pubertal through the post-pubertal time periods of a dairy replacement heifer's life.

The pre-pubertal phase is a very critical time in the dairy calf's life. During this time, the mammary system is growing allometrically (Sinha and Tucker, 1969). The allometric phase can be initiated at 2 to 3 mo, 150 to 180d prior to the female exhibiting her first estrus (Sinha and Tucker, 1969). According to the studies of Heinrichs (1993), Sejrsen et al (1982), and Waldo (1989), the most critical period of mammary gland growth is likely to be 3 to 9 mo of age, prior to puberty.

The NRC (2001) recommends that ADG for 10 to 67 wk old dairy heifers be 0.7 to 0.8 kg/d (Kertz et al., 1987). Although it is the desire of the dairy producer to maximize growth and efficiency, the dairy calf must be fed in a restricted manner to result in adequate ADG so that mammary gland development occurs uninterrupted and subsequent milk production is unaffected (Sejrsen et al., 2000). Mammary gland development can be inhibited due to fat deposition in the glands as a result of overfeeding heifers (Brown et al., 2005a, Sejrsen and Purup, 1997). The magnitude of this

irreversible mammary gland suppression can be altered due to the different possible diets. According to Capuco et al. (1995), the reduced mammary DNA is greater when heifers are fed a corn-based diet compared to a higher protein diet, such as alfalfa. Therefore, the type of diet and protein level can be modified to maximize efficiency of growth and mammary duct development (Sejrsen and Purup, 1997).

In a study by Sejrsen et al (1982), 12 Holstein-Friesian pre-pubertal heifers were fed a 60:40 forage to concentrate ratio either ad libitum or restricted. Heifers fed the ad libitum ration had 23% and 32% less mammary secretory tissue weights and DNA content, respectively (Hoffman and Funk, 1992, Sejrsen et al., 1982). It is suggested that impairment of the mammary system due to feeding excessive energy is due to altered secretion of hormones, including growth hormone (GH), that regulate mammary development (Sejrsen et al., 1983). Furthermore, Sejrsen et al (1983), states that this alteration can be prevented by dietary or pharmacological manipulation of endogenous GH or supplying exogenous GH. Another possibility to minimize the modification of secreted hormones into the mammary system is to feed Melengesterol Acetate[®] (MGA) (Pritchard et al., 1954, Sejrsen et al., 1982). Pritchard et al., (1954) reported that feeding MGA from 2.5 mo til breeding (120 cm wither height) aided in increased mammary DNA and RNA by 60% ($P < 0.01$). Furthermore, MGA is an inexpensive, efficient additive that can easily be added to rations of larger-scaled production systems.

Although excess growth and body condition within the dairy replacement heifer can occur, there are potential ways that accelerated growth can be attained without detrimentally affecting the mammary system. Hoffman and Funk (1992) report that Smith et al. (1986), found no differences in secretory tissue development in heifers

gaining either 725 or 950 g/d when the heifers weighed between 175 to 325 kg. Heifers that have a managed growth rate during critical points of mammary development and gestation accumulate fewer lipids, resulting in an enhanced lactation compared to their over-conditioned counterparts (Choi et al., 1997, Coffey et al., 2006). Dairy producers can maximize lifetime profitability of heifers by decreasing the age of onset of puberty and first calving, by providing a diet that insures proper protein intake, but does not cause excess fattening (Brown et al., 2005b). Some researchers report that increased protein levels in pre-pubertal rations might be needed for optimum development of the mammary system (Lammers and Heinrichs, 2000, VandeHaar, 1997). Taking this a step further, in a study performed by Radcliff et al. (1997), mammary secretory tissue growth was unaffected in pre-pubertal heifers fed a CP to ME ratio of 71:1 g/Mcal and gaining 1200g/d (Lammers and Heinrichs, 2000).

Other researchers argue that ADG can be increased to .9 kg or 1kg without excess condition occurring for animals that may have higher growth capacity (Bagg et al., 1985, Kertz et al., 1987). According to Heinrichs et al (1992) and Sejrsen et al (1982), larger ADG can occur as long as the corresponding skeletal growth occurs too. Zanton and Heinrichs (2007) reported there is a need for more research to be done in this area to determine a strategy to accelerate lean growth of dairy heifers without subsequently reducing lactogenesis of the mature cow.

After the onset of puberty occurs, ADG in post-pubertal dairy replacement heifers becomes less important due to the fact that studies have shown that increased ADG, at this time period, does not affect mammary development (Sejrsen et al., 1982), and subsequent milk production in the cow (Grummer et al., 1995, Hoffman et al., 1996,

Zanton and Heinrichs, 2007). As a result, there are few studies on post pubertal heifer growth and its effects, whether negative or positive, on milk production (Bagg et al., 1985, Kertz et al., 1987).

Economics and Dairy Replacement Heifers

Dairy heifers are grown with the primary intention of being placed into a milking herd upon parturition. Currently, many dairymen across the U.S. raise their own heifers as replacements into the milking herd. Almost two decades ago, a survey reported that contract heifer growers were utilized by a very small percentage (1.6%) of dairy operations, despite the possible economic benefits predicted (Heinrichs et al., 1994, Willet, 1990). However, as dairy operations continue to grow in herd size, there is an increasing number of producers that are having their heifers raised by a custom heifer grower (Wolf, 2003). The dairy producer can sell his heifer(s) to a dairy replacement grower and buy them back; however, most dairymen choose to retain ownership of their heifers and contract someone to raise the heifers until they return to the dairy farm. The rate of payment for this service is usually by day on the heifer grower's farm and/or by other methods including weight gain (Wolf, 2003).

Raising dairy heifer replacements, surprisingly, accounts for a substantial part of the economics on the dairy farm. Of total farm expenses, raising dairy heifers to prepare them to enter the milking herd represents 15-20% of all the farm's expenses (Brown et al., 2005b, Heinrichs, 1993, Place et al., 1998). Furthermore, approximately 40 to 70% of the cost of raising dairy replacement heifers comes from feed costs (Buch et al., 1955, Stelwagen and Grieve, 1990).

The economics of heifer raising and marketing dairy replacement heifers has undergone a substantial amount of change in recent years. The wide-spread implementation of female sexed semen in dairy heifers is an example of a management tool that is changing economics. Due to their increased fertility over cows, dairy heifers are ideal and more likely to be inseminated with female sexed semen. Breeding heifers with sexed semen provides obvious economic advantage for dairy producers. These include an increase supply of heifers available for purchase and allowing for greater growth from within the herd (De Vries et al., 2008, Weigel, 2004). By having an increased supply of heifers, dairy producers have a greater opportunity to cull poor growing heifers, thereby avoiding future losses as poor performing milk cows (De Vries et al., 2008). Furthermore, as the replacement heifer supply meets and exceeds the demand of dairymen, the purchase price for dairy heifers will decrease (De Vries et al., 2008). It is expected that as female sexed semen becomes increasing popular to dairymen, they will in turn seek the labor of a custom heifer grower, eliminating the purchase price aspect, and focus will shift primarily to the rearing of the heifer (De Vries et al., 2008).

The optimum growth pattern for dairy heifers is one that allows a heifer to develop to full lactation potential at a desired age all while minimizing the cost to the farm (Place et al., 1998). In difficult times in the dairy industry, it may be challenging to pay these expenses, due to the fact that these animals are not generating any income unless they are either sold or enter the milking herd. The return for investing in proper feeding and management of dairy replacement heifers is delayed for years. Zanton and Heinrichs (2005) stated that raising dairy heifers is a very important aspect of whole farm

management that can be characterized as a long-duration, high-cost period that creates a lag in capturing a return on investment. Looking at the overall economics and the producing ability of the dairy heifer, the rate of growth from birth to the first parturition is of most importance (Heinrichs, 1993, Heinrichs and Hargrove, 1987). Thus, if the growing period could meet the recommendations of 22 to 24 mo of age at first parturition, the time between expenditure and revenue generation could decrease, and the costs associated with the non-productive period could be reduced (Ettema and Santos, 2004, Zanton and Heinrichs, 2007).

In the 1990s data from three studies: Greaser (1992), Heinrichs (1993), and Willet et al. (1992); suggests that the actual cost of raising dairy replacement heifers from birth to parturition at 24 mo to be \$1150 to \$1250 per heifer; with each additional month after 24 mo costing the producer \$55 to \$65 per heifer. It is to be noted that since the 1990s, feed cost have rose appreciably (~ 50 to 100 %). Hill (2008) and Tozer and Heinrichs (2001) state that by reducing the age at calving by 1 mo can decrease the cost of heifer rearing by 4.3%. These calculations and estimates were reported well before the energy and feed costs increased over the last decade, thus the cost of raising dairy replacement heifers has increased since these studies of estimated costs in raising heifers were published. Furthermore, the most effective methodology for reducing rearing cost is to significantly reduce the rearing time to first calving (Hoffman and Funk, 1992, Sejrsen and Purup, 1997). Moderately sized commercial heifer producers can save thousands of dollars by decreasing rearing time in their dairy replacement heifers.

Throughout the literature there are several reports that make different recommendations regarding the most desirable age at calving to maximize production

and profit. Some researchers assert that by reducing the age at first calving the producer is likely to lose milk yield for heifers that calve less than 22 mo of age (Gardner et al., 1977, Hoffman et al., 1996, Little and Kay, 1979, Peri et al., 1993). Comparison of production records of first calf heifers that were fed to attain two different ages at calving reveals that accelerated programs may be better than less accelerated programs. Of the two ages, 23 mo and 26 mo, the cows calving at 23 mo produced 1,475 kg more milk and had 107 d more of productive life (Clapp, 1979, Hoffman and Funk, 1992). Furthermore, Gill and Allaire (1976) evaluated 933 cows and determined that maximum performance occurred when heifers were grown to calve at 23 mo, but optimum profit occurred in females that calved two months later because these heifers had more days of heard life than those heifers that calved at 25 mo (Hoffman and Funk, 1992). Although the data is readily available for producers to see the benefits of calving at or near 24 mo of age, the implementation of accelerating heifer growth programs to decreased calving age on herds in the U. S. has been relatively slow (Hoffman and Funk, 1992, Nieuwhof et al., 1989, Powell, 1985). This may be due to one or two reasons: the inability of the replacement heifer to partition nutrients correctly when rearing rates are accelerated or some producers feel larger cows produce more milk, thus striving to produce a older, larger heifer at calving (Hoffman and Funk, 1992). However, a dairy producer will more likely to observe the maintenance cost for the older heifers as exceeding the value of the added production of the heifer by delaying her age at first calving (Miller and Mcgilliard, 1959).

There are many opportunities for producers to become more efficient in their heifer rearing strategy, resulting in more profitability. One way is to decrease costs in the early stages of the heifer's life. It was observed that the cost per kg of BW gain and

wither height gain was least and most efficient in the heifer's first 6 mo of life (Brown et al., 2005b, Kertz et al., 1998). It may be difficult for a producer to realize this early period of development as an opportunity to reduce costs because a vast majority of heifer growers think in terms of dollars per ton of feed and not cost per rate of gain (Kertz et al., 1998). Because of this mindset, producers believe that younger calves cost more to raise per unit gain than their older herd mates due to the fact that calf feeds usually cost more per unit weight because of their increased nutrient density and palatability (Kertz et al., 1998). Thus, it is vital for a dairymen or custom heifer grower to provide adequate nutrients to ensure proper growth in the early phase of the calf's life that will in turn make her more productive and profitable as a cow.

Digestibility and utilization of nutrients also plays a crucial role in the profitability of a dairy replacement heifer production system. If the diet is less than optimum in nutrient digestibility of nutrients occurring, the cow is expelling nutrients that should have been digested and retained; therefore, the heifer is not reaching her full growth potential. Digestibility is a major dietary constraint that can limit performance and growth rate of dairy replacement heifers. As a result, the producer must desired quantity and quality feedstuffs so that the heifer will reach her desired weight at parturition (Gabler and Heinrichs, 2003b). Thus, efficient utilization of dietary CP and energy yielding nutrients by pre-pubertal Holstein heifers can minimize rearing costs and maximize the productivity of the heifer (Gabler and Heinrichs, 2003a). Also, it is possible to decrease the cost of heifer rearing operations by weaning calves earlier, as this is one of the many factors that affect the overall cost of raising heifers (Heinrichs, 1993). However, to accomplish this effectively, the producer must make sure that the heifers are

receiving adequate nutrition from dry feed, so that growth is not stunted and/or the calf is more susceptible to illness. Another possibility of reducing cost in the heifer rearing system is the implementation of restricted feeding of more highly digestible feeds. Restricting intakes of more digestible combinations of forages and concentrates may be beneficial by reducing total output of feces, which would likely reduce costs associated with manure removal and bedding (Moody et al., 2007). Overall, if the optimum growth pattern for dairy heifers is implemented as defined by Swanson (1967), this regimen will help develop a heifer's full lactation potential at the desired age with minimal expense to the producer (Heinrichs and Hargrove, 1994).

The Effects of Heifer Growth on Milk Production and Efficiency

It is understood that for a cow to be profitable, she must grow as a heifer. This brings one to ask the age old question: is heifer growth (ADG and/or weight at calving) related to milk production? If there is a relationship, how strong is the correlation? This section will examine this relationship to determine whether larger cows always produce more milk and stay in the herd longer. Over the past seventy five years, several studies have been conducted to determine whether or not older and larger heifers produce more milk when compared to their younger and smaller herd mates.

Early studies, such as Davis and Willet (1938) observed records from 76 Holstein heifers and found that there was no relationship between production and percentage increase in weight, wither height, and chest girth from birth to 2 yr (Holtz et al., 1961). According to a study performed by Lee (1997) reported low correlations ($r < 0.2$) between weight, gain, and feed intake to subsequent milk production. This led Lee

(1997) to suggest that there are no strong associations between heifer rearing traits and first lactation yield traits. This finding is supported by research from Sejrnsen et al. (2000).

Many articles use weight at calving as the heifer growth evaluation parameter when comparing growth to production. Most published reports indicate that heifer growth does indeed play a role in milk production. In an evaluation of 305,000 production records by Keown and Everett (1986), the optimum weight at first calving was determined to be 590-635 kg (Hoffman, 1997, Hoffman and Funk, 1992). Other studies show that increasing calving weight has a positive effect on first lactation milk yield (Clark and Touchberry, 1962, Fisher et al., 1983, Harville and Henderson, 1966, Heinrichs and Hargrove, 1987, Hoffman and Funk, 1992, Keown and Everett, 1986, Lin et al., 1985, Miller and McGilliard, 1959). This positive relationship between BW at calving and milk yield is mainly due to a positive relationship between growth rate capacity and milk yield (Sejrnsen et al., 2000). Also, it is noted that most dairy operations with higher production levels demonstrated greater growth in their dairy calves (Heinrichs and Losinger, 1998) helping to maintain the production cycle. Positive correlations were also reported between the implementation of coccidiostats and ionophores in feeding heifers and lactating cows (Heinrichs and Losinger, 1998).

In summary, larger cows produce more milk and the most profitable cows are those that calve around 2 yr of age. Now the question arises as to what benchmarks do heifers need to meet as they are growing to produce optimum lactation. This is provided in Swanson (1967):

- a) A moderately growth rate of heifer calves resulting in just enough body size and development to allow breeding at 14 mo.
- b) Continue the moderate growth rate, possibly on roughage feed only, until 9 to 12 wk prepartum.
- c) Gradually increase the level of feeding by adding concentrate, so that the heifer is gaining weight rapidly before calving.
- d) Continue feeding the heifer liberally through the 1st lactation, to allow for growth as well as lactation.

This is a start in devising a plan to raise dairy replacement heifers; however, more recent research has determined that more specific parameters for growing dairy replacement heifers should be targeted to maximize lactation production. First, ADG for dairy heifers weighing 150 to 320 kg, should be 0.8 kg/day, to maximize milk production in the first lactation (Zanton and Heinrichs, 2005). On the contrary, Zanton and Heinrichs (2005), also point out that other researchers believe that pre-pubertal gains should be less than 0.8 kg, around 0.6 to 0.7 kg/d to maximize milk production for larger breeds of dairy cattle (Foldager and Sejrsen, 1987, Sejrsen et al., 2000). However, Holtz et al., (1961) suggested that heifer ADG has no significant effect on milk production in the second and subsequent lactations.

Crossbreeding and its Effects

Over the last few years, dairy producers have become more interested in crossbreeding and the benefits that could be reaped through this approach. It is surprising that increased cross-breeding is being adopted by dairy producers due to the fact of the dominance of the Holstein breed in America and her superiority in fluid milk production

(Heins et al., 2008). Dairy crossbreeding is a topic of interest because of producers' concerns over fertility, cow health, and calf survival (Funk, 2006, Heins et al., 2008). For farmers that have implemented crossbreeding on their dairy farm, they have likely crossed their Holstein cows to Jersey, Swedish Red, or other smaller breeds. The most common crossbred is the Jersey X Holstein (JH).

When compared to purebred Holsteins, Heins et al. (2008), found JH females to be smaller in stature (133.6 vs. 142.5 cm), decreased with between thurls (46.6 vs. 50.5 cm), and narrower between pins (11.2 vs. 12.4 cm). There was a decrease in heart girth (178.0 vs. 189.8 cm) in the JH females; furthermore the JH and other crossbred dairy females present a concern to their owners in their increased variation in body size (Heins et al., 2008, Weigel and Barlass, 2003).

Other literature agrees with this decrease in stature and states that there are substantial additive genetic differences between dairy breeds and sire groups within a breed for size and growth rate of replacement heifers (Lee, 1997, Lee et al., 1988). However, rump angle did not change between JH and pure Holsteins (6.0 vs. 5.7 cm) (Heins et al., 2008), and is consistent with previous work (Mcdowell and Mcdaniel, 1968). In general, cross breeding will decrease the weight, height, and gain of heifers. By having a smaller female milking such as the JH, a dairy producer is able to lower his or her maintenance costs (Heins et al., 2008).

Dairy Youth Related Activities

Today's youth have many opportunities to become involved with several activities related to the dairy industry. These activities include The National 4-H Dairy

Conference, Dairy Cattle Judging Contests, Dairy Quiz Bowls, and Dairy Cattle Shows. It is to be noted that except for the National 4-H Dairy Conference, these activities all begin at the county level and progress through the district, state and national levels. For youth involved in any of these events, at any level of participation, it is an opportunity for them to be exposed to the dairy industry and observe its contribution to society. This will, in turn, provide America with the next generation of dairy related professionals. These activities will now be discussed in detail.

The National 4-H Dairy Conference is held annually in conjunction with the World Dairy Exposition. This well-attended event was established in 1954, and has been held in Madison, Wisconsin since 1970 (Davis et al., 1997). The students, usually 15-18 years old, attend the conference and meet with other students with similar interest in regards to the dairy industry (Davis et al., 1997), as well as many leaders in the industry. Conference attendees are given the opportunity of refining their understanding of dairy production processing, marketing, product use, and available dairy careers (Davis et al., 1997).

More commonly attended by dairy youth individuals are the State, Regional, and National Dairy Judging Contests. Students practice for weeks and even months prior to the contest to learn to evaluate and select cattle based on guidelines in the Purebred Dairy Cattle Association Unified Score Card, first copyrighted in 1943. Judging contests help train individuals for making career choices and benefits their personal character (Guthrie and Majeskie, 1997). Dairy judging can either create or further a young persons personal attributes such as logical reasoning, decision making, honesty, defense for a decision,

pleasantness, etc. that will benefit them now and throughout their lives (Guthrie and Majeskie, 1997, Trimberger et al., 1987).

Dairy quiz bowls also further the development of dairy youth. Through the quiz bowl process, participants are able to develop increased knowledge of dairy animals, enhance their awareness of the dairy industry, and learn individual alertness and self confidence (Spike, 1997). Furthermore, participants in the dairy quiz bowl are more likely to seek further studies in the dairy industry and dairy science if they attend a post-secondary school (Spike, 1997). Many states have district and state quiz bowls annually. The national contest has been held annually since its establishment thirty years ago. It is held during the North American International Livestock Exposition in Louisville, Kentucky.

As the focus shifts to youth's participation in dairy cattle shows it is important to point out that there are few resources that contribute data interpretation and information in regards to this wonderful, and somewhat historical activity. There are several reasons as to why this omission may have occurred; however, it is the authors' purpose, in this section and subsequent chapters, to discuss the Georgia Commercial Heifer Show and its importance to Georgia's youth and dairy industry. Much of the following information from the literature was from beef shows; however, this information applies directly to the dairy cattle show ring as well.

For over 100 years, farmers around the globe have shown their dairy cattle at local, district, state, regional, national, and international shows. Darlow (1958) stated that showing animals helps build greater demand for the product, a better understanding of one another's problems, an extension and dissemination of knowledge, and the

promotion of prosperity for everyone in the field of animal husbandry. It is the farmer's desire to present his or her animals to a judge in which the judge compares their animals to other animals within the ring, all while comparing all the animals to the ideal individual for that particular breed and species.

When one exhibits their animals to the judge, the purebred breeder is presenting the end result of the combined contributions made by scientists and himself (Darlow, 1958). According to Darlow (1958), it is the judge's responsibility to interpret to the public the kind of animal that should be produced. Over the years, shows have influenced the standard of type (Darlow, 1950). This solidifies the need for the Purebred Dairy Cattle Association to update the Unified Score Card every 10-20 years.

Although showing dairy heifers can be attributed to the advancements of both the scientist and producer, there is a social gap between these two. In Darlow's entry, he tried to bridge this gap and state the causes as to why the interaction never has prospered. Darlow (1958) believes that there are scientists among the agricultural workers who think livestock shows are obsolete, and that if they were ever useful, they are no longer. Current dairy scientists are focused on specific research problems related to profitability and are far removed from showing. Advancements in genetic research has lessened the need of using phenotypic evaluation to improve profitability on the farm. Darlow (1958) trusts that the most successful livestock breeder, the producer of purebred livestock today, is a man who is making use of both the art and science of livestock breeding and the art and science of livestock nutrition and management. This is still apparent in today's show ring and industry, over 50 years after Darlow's article was published.

As all are aware, it is virtually impossible now for a young person to start farming without having the infrastructure of the farm already laid out in front of them. This was apparent many years ago, as Aiton (1965) stated in his research that for a boy to get started in farming, he could only marry into or inherit the farm. However, over the last century, many farm youth have been able to gradually grow into the occupation after their involvement in livestock youth programs, rather than having no childhood experiences on the farm and starting to work on the farm directly after entering the work force (Aiton, 1965).

Over the years, 4-H and FFA programs, such as those provided currently have helped to retain some farm youth on the farms that may have been lost to non-farm occupations. Furthermore, these same programs are readily available to the non-farm youth as well. Many of these youth yearn for the opportunity to work with animals such as dairy heifers; therefore, with youth leaders and dairy producers providing livestock for these children to show, these non-farm children are provided the chance to be near dairy cattle (Schwanke, 1997). As a result, these youth are able to learn basic knowledge of the dairy industry which can develop further by teaching life skills such as responsibility, loving care and affection, biological education, technology, glamour, empathy, profit, and challenge (Aiton, 1965, Schwanke, 1997). Aiton (1965) believes that there is a direct transfer into good character and citizenship for those youth that have 4-H livestock projects; furthermore, many of those who have participated or involved would readily agree with Aiton when he postulates that there is nothing quite equal in value or stimulation to a successful 4-H livestock project experience. Also, Darlow (1958) states that stock shows have proven to be the outstanding classrooms or laboratories.

As time progresses and dairy farms continue to decrease in number, more and more students involved in dairy related programs are from a non-farm rural or urban background, which is a challenge to provide the best education for the changing clientele (Schwanke, 1997). Although there is a decrease in the number of youth from the farm, there has been an increase in the number of youth involved with 4-H. From the USDA (USDA Annual 4-H Youth Development Enrollment Report. 1985-1994) youth report, Schwanke (1997) was able to determine that both dairy and total 4-H project numbers had increased approximately 5,000 and 1,000,000, respectively from 1985 to 1994. Dairy projects have increased gradually, a similar trend to the total number of 4-H projects during this time period; furthermore, there were evident increases in the eastern, southern, and western regions during this time period (Schwanke, 1997). Looking at the involvement of youth in 4-H from a gender basis, it is necessary to point out the sharp decrease of margin between the males and females. Schwanke (1997) was able to determine that in 1985 there were over 10,000 more males involved in 4-H, but this number declined sharply to only almost 2,400 more males involved in 1994 (USDA Annual 4-H Youth Development Enrollment Report. 1985-1994). Currently, this is apparent at livestock shows where the majority of exhibitors entering the show ring with their dairy livestock project are female.

Across the United States, there are many youth programs that promote involvement of children in dairy cattle shows. This is very apparent in states or regions in which dairy cattle shows are very popular. Almost all these involve showing registered cattle. Among these programs the ideas may differ slightly but the main objective is to provide youth the opportunity to show a dairy heifer or cow, whether

purchased, leased, or borrowed. This in turn will allow for recognition of that individual all while developing career-building attributes that will help these youth in the future. Just in the Southeastern United States, five states quickly come to mind with their outstanding youth shows programs: Georgia (Commercial Dairy Heifer Show), North Carolina (Dairy Youth Foundation), South Carolina (Heifer Project), Tennessee (Jersey Youth Program), and Maryland (Managerial Lease Agreement). Schwanke (1997) states that the agreement in Maryland allows nonfarm youth or those farm youth that may not have access to purebred dairy cattle to participate in shows. The Maryland Cooperative Extension Service developed the Managerial Lease Agreement in 1988; as a result, there has been increased participation by all involved attendees, including youth, their parents, and dairy producer providing the animals (Schwanke, 1997). Through a personal interview with the late Dr. Majeskie, Schwanke (1997) was able to determine that 78 Maryland nonfarm youths were able to participate in dairy cattle shows through the managerial lease agreement. Many states have successfully adopted a similar program that models the lease agreement established by Dr. Majeskie and the Maryland Extension Service.

The Commercial Dairy Heifer Show in Georgia is very unique program. This show was established by 4-H and FFA Advisors, along with faculty in the Animal and Dairy Science Department at the University of Georgia, as a way for Georgia's youth to show dairy heifers, learn about the industry, meet industry leaders, and possibly start a career within the dairy industry. Purebred show numbers were down. This program was established in 1996, with the first show occurring in February 1997. Because of the monies needed to show registered dairy animals, there are many children and families

that cannot meet the expense of maintaining a registered dairy animal. The majority of dairy cattle in Georgia are not registered because Georgia is in a fluid milk market, dairy producers across the state are primarily concerned with keeping their herds healthy and putting milk into the bulk tank.

Norman et al. (2001) reported that only 15% of cows within herds over 150 head are registered. Thus, with a good supply of unregistered, commercial dairy heifers and a good number of youth belonging to established 4-H and FFA programs that were interested in dairy cattle made establishing the Commercial Dairy Heifer Program feasible in Georgia. Both farm and non-farm students now receive the benefits and learn the responsibilities of being able to show dairy heifers in an organized show in this program.

The number of Commercial Dairy Heifer Show annual entries into the State Junior Livestock Show is illustrated in Figure 1. This is one of the largest shows in the Southeast. Over the past few years, there has been an overall steady trend in the number of entries each year, peaking in 2002 (359), and staying near 300 since 2002.

Objectives of Studies

The objectives of this thesis was to examine growth parameters of heifers enrolled in the Georgia Commercial Dairy Heifer Program, to determine whether any relationship exists between growth and placing within one of the shows in this youth program. After calculating and evaluating ADG of these females, other growth measurements were collected to determine their relationships with age, ADG, and placing within a show. The growth measurements of these commercial dairy heifers were compared to the guidelines

set by dairy researchers to determine whether the heifers were meeting industry standards.

CHAPTER 2
THE RELATIONSHIP BETWEEN WEIGHT, AGE, AND AVERAGE DAILY GAIN,
TO PERFORMANCE IN THE SHOW RING OF GEORGIA COMMERCIAL DAIRY
HEIFERS¹

¹London, M.L., J.K. Bernard, M.A. Froetschel, W. M. Graves. To be submitted to *The Journal of Dairy Science*.

Abstract

Three trials were conducted to determine the relationship between growth and placing in the show ring. In trial one, 1,744 commercial dairy heifers (all breeds and crossbred animals) were evaluated to determine effects of growth on placing within Georgia Commercial Dairy Heifer Shows from 2007-2010. Age and ADG were strongly inversely correlated ($r = -0.89$, $P < 0.0001$). Mean average daily gain (ADG) for all heifers was determined to be 0.65 kg, below industry guidelines set at 0.7-0.8 kg. No strong relationship ($r = -0.07005$, $P = 0.0034$) was observed between ADG and placing. Heavier heifers, within a class, showed a small positive ($r = 0.10399$, $P < 0.0001$) relationship with placing. For trial 2, 238 heifers shown at the 2010 Georgia Junior National Livestock Show were evaluated for ADG, placing, body weight, age, wither height, hip height, hip width, jaw width, and switch clearance from the ground. Height at withers had a moderate relationship ($r = 0.42$, $P < 0.0001$) with placing, followed by hip height ($r = 0.32$, $P < 0.0001$). A positive relationship ($r = 0.65$, $P < 0.0001$) was observed between wither height and hip height. The correlation between weight and placing was determined ($r = 0.11$, $P = 0.10$). Age and ADG had a strong inverse relationship ($r = -0.87$, $P < 0.0001$). Switch clearance from ground demonstrated a positive ($r = 0.17$, $P < 0.01$) correlation with placing. Trial 3 evaluated 1,489 Holstein heifers shown from 2007-2010 and determined that 63.75% did not meet industry guidelines for weight gain. The 2007 and 2009 University of Georgia Commercial Dairy Heifer Shows reported 45% of animals shown achieved the industry guidelines for weight gain. Performance and physical features associated with age indicates that commercial dairy heifers are underfed according to industry standards. This has economic implications because these

animals will likely require more time before they enter the milk herd. However, the Commercial Dairy Heifer Program is vital for youth development in Georgia.

INDEX WORDS: Average Daily Gain, Georgia Commercial Dairy Heifer Program

Introduction

The dairy industry is a producer driven, diversified, constantly changing industry, consisting of several types of production, such as the growth and development of dairy heifers. Dairy producers are constantly striving generate income over production costs while meeting the requirements of milk processors and consumers, while producing a safe and wholesome product, and abiding by regulations set by governing bodies.

Profitable dairy production is dependent on producers paying strict attention to attaining cost effective and efficient milk production. Over the last century, many new technologies have been introduced and put into practice that facilitates dairy cow production and efficiency. Although most would argue that the dairy cow has always been the most efficient and productive food producing animal known to the human race, today's cows are milking much more than the cows 100, 50, 25, and even 10 years ago. Attention to developing the immature dairy cow prior to lactation is recognized as being very critical to improved profitability and lifetime production.

Raising dairy replacement heifers is a key component to dairy production. Dairy heifers are grown with the goal that these females eventually entering the milking herd and producing milk according to their genetic potential. The use of the adjective, replacement, refers to dairy producers consistently needing to replace or add dairy cows to the milking herd. Replacement heifers can be used to maintain herd size or expand

herd size depending on culling rate. Almost all dairy herds in the U.S. have expanded their herds in order to maintain farm income over inflation with a prevalent occurrence of sub-optimal milk prices in the last 25 years. Dairy replacement heifer production is generally performed by dairy producers on their farm; however, there is a trend for more replacement heifers to be developed off the farm through contractual agreements with dairy replacement heifer growers. Dairy heifer rearing is vital to the industry and to continuing the dairy production cycle. It is also can be a means to attract interested youth involved in dairy heifer shows to join the dairy industry and one day become owners, managers, technical personnel, leaders, and advocates of this prosperous and wholesome industry.

Rural youth education programs are vital for developing participants into successful young men and women. Programs such as the Georgia Commercial Dairy Heifer Program give youth across the state the opportunity to exhibit a dairy heifer, gain knowledge of the dairy industry, and develop personal qualities that will benefit them throughout their life. This program, now in its 14th year, has benefited many youth throughout Georgia. Many participants come from rural, non-farming backgrounds. Because of their involvement with dairy heifers and even other youth livestock programs, a number of these young adults have sought an education as well as successful careers related to animal agriculture. Furthermore, if these individuals choose a career outside of agriculture, they still will always be mindful of the goodness of animal agriculture, and its importance, to society as a whole.

Materials and Methods

Average Daily Gain and its relationships

For this study, records from 1744 commercial dairy heifers shown in 2007 through 2010 were used to determine if average daily gain (ADG) or other growth factors had any effect on a judge's placing. The BW gain of these heifers was compared to the projected ADG values from the NRC (2001) and Kertz et al. (1987). All heifers were shown in two different shows, The University of Georgia Commercial Dairy Heifer Show (Athens, GA) and The Georgia Junior National Livestock Show (Perry, GA), that were held on the second and fourth Saturdays in February. The study included observations from eight shows, one show/location/year from 2007-2010. These two annual shows were selected for this because of the number of animals shown within them. On average, these shows attribute to the largest (based on number of animals exhibited) two shows held in the Georgia and compare, in number, to regional shows held throughout the Southeastern United States.

To be eligible for one of these shows, the exhibitor must be a member of a 4-H or FFA chapter, and be least nine years old. Exhibitors become ineligible to show upon graduation from High School. Most of the exhibitors are Middle and High School students. Dairy heifers are eligible to be exhibited in the commercial shows as long as they are not registered with a breed association, and be born between March 1st and September 30th of the previous year. The dairy heifer must meet the general health requirements of the Georgia Department of Agriculture and the BW must meet the minimum and maximum requirements set by the superintendent at the time of check-in.

This is to ensure that these heifers are receiving proper nutrition, and not being over or underfed for their age.

Any heifer that was not within these weigh requirements was disqualified from the show and was removed from the study. In most cases, the superintendent must trust and assume that the exhibitor is providing accurate information about his or her heifer's information, i.e. birth date and not being registered with a breed association. According to Norman et al. (2001), in purebred programs, many birth dates for some animals may have been altered intentionally to be assigned a younger show class. However, when studying farms with commercial dairy cows, it was determined that the accuracy of reported birth dates were likely reasonably correct, when it was determined that the offspring studied had a more uniform rate of births throughout each month (Norman et al., 2001). For the purpose of this study, the assumption is made that the exhibitors, breeders, teachers, and volunteers are making ethical choices and providing accurate information, thus making the results of this study valid.

Upon registering for one of the shows, exhibitors and their 4-H or FFA advisors provided the show superintendent information that was used in the study. This included breed of the heifer, birth date of the heifer, identification of heifer, and the county the exhibitor resides. When an exhibitor and commercial dairy heifer initially arrive at a show, they are checked in, officially weighed, and then exhibitors and their animals into logical showmanship and weight classes. Upon Check-in at the show, the information provided in the registration form is verified by the superintendent and exhibitor. After this verification process is completed, the commercial dairy heifer is weighed and recorded by the superintendent or show staff.

After all the heifers are checked and weighed in, youth participate in showmanship based on their grade in school. Before or while showmanship is occurring, the superintendent and show staff split the heifers in equal groups of similar weight. This group of heifers is considered a weight class and will compete against each other. The competition within the class is based on confirmation of the heifers within in the class as compared to ideal. When evaluating dairy heifer conformation, the judge is basing their evaluation on three main criteria: frame, dairy strength, and rear feet and legs. Although there is no official scorecard for the dairy heifer, almost all refer to the Purebred Dairy Cattle Association (PDCA) Dairy Cow Unified Score Card (2009). In this score card udder is evaluated; however, due to heifers not possessing a functional udder, this section carries little significance as the judge evaluates udder promise, the appearance of developing into a desirable mammary system. The judge will also evaluate the udder and determine if defects are present.

In regards to evaluating dairy heifer frame, the judge is looking at the overall dimensions of the heifer. In short, he or she is evaluating height at the point of withers, length of the dairy heifer from head to tail. The judge will also view the heifer and determine whether she is structurally sound. For this to occur, the judge will evaluate her back, or topline, and determine its straightness. Also, the judge will evaluate the heifer's rump, and determine whether the slope from hooks to pins is correct and the amount of width she possesses, a direct relationship to her ability to calve.

When evaluating dairy strength, the judge is looking for a heifer that combines width throughout the heifer, all while looking feminine and not carrying any excessive condition, or flesh. Furthermore, the judge will consider the overall circumference of the

body, the depth, length and width through the barrel. This is directly proportionate to the amount of feed the heifer can consume, store, and utilize for maintenance and growth; equally important, this direct relationship will continue as this heifer calves and begins to produce milk.

The third section to evaluate is rear feet and legs. The judge will evaluate the heifer as she walks and determine whether she has the correct movement necessary for her to have mobility and to support a large body mass as a mature cow. This range of movement is also vital as the heifer becomes a cow and must walk to the milking parlor twice or three times a day. Rear feet and leg evaluation focuses around the hock, and determining that the angle of the hock is correct in relation to the thurl and hoof. A correct angle to the hock will give the flexibility the heifer needs to move correctly. Too steep of an angle, causes the heifer to be stiff in her leg and will likely result in leg problems as the heifer matures. Equally important, a small angle will cause more weight to be put upon the back of the hoof and pastern, likely resulting in the heifer becoming weak in her pasterns.

After all of these points of interest are evaluated, the judge ranks the heifers within each class. By combining all the evaluation points previously mentioned, the judge's ranking is based upon which animals best combine all these desirable characteristics. The ranking order was collected by the superintendent or an assistant. Upon completion of the weight classes, the judge will select the overall champion and the reserve grand champion of the show from the top individual heifers from each class. Although the study was not initiated until the beginning of 2009, accurate participation records had been collected for both the University of Georgia Commercial Dairy Heifer

Show and The Georgia Junior National Livestock Show. Data from both shows for 2007 through 2010 shows were recorded at both locations. Upon completion of the 2010 show season, information from these eight shows was compiled into a single data set contained in a Microsoft Excel[®] spreadsheet. In this spreadsheet, each commercial dairy heifer's information was entered. These include: identification of the heifer, year the heifer was shown, the show it was shown in, weight of the heifer, date of the weigh-in, respective weight class the heifer competed in, breed of the heifer, county in which exhibitor resides, birth date of heifer, and placing within the weight class. Next the heifers were sorted based on their breed. The average birth weight for each breed type as provided from research from Tyler and Ensminger (2006) was entered for each calf and used in ADG estimations. For crossbreeds, the average birth weight of the parent breeds was used for the birth weight of those heifers.

The age of the commercial dairy heifer was calculated by taking the birth date of the heifer and subtracting it from the date of the weigh in. This difference was reported on a day basis. ADG was calculated for each heifer, taking the average birth weight, subtracting the weight at the show from it; then dividing this difference into the age (in days) of the heifer. Each class was then sorted by their ADG, in descending order, and given a rank based on this order. Next, BW and age were ranked as well, each were given a rank of 1 for the heaviest and oldest, respectively. Now having a ranking for placing in the show, ADG, BW, and age for each heifer, all of these ranking were then put into a percentage by taking each ranking and dividing by the total number of heifers within that class. These percentages were then correlated using the Pearson and Spearman correlation calculations in SAS (SAS Institute, 2008). Then each placing and

ADG rank was evaluated further. For each ranking in ADG, the average placing and ADG were reported. In each placing, ADG and average ADG rank were evaluated.

Pennsylvania State growth spreadsheet measurements and their relationships

For the second section in the study, 238 heifers shown in the 2010 Georgia Junior National Livestock Show were further evaluated upon check-in at the show.

Measurements were taken and entered in the Growth Monitor Spreadsheet (Pennsylvania State University, State College, Pennsylvania), and used to determine whether these

heifers were being developed properly, and decide whether a relationship was present between any of these measurements and the judge's placing in the show. After the

heifers were weighed, several specific anatomical distances were measured in each heifer including hip height, wither height, hip width, jaw width, and switch clearance.

For hip height, the measurement was taken along top and middle of the back of the heifer and measured the distance from this point to the ground. Similarly, wither height was

measured from the top of the back, at the shoulder, to the ground. The hip height, wither height, and switch distance were measured with a Ketchum Deluxe Livestock Measure

(Ketchum Manufacturing Incorporated, Brockville, Ontario, Canada). The hip width was measured as the width between the thurl joints. In addition to these measurements for the

Pennsylvania State Growth Spreadsheet (State College, Pennsylvania), jaw width and the distance from the end of the switch to the ground were taken to see if any other

measurements could be related to placing in the show. The hip width and jaw width were measured by a custom-designed instrument from the University of Georgia

Instrument Shop shown in figure 2. Input into the Pennsylvania State Growth Manual Spreadsheet included: date of measurement, identification of the heifer, birth date of

heifer, weight, hip height, wither height, and hip width. The Ayrshire, Brown Swiss, Holstein, and Jersey heifers were entered into their respective breed spreadsheets.

Twenty two heifers measured were crossbreds and were removed from the Penn State growth spreadsheets, but still used in the comparison to determine a relationship between these anatomical measurements and placing in a show. Eleven (4.6 %) heifers were omitted in the relationship between switch length from ground and placing rank due to them having docked tails.

Information from the database from the first section and these anatomical measurements were merged for the purpose of a statistical analysis and generating correlations. When the data was merged, correlations were calculated, to determine relationships between these measurements and the placing in the show. Similar to the ranking system in used in previous section, the wither height, hip height, hip width, jaw width, and switch clearance were ranked. For the height and clearance measurements, a rank of 1 was given to tallest individual heifer within the class. For the width measurements, the widest heifer within the class was given a rank of 1. Also, a rank of 1 was given to the heifer that possessed the most clearance from the end of her switch to the ground. Furthermore, after these rankings were given, a percentage was then given for each measurement by dividing the rank into the number of individuals within the class. For animals with equal measurements, there were given the same rank (i.e. in class one, two heifers had 99.06 cm for wither height and no other animals in the class were taller, both were given a rank of 1). All of these rankings were then correlated using the spearman correlation procedure in SAS[®] to determine potential relationships that may exist between growth and development and placement in the show by a judge.

Holstein Weight Evaluation

After using the Pennsylvania State Growth Spreadsheet for the 2010 Georgia Junior National Livestock Show, the decision was made to enter data from all the shows into the spreadsheet. Most of the heifers shown were Holsteins; therefore a subset of data using only Holsteins was analyzed. These 1,489 heifers were entered into the Spreadsheet with the objective of identifying heifers not meeting the weight guidelines, based on age. Furthermore, the goal was to determine if certain counties were more or less abiding to industry growth and development guidelines. Of the measurements evaluated in the spreadsheet, BW was the only measurement used in this section due to the fact that the anatomical measurements were not recorded for all shows prior to the 2010 Georgia Junior National Livestock Show. Information used for this analysis included: identification, BW, and age for each individual. After entering this data into the spreadsheet, the spreadsheet is able to predict heifers underweight for age. Standards are based on the results of measuring a large number of heifers of various breeds throughout the United States. Upon determining whether each heifer was meeting the guidelines set forth in the Pennsylvania State Growth Spreadsheet, the information was then transferred back into a Microsoft Excel[®] spreadsheet. In this spreadsheet, proportions of under or meeting weight requirements were determined based on show and county. Also, the difference between guidelines in the spreadsheet and the weight of the individual heifer were determined. These data were then grouped based on this difference, desiring to determine how much of a difference between the actual weight and the guidelines from the spreadsheet existed. Heifers that were underweight were grouped as follows: more than 50 kg underweight, more than 25 to 50 kg underweight,

and less than 0 kg to 25 kg underweight. Similarly, heifers that met BW requirements were grouped: 0 kg difference to 25 kg exceeding the requirement, more than 25 to 50 kg, and greater than 50 kg.

Results and Discussion

Average Daily Gain and its relationships

Mean ADG for the animals participating in eight shows over a four year period (2007-2010) were calculated for each show and are presented in table 2. For all shows combined, the ADG was 0.65 kg, which is below the recommended ADG levels of 0.7 to 0.8 kg per day (Kertz et al., 1987, NRC, 2001, and Zanton and Heinrichs, 2005). The ADG sorted by breed and county is presented in tables 3, 4, and 5 respectively. Breeds and crossbreeds with less than ten observations were combined together and form the other breeds section. This combining held true for counties as well. Jerseys had the lowest ADG of 0.52 kg, followed by Jersey-Holsteins (0.53 kg), and Brown Swiss (0.55 kg). Holsteins had the highest ADG with a calculated average of 0.66. Counties that had mean ADG within previously suggested values at or over 0.7 kg were Wilcox (0.77 kg), Murray (0.75 kg), Oglethorpe (0.72 kg), Putman (0.70 kg), and Whitefield (0.70 kg). The counties with ADG values lower than 0.55 kg were Greene (0.55 kg), Dade (0.54 kg), Dawson (0.54 kg), Peach (0.52 kg), and Macon (0.36 kg).

After evaluation of each ADG rank and placing for each class, the results are found in table 6. For the ADG rankings 1,2,3,4, and 5 within a class, the ADG for these rankings are 0.82 kg, 0.75 kg, 0.72 kg, 0.69 kg, 0.66 kg; respectively. For the first five placings within a class, the first four had a mean ADG of 0.65 kg and the fifth had a mean ADG of 0.64 kg. Average ADG rank for these five placings were 6.02, 5.96, 6.21,

6.21, and 6.51; respectively. This indicates that commercial dairy heifers that placed 1st through 5th in a class had a ranking at or near 6 for ADG, indicating that five to six individuals in the class had more desirable ADG levels.

Although the relationship was not strong there was a statistically significant correlation between placing rank and ADG rank in a particular class (Table 7). For 1,744 heifers evaluated, the correlation between these two parameters was determined ($r = -0.07$, $P = 0.0034$). When placing and BW were analyzed, a small positive relationship was found between placing rank and weight rank (heaviest to lightest) ($r = 0.10$, $P < 0.0001$). Similarly, placing rank and age rank (oldest to youngest) were not strongly related ($r = 0.091$, $P = 0.0002$). It is important to point out that many of the heifers that were evaluated for this study were observed at both shows. Although, two observations occurred, the placing within each show was independent from each other, since different judges evaluated and placed at the shows. Similarly, correlations between weight, gain, and feed intake were small ($r < 0.2$) when related to milk production as the heifer enters the milking herd (Lee, 1997). Further research measuring milk production of heifers shown in the Commercial Dairy Heifer Program is necessary to prove or refute Lee's findings. A strong, negative relationship was observed between ADG rank and age ($r = -0.89$, $P < 0.0001$). This was expected due to the indirect relationship of these two. For instance, if weight is equal in two dairy heifers, the one that is younger will likely have a higher ADG.

Pennsylvania State growth spreadsheet measurements and their relationships

During the 2010 Georgia Junior National Livestock Show, 238 Commercial Dairy Heifers were measured for their weight, jaw width, wither height, hip height, hip width,

and the distance from the end of the switch to the ground, referred to as switch clearance. These measurements were taken to help provide a more complete measure of growth and age related development in the dairy replacement heifer (Heinrichs and Hargrove, 1991, Hoffman, 1997). After entering the data into the Pennsylvania State Growth Spreadsheet, graphs were established for weight, wither height, hip height, and hip width; furthermore, graphs of these measurements are presented in figures 3 through figure 6, respectively. For each graph, a fitted line is given for the heifers based on their measurements and age. In the weight graph, the line representation is well below the median line. Surprisingly, wither height is most near the 75th percentile for all ages of the Holstein heifers. Because approximately half of wither height growth occurs before 6 mo of age (Kertz et al., 1998), these heifers will likely be able to reach proper wither height as mature cows. To increase wither height even greater from the standard, dairy producers and heifer growers alike can increase crude protein in the pre-weaned diet (Brown et al., 2005b). Hip height is near the lower guidelines set and hip width is near the upper end for the younger heifers, decreasing their average ranking as the heifers get older.

In determining relationships between any of the measurements taken, age and ADG, just as in the first section, had the strongest relationship ($r = -0.87$, $P < 0.0001$). As expected, there was a strong relationship ($r = 0.65$, $P < 0.0001$) between wither height and hip height. Furthermore, both of these are moderately related to the placing rank within a class. Wither height and placing calculated correlation was ($r = 0.42$, $P < 0.001$). Similarly, hip height and placing were moderately related ($r = 0.32$, $P < 0.0001$). Surprisingly, there were relationships observed between switch clearance and the other growth and development measurements. In general, switches were clean and brushed

out. Switch clearance had a stronger relationship to placing ($r = 0.17$, $P = 0.0125$), than ADG ($r = -0.02$, $P = 0.7563$). Of the anatomical measurements taken, switch clearance was more closely correlated to ADG ($r = 0.23$, $P = 0.0008$). A complete list of all anatomical correlations can be found in table 8. Data from crossbred dairy heifers were included in the correlation equations; however, due to lack of a growth spreadsheet for crossbreds, they were not entered into the Pennsylvania State Growth Spreadsheet.

As producers become more concerned over fertility, calf survival, and overall health within their cattle, they may implement more crossbreeding systems in their herds (Heins et al. 2008). As a result, more crossbred heifers will be exhibited in the Georgia Commercial Dairy Heifer Program. Also, if there is an increase in crossbred dairy replacement heifers across the United States, dairy producers would benefit from guidelines establish for wither height and measurements, to evaluate growth, in detail, within these animals. However, crossbred heifers will likely be difficult to study due to their increased variation in body size (Heins et al. 2008; Weigel and Barlass, 2003).

Holstein Weight Evaluation

1,489 Holstein heifers evaluated for actual weight versus the predicted weight. 538 (36.25%) heifers met or exceeded requirements. The two shows with the highest proportion of adequately grown heifers was the 2007 and 2009 University of Georgia Commercial Dairy Heifer Shows. At both of these shows, 45% of the Holsteins shown were growing to industry guidelines. From 2007-2010, 951 (63.75 %) of the Holstein heifers evaluated failed to meet the guidelines set forth in the Penn State Growth Spreadsheet (Pennsylvania State University, State College, Pennsylvania). This percentage appears to be increasing since 2007 where Holsteins shown in the University

of Georgia Commercial Dairy Heifer Show comprised of only 55% of entries that were not meeting weight guidelines. Moreover, the 2010 Georgia Junior National Livestock Show had over 70 % of its entries that did not meet these established guidelines. Factors that can attribute to failing to meet the guidelines can be poor genetics, nutrition, management, and environment (Heinrichs and Hargrove, 1987). In addition, dairy heifers are often fasted prior to being weighed at check-in because a shrunk-weight enables a greater chance for a heifer to be placed in a smaller weight class. A more detailed look at each individual show and its composition of heifers performing or not performing to the guidelines is presented in table 9.

Each county was evaluated to determine whether their Holstein heifers were or were not achieving weight guidelines. With over 25 counties showing through these four years, there was a wide range of proportions of heifers below or meeting weight guidelines. Counties that had over 85% of their Holstein heifers not meeting weight were Chattooga (87.8 %), Dawson (92.3), Perry (93.1%), and Macon (95.5 %). On the contrary, some counties proved to have over half of the Holstein heifers exhibited meet or exceed weight guidelines. Wilcox (66.2 %) exhibited the highest proportion of heifers meeting industry guidelines followed by: Murray (35.7 %), Whitfield (60.0 %), Oglethorpe (53.16 %), and Putnam (52.94 %). A complete list of each county's proportion of Holstein heifers meeting weight requirements is located in table 10.

After breaking down the differences between suggested weight and actual weights, the highest proportion of heifers that were below specifications were within 25 kg of meeting the guidelines for shows during 2007-2009. For the 2010 shows, the highest proportion of underweight heifers was underweight by at least 25 kg upwards to

50 kg underweight. For heifers that were meeting or exceeding Pennsylvania State's guidelines, the highest proportion of these heifers was within 25 kg of the benchmark. This was true for all eight shows observed in the four years observed. A breakdown of each show and the difference in actual weights from suggested weights is available in table 11.

It is imperative to discuss the possible effects for these heifers that are underweight for their age. As previously discussed, rate of growth has a direct effect on when a heifer becomes sexually mature (Heinrichs, 1993). Furthermore, weight of the heifer is the main determining factor of when the onset of puberty occurs (Coffey et al., 2006, Sejrsen and Purup, 1997, Tyler and Ensminger, 2003, Van Amburgh, 1993). For these 951 heifers that are not meeting the guidelines from the spreadsheet, it is probable that the onset of puberty was delayed. However, this remains to be proven and it would be difficult to ascertain due to the fact that these heifers are reared across Georgia. Perhaps a subset of heifers from a few farms could be measured. It is to be noted that several environmental differences between the different regions in the United States. Future research is needed to verify that the growth curves from the Pennsylvania State Growth Manual Spreadsheet do apply to dairy heifer growth in the Southeastern United States. However it is to be noted that the Pennsylvania State Growth Manual Spreadsheet is the growth evaluator of choice for most dairy rearing operations across the country.

Another consequence of being underweight would be an increase in age at first calving. Rate of growth, or ADG, has a direct effect on age at first calving and productivity per day of herd life (Heinrichs, 1993). Since most of the heifers involved in the Georgia Commercial Dairy Heifer Program are leased, they are returned to their

owners after the show season has been completed. For these heifers that are not meeting weight guidelines, it is possible that these heifers are calving later in their life, increasing the non-productive period for the female and increasing the cost to raise the dairy replacement heifer (Brown et al., 2005b, Greaser, 1992, Heinrichs, 1993, Place et al., 1998, Willet et al. 1992). This can be reversed by increasing the amount of energy and protein in the dairy replacement heifer ration (Brown et al., 2005b, Gabler and Heinrichs, 2003b, Lammers and Heinrichs, 2000), especially during the first six months of a dairy replacement heifer's life, when the cost per kg of BW gain is less than any other time period (Brown et al., 2005b, Kertz et al., 1998).

Overall, it appears that calves shown in the Georgia Commercial Dairy Heifer Program are being under-fed. This may cause dairy producers to be less willing to provide animals for youth exhibitors participating in commercial heifer shows in the future. In order to insure future success of this activity, officials should provide more careful weight guidelines for heifers participating in the show. Exhibitors should be better educated on proper feeding and an estimated ADG range that fits standard industry growth criteria.

Conclusions

When comparing Commercial Dairy Heifers within a class at one of the Commercial Dairy Heifer Shows, evidence indicates there are no strong relationships between ADG, BW, and age with placing. As expected, there is an indirect relationship between age and ADG. Future studies might consider researching heifers throughout each female's mature life in the milking herd. By observing these heifers as cows, relationships between efficiency in the milking herd and performance within the heifer

show. Further, comparisons between heifers exhibited within the show and their non-shown herd mates are needed to determine whether the Commercial Dairy Heifer Program is a positive or negative benefit to Georgia's dairy replacement heifers. Currently, no milk production records are available for these heifers to determine if any of these observed measurements can be related to milk production.

After evaluating frame measurements of the heifers shown, wither height had the strongest relationship to placing within a class. After observing that switch clearance had a stronger relationship to placing than ADG, weight, age, and hip width, future studies may or may not solidify the importance of this measurement to placing within a class. Furthermore, other anatomical measurements may prove to be related to placing. Because of stature's significance in evaluating dairy heifers, it is possible that wither height may indeed be the strongest indicator of how well a dairy replacement heifer performs in a particular show.

Holstein heifers shown in the Commercial Dairy Heifer Program were evaluated for growth; a majority of these heifers did not meet industry's growth expectations. When looking at each county's proportion of underweight heifers, these results mirror the calculated ADG values for each county in the first section. Counties with low ADG values had higher proportions of underweight heifers. No single reason was identified as to why a majority of these dairy replacement heifers are underachieving. Whether the culprit is poor genetics, nutrition, environment, or other sources, people associated with the Commercial Dairy Heifer Program must be made aware of this problem within the Commercial Dairy Heifer Program. Many see it in the ring anyway. However, the development of tomorrow's dairy leaders and producers hinge on their involvement

within this program. Therefore, minor deviances from growth guidelines may not be as detrimental as one would think.

Furthermore, these same people should be informed of how to improve heifer growth. Whether it is to increase protein, improve environment conditions, it is important for there to be an increase in the number of heifers growing near or exceeding industry guidelines. The suggestions of 0.7 to 0.8 kg ADG should be a priority to those associated with the Commercial Dairy Heifer Program. This in turn will allow the owner of these heifers to reap the economic benefit of properly grown dairy replacement heifers and productive cows entering the milking herd in the future.

CHAPTER 3

IMPLICATIONS

The purpose of this research was to evaluate growth of dairy replacement heifers shown in the Commercial Dairy Heifer Program. After completing this study, it is apparent that exhibitors, producers, and school personnel should strive to execute better rearing methods for these females. This could be enforced by changing the eligibility recommendations to mirror industry growth suggestions. If improved rearing methods occur, the owner may be able to increase productivity as the heifer matures. While measuring wither height and other measurements, the goal was to determine some measurement that could be related to and predict the placing of the commercial dairy heifer in the show. Further research may find a measurement that has a stronger relationship to placing, than wither height. These measurements may possibly help to validate whether age information provided by the owner, exhibitor, and or volunteer. Although it is believed that most exhibitors do report accurate ages of these heifers, if the age was confirmed by researchers, a more detailed, accurate evaluation of heifer growth within the Commercial Dairy Heifer Show can be completed.

References

- Aiton, E. W. 1965. Extensions Challenge in Relation to Youth of Tomorrow. *J Anim Sci* 24(1):273-278.
- Bagg, J. G., D. G. Grieve, J. H. Burton, and J. B. Stone. 1985. Effect of Protein on Growth of Holstein Heifer Calves from 2 to 10 Months. *J Dairy Sci* 68(11): 2929-2939.
- Bartlett, K. S., F. K. McKeith, M. J. VandeHaar, G. E. Dahl, and J. K. Drackley. 2006. Growth and body composition of dairy calves fed milk replacers containing different amounts of protein at two feeding rates. *J Anim Sci* 84(6):1454-1467.
- Blome, R. M., J. K. Drackley, F. K. McKeith, M. F. Hutjens, and G. C. McCoy. 2003. Growth, nutrient utilization, and body composition of dairy calves fed milk replacers containing different amounts of protein. *J Anim Sci* 81(6):1641-1655.
- Brown, E. G., M. J. VandeHaar, K. M. Daniels, J. S. Liesman, L. T. Chapin, J. W. Forrest, R. M. Akers, R. E. Pearson, and M. S. W. Nielsen. 2005a. Effect of increasing energy and protein intake on mammary development in heifer calves. *J Dairy Sci* 88(2):595-603.
- Brown, E. G., M. J. VandeHaar, K. M. Daniels, J. S. Liesman, L. T. Chapin, D. H. Keisler, and M. S.W. Nielsen. 2005b. Effect of increasing energy and protein intake on body growth and carcass composition of heifer calves. *J Dairy Sci* 88(2):585-594.
- Buch, N. C., W. J. Tyler, and L. E. Casida. 1955. Postpartum Estrus and Involution of the Uterus in an Experimental Herd of Holstein-Friesian Cows. *J Dairy Sci* 38(1): 73-79.
- Capuco, A. V., J. J. Smith, D. R. Waldo, and C. E. Rexroad. 1995. Influence of prepubertal dietary regimen on mammary growth of Holstein heifers. *J Dairy Sci* 78(12):2709-2725.
- Choi, Y. J., I. K. Han, J. H. Woo, H. J. Lee, K. Jang, K. H. Myung, and Y. S. Kim. 1997. Compensatory growth in dairy heifers: The effect of a compensatory growth pattern on growth rate and lactation performance. *J Dairy Sci* 80(3):519-524.
- Clapp, H. J. 1979. Growth management of dairy heifers. Ontario Ministry Agriculture Factsheet No. 412/10. Woodstock, ON, Can.
- Clark, R. D. and R. W. Touchberry. 1962. Effect of BW and Age at Calving on Milk Production in Holstein Cattle. *J Dairy Sci* 45(12):1500-1510.

- Coffey, M. P., J. Hickey, and S. Brotherstone. 2006. Genetic aspects of growth of Holstein-Friesian dairy cows from birth to maturity. *J Dairy Sci* 89(1):322-329.
- Darlow, A. E. 1950. Influence of Shows on Productive Values in Beef Cattle. *J Anim Sci* 9(3):331-334.
- Darlow, A. E. 1958. 50 Years of Livestock Judging. *J Anim Sci* 17(4):1058-1063.
- Davis, H. P. and E. L. Willett. 1938. Relation between rate of growth and milk and fat production. *J Dairy Sci* 21(10):637-642.
- Davis, P., B. R. Moss, V. Anderson, and C. K. Ward. 1997. The National 4-H Dairy Conference: A youth learning experience. *J Dairy Sci* 80(8):1895-1897.
- De Vries, A., M. Overton, J. Fetrow, K. Leslie, S. Eicker, and G. Rogers. 2008. Exploring the impact of sexed semen on the structure of the dairy industry. *J Dairy Sci* 91(2):847-856.
- Erb, H. N., R. D. Smith, P. A. Oltenacu, C. L. Guard, R. B. Hillman, P. A. Powers, M. C. Smith, and M. E. White. 1985. Path Model of Reproductive Disorders and Performance, Milk Fever, Mastitis, Milk-Yield, and Culling in Holstein Cows. *J Dairy Sci* 68(12):3337-3349.
- Ettema, J. F. and J. E. P. Santos. 2004. Impact of age at calving on lactation, reproduction, health, and income in first-parity Holsteins on commercial farms. *J Dairy Sci* 87(8):2730-2742.
- Fisher, L. J., J. W. Hall, and S. E. Jones. 1983. Weight and Age at Calving and Weight Change Related to 1st Lactation Milk-Yield. *J Dairy Sci* 66(10):2167-2172.
- Foldager, J. and K. Sejrsen. 1987. Mammary gland development and milk production in dairy cows in relation to feeding and hormone manipulation during rearing. *Research in Cattle Production*.
- Funk, D. A. 2006. Major advances in globalization and consolidation of the artificial insemination industry. *J Dairy Sci* 89(4):1362-1368.
- Gabler, M. T. and A. J. Heinrichs. 2003a. Dietary protein to metabolizable energy ratios on feed efficiency and structural growth of prepubertal Holstein heifers. *J Dairy Sci* 86(1):268-274.
- Gabler, M. T. and A. J. Heinrichs. 2003b. Effects of increasing dietary protein on nutrient utilization in heifers. *J Dairy Sci* 86(6):2170-2177.
- Gardner, R. W., J. D. Schuh, and L. G. Vargus. 1977. Accelerated-Growth and Early Breeding of Holstein Heifers. *J Dairy Sci* 60(12):1941-1948.

- Gardner, R. W., L. W. Smith, and R. L. Park. 1988. Feeding and Management of Dairy Heifers for Optimal Lifetime Productivity. *J Dairy Sci* 71(4):996-999.
- Gill, G. S. and F. R. Allaire. 1976. Relationship of Age at 1st Calving, Days Open, Days Dry, and Herd-Life to a Profit Function for Dairy-Cattle. *J Dairy Sci* 59(6): 1131-1139.
- Grummer, R. R., P. C. Hoffman, M. L. Luck, and S. J. Bertics. 1995. Effect of Prepartum and Postpartum Dietary Energy on Growth and Lactation of Primiparous Cows. *J Dairy Sci* 78(1):172-180.
- Guthrie, L. D. and J. L. Majeskie. 1997. Dairy cattle judging teaches critical life skills. *J Dairy Sci* 80(8):1884-1887.
- Harville, D. A. and C.R. Henderson. 1966. Interrelationships Among Age, Body Weight, and Production Traits During First Lactations of Dairy Cattle. *J Dairy Sci* 49(10): 1254-1261.
- Heinrichs, A. J. 1993. Raising Dairy Replacements to Meet the Needs of the 21st-Century. *J Dairy Sci* 76(10):3179-3187.
- Heinrichs, A. J. and G. L. Hargrove. 1987. Standards of Weight and Height for Holstein Heifers. *J Dairy Sci* 70(3):653-660.
- Heinrichs, A. J. and G. L. Hargrove. 1991. Standards of Weight and Height for Guernsey and Jersey Heifers. *J Dairy Sci* 74(5):1684-1689.
- Heinrichs, A. J. and G. L. Hargrove. 1994. Standards of Weight and Height for Ayrshire, Brown Swiss, and Milking Shorthorn Heifers. *J Dairy Sci* 77(6):1676-1681.
- Heinrichs, A. J. and W. C. Losinger. 1998. Growth of Holstein dairy heifers in the United States. *J Anim Sci* 76(5):1254-1260.
- Heinrichs, A. J., G. W. Rogers, and J. B. Cooper. 1992. Predicting Body-Weight and Wither Height in Holstein Heifers Using Body Measurements. *J Dairy Sci* 75(12):3576-3581.
- Heinrichs, A. J. and L. A. Swartz. 1991. Management of dairy heifers. Pennsylvania State Univ. Ext. Cir. 385 Pennsylvania State Univ. Ext., University Park.
- Heinrichs, A. J., S. J. Wells, H. S. Hurd, G. W. Hill, and D. A. Dargatz. 1994. The National Dairy Heifer Evaluation Project - a Profile of Heifer Management-Practices in the United-States. *J Dairy Sci* 77(6):1548-1555.

- Heins, B. J., L. B. Hansen, A. J. Seykora, D. G. Johnson, J. G. Linn, J. E. Romano, and A. R. Hazel. 2008. Crossbreds of Jersey x Holstein compared with pure Holsteins for production, fertility, and body and udder measurements during first lactation. *J Dairy Sci* 91(3):1270-1278.
- Hill, S. R., K. F. Knowlton, K. M. Daniels, R. E. James, R. E. Pearson, A. V. Capuco, and R. M. Akers. 2008. Effects of milk replacer composition on growth, body composition, and nutrient excretion in preweaned holstein heifers. *J Dairy Sci* 91(8):3145-3155.
- Hoffman, P. C. Nutrition and Environment- Improving Heifer Growth. University of Wisconsin Cooperative Extension.
- Hoffman, P. C. Optimum Growth Rates for Holstein Replacement Heifers. University of Wisconsin Cooperative Extension.
- Hoffman, P. C. 1997. Optimum body size of Holstein replacement heifers. *J Anim Sci* 75(3):836-845.
- Hoffman, P. C., N. M. Brehm, S. G. Price, and A. PrillAdams. 1996. Effect of accelerated postpubertal growth and early calving on lactation performance of primiparous Holstein heifers. *J Dairy Sci* 79(11):2024-2031.
- Hoffman, P. C. and D. A. Funk. 1992. Applied Dynamics of Dairy Replacement Growth and Management. *J Dairy Sci* 75(9):2504-2516.
- Holtz, E. W., A. S. Hodgson, and R. E. Erb. 1961. Relationship between Rate of Gain from Birth to 6 Months of Age and Subsequent Yields of Dairy Cows. *J Dairy Sci* 44(4):672-678.
- Keown, J. F. and R. W. Everett. 1986. Effect of Days Carried Calf, Days Dry, and Weight of 1st Calf Heifers on Yield. *J Dairy Sci* 69(7):1891-1896.
- Kertz, A. F., B. A. Barton, and L. F. Reutzel. 1998. Relative efficiencies of wither height and BW increase from birth until first calving in Holstein cattle. *J Dairy Sci* 81(5):1479-1482.
- Kertz, A. F., L. R. Prewitt, and J. M. Ballam. 1987. Increased Weight-Gain and Effects on Growth-Parameters of Holstein Heifer Calves from 3 to 12 Months of Age. *J Dairy Sci* 70(8):1612-1622.
- Lammers, B. P. and A. J. Heinrichs. 2000. The response of altering the ratio of dietary protein to energy on growth, feed efficiency, and mammary development in rapidly growing prepubertal heifers. *J Dairy Sci* 83(5):977-983.

- Lee, A. J. 1997. The interplay of feeding and genetics on heifer rearing and first lactation milk yield: A review. *J Anim Sci* 75(3):846-851.
- Lee, A. J., C. Y. Lin, A. J. Mcallister, K. A. Winter, G. L. Roy, J. A. Vesely, J. M. Wauthy, T. R. Batra, and A. S. Atwal. 1988. Growth and Feed-Efficiency of Pureline and Crossline Dairy Heifers. *J Dairy Sci* 71(4):1000-1010.
- Lin, C. Y., A. J. Mcallister, T. R. Batra, A. J. Lee, G. L. Roy, J. A. Vesely, J. M. Wauthy, and K. A. Winter. 1988. Effects of Early and Late Breeding of Heifers on Multiple Lactation Performance of Dairy-Cows. *J Dairy Sci* 71(10):2735-2743.
- Lin, C. Y., A. J. Mcallister, and A. J. Lee. 1985. Multitrait Estimation of Relationships of 1st-Lactation Yields to Body-Weight Changes in Holstein Heifers. *J Dairy Sci* 68(11):2954-2963.
- Little, W. and R. M. Kay. 1979. Effects of Rapid Rearing and Early Calving on the Subsequent Performance of Dairy Heifers. *Anim Prod* 29(Aug):131-142.
- Mcdowell, R. E. and B. T. Mcdaniel. 1968. Interbreed Matings in Dairy Cattle .I. Yield Traits Feed Efficiency Type and Rate of Milking. *J Dairy Sci* 51(5):767-777.
- Meijering, A. 1983. Morphologic Aspects of Dystocia in Dairy Heifers. *J Dairy Sci* 66(Suppl.1):108.(Abstr.).
- Miller, R. H. and L. D. Mcgilliard. 1959. Relations between Weight at 1st Calving and Milk Production during the 1st Lactation. *J Dairy Sci* 42(12):1932-1943.
- Moody, M. L., G. I. Zanton, J. M. Daubert, and A. J. Heinrichs. 2007. Nutrient utilization of differing forage-to-concentrate ratios by growing Holstein heifers. *J Dairy Sci* 90(12):5580-5586.
- National Research Council. 2001. Nutrient Requirements of Dairy Cattle. Vol. 7th rev. ed. National Academy of Science, Washington, D.C.
- Nieuwhof, G. J., R. L. Powell, and H. D. Norman. 1989. Ages at Calving and Calving Intervals for Dairy-Cattle in the United-States. *J Dairy Sci* 72(3):685-692.
- Norman, H. D., J. L. Edwards, and J. R. Wright. 2001. Accuracy of recorded birth and calving dates of dairy cattle in the United States. *J Dairy Sci* 84(9):2089-2096.
- Pecsok, S. R., J. N. Spain, and M. J. Monson. 1992. Optimal Heifer Growth-Rates Based on Forage and Concentrate Price Relationships. *J Dairy Sci* 75(7):2030-2037.
- Pennsylvania State University. Growth Monitor Excel Spreadsheets.
<http://www.das.psu.edu/research-extension/dairy/nutrition/heifers>.

- Peri, I., A. Gertler, I. Bruckental, and H. Barash. 1993. The Effect of Manipulation in Energy Allowance during the Rearing Period of Heifers on Hormone Concentrations and Milk-Production in 1st Lactation Cows. *J Dairy Sci* 76(3):742-751.
- Place, N. T., A. J. Heinrichs, and H. N. Erb. 1998. The effects of disease, management, and nutrition on average daily gain of dairy heifers from birth to four months. *J Dairy Sci* 81(4):1004-1009.
- Powell, B. L. 1985. Trend of Age at 1st Calving. *J Dairy Sci* 68(3):768-772.
- Pritchard, G. I., W. H. Riddell, and W. B. Durrell. 1954. The Effect of Different Levels of Dietary Terramycin on the Growth of Young Dairy Calves. *J Dairy Sci* 37(6):654-654.
- Purebred Dairy Cattle Association. 2009. Dairy Unified Scorecard. Purbred Dairy Cattle Association, Madison, WI.
- Radcliff, R. P., M. J. Vandehaar, A. L. Skidmore, L. T. Chapin, B. R. Radke, J. W. Lloyd, E. P. Stanisiewski, and H. A. Tucker. 1997. Effects of diet and bovine somatotropin on heifer growth and mammary development. *J Dairy Sci* 80(9):1996-2003.
- SAS Institute. 2008. SAS User's Guide: Statistics, Version 9.2 Edition. SAS Inst., Inc., Cary, NC.
- Schwanke, C. A. 1997. Dairy youth programming: Where we've been, and where we go from here. *J Dairy Sci* 80(8):1880-1883.
- Sejrsen, K., J. T. Huber, and H. A. Tucker. 1983. Influence of Amount Fed on Hormone Concentrations and Their Relationship to Mammary Growth in Heifers. *J Dairy Sci* 66(4):845-855.
- Sejrsen, K., J. T. Huber, H. A. Tucker, and R. M. Akers. 1982. Influence of Nutrition on Mammary Development in Prepubertal and Post-Pubertal Heifers. *J Dairy Sci* 65(5):793-800.
- Sejrsen, K. and S. Purup. 1997. Influence of prepubertal feeding level on milk yield potential of dairy heifers: A review. *J Anim Sci* 75(3):828-835.
- Sejrsen, K., S. Purup, M. Vestergaard, and J. Foldager. 2000. High BW gain and reduced bovine mammary growth: physiological basis and implications for milk yield potential. *Domest Anim Endocrin* 19(2):93-104.

- Sinha, Y. N. and H. A. Tucker. 1969. Mammary Development and Pituitary Prolactin Level of Heifers from Birth through Puberty and during Estrous Cycle. *J Dairy Sci* 52(4):507-512.
- Smith, J. J., A. V. Capuco, and D. R. Waldo. 1986. Influence of diet and prepubertal growth rate of Holstein heifers on mammary gland histology. *J Dairy Sci* 69(Suppl. 1).
- Spike, P. W. 1997. Nontraditional knowledge-based dairy youth activities and events. *J Dairy Sci* 80(8):1891-1894.
- Stelwagen, K. and D. G. Grieve. 1990. Effect of Plane of Nutrition on Growth and Mammary-Gland Development in Holstein Heifers. *J Dairy Sci* 73(9):2333-2341.
- Swanson, E. W. 1967. Optimum Growth Patterns for Dairy Cattle. *J Dairy Sci* 50(2): 244-252.
- Thompson, J. R., E. J. Pollak, and C. L. Pelissier. 1983. Interrelationships of Parturition Problems, Production of Subsequent Lactation, Reproduction, and Age at 1st Calving. *J Dairy Sci* 66(5):1119-1127.
- Tozer, P. R. and A. J. Heinrichs. 2001. What affects the costs of raising replacement dairy heifers: A multiple-component analysis. *J Dairy Sci* 84(8):1836-1844.
- Trimberger, G. W., W. M. Etgen, and D. M. Galton. 1987. *Dairy Cattle Judging Techniques*. 4th edition ed. Waveland Press, Inc, Prospect Heights, Illinois.
- Tyler, H. D. and M. E. Ensminger. 2006. *Dairy Cattle Science*. Fourth edition ed. Pearson Prentice Hall, Upper Saddle River, New Jersey.
- USDA Annual 4-H Youth Development Enrollment Report. 1985-1994. USDA, ed, Washington, DC.
- Van Amburgh, M. E., and D. M. Dalton. 1993. Growth and nutrition of heifers from weaning to breeding weight. No. 165 in *Proc. Secon Biennial Northeast Heifer Manage. Symp*, Cornell Univ., Ithaca, NY.
- VandeHaar, M. J. 1997. Dietary protein and mammary development of heifers: analysis from literature data. *J Dairy Sci* 80 (Suppl. 1).
- Weigel, K. A. 2004. Exploring the Role of Sexed Semen in Dairy Production Systems. *J Dairy Sci* 87(E. Suppl.):E120-E130.
- Weigel, K. A. and K. A. Barlass. 2003. Results of a producer survey regarding crossbreeding on US dairy farms. *J Dairy Sci* 86(12):4148-4154.

- Wickersham, E. W. and L. H. Schultz. 1963. Influence of Age at First Breeding on Growth, Reproduction, and Production of Well-Fed Holstein Heifers. *J Dairy Sci* 46(6):544-549.
- Willet, G. S. 1990. The economics of home-grown versus custom-raised dairy replacement heifers. *Farm Business Management Rep.* EB 1537 Washington State University, Pullman.
- Wolf, C. A. 2003. Custom dairy heifer grower industry characteristics and contract terms. *J Dairy Sci* 86(9):3016-3022.
- Zanton, G. I. and A. J. Heinrichs. 2005. Meta-analysis to assess effect of prepubertal average daily gain of Holstein heifers on first-lactation production. *J Dairy Sci* 88(11):3860-3867.
- Zanton, G. I. and A. J. Heinrichs. 2007. The effects of controlled feeding of a high-forage or high-concentrate ration on heifer growth and first-lactation milk production. *J Dairy Sci* 90(7):3388-3396.

Table 1. Optimum growth patterns for Holstein heifers in ideal conditions (Hoffman, undated).

Age Mo	Upper Range				Lower Range			
	BW kg	ADG kg	WH cm	BL cm	BW kg	ADG kg	WH cm	BL cm
0.0	42.2		76.2	81.3	42.2		76.2	81.3
1.0	63.0	0.7	81.3	86.4	63.0	0.7	81.3	86.4
2.0	83.9	0.7	86.4	94.0	83.9	0.7	86.4	94.0
3.0	109.8	0.8	91.4	99.1	107.0	0.8	91.4	99.1
4.0	135.2	0.8	99.1	104.1	130.2	0.8	96.5	104.1
5.0	161.0	0.8	101.6	109.2	153.8	0.8	101.6	109.2
6.0	186.0	0.8	104.1	116.8	176.9	0.8	104.1	114.3
7.0	211.8	0.8	109.2	121.9	200.0	0.8	106.7	119.4
8.0	236.8	0.8	111.8	127.0	222.7	0.8	109.2	121.9
9.0	263.1	0.8	111.8	132.1	246.8	0.8	111.8	127.0
10.0	288.0	0.8	116.8	134.6	269.9	0.8	114.3	132.1
11.0	313.9	0.8	116.8	139.7	293.0	0.8	116.8	137.2
12.0	338.8	0.8	119.4	142.2	315.7	0.8	116.8	139.7
13.0	364.7	0.8	121.9	147.3	339.7	0.8	119.4	142.2
14.0	390.1	0.8	124.5	149.9	362.9	0.8	121.9	147.3
15.0	415.9	0.8	127.0	154.9	386.0	0.8	124.5	149.9
16.0	440.9	0.8	127.0	157.5	408.7	0.8	127.0	152.4
17.0	466.7	0.8	129.5	160.0	431.8	0.8	127.0	154.9
18.0	491.7	0.8	132.1	162.6	455.9	0.8	129.5	157.5
19.0	518.0	0.8	132.1	165.1	479.0	0.8	132.1	160.0
20.0	543.0	0.8	134.6	165.1	501.7	0.8	132.1	162.6
21.0	568.8	0.8	137.2	167.6	524.8	0.8	134.6	165.1
22.0	593.8	0.8	137.2	170.2	548.8	0.8	134.6	167.6
23.0	619.6	0.8	139.7	170.2	572.0	0.8	137.2	167.6
24.0	645.0	0.8	142.2	172.7	594.7	0.8	137.2	170.2
7-d postpart.	581.1				535.7			
30-d postpart.	540.7				499.9			

¹WH=wither height, BL= body length from the point of shoulder to the ischium.²Pelvic area > 260 cm².

Table 2. A detailed look at age, weight, and ADG from 2007-2010.

Show	# of Obs.	% of total Obs.	Mean Age, d	SEM, age	Mean Weight, kg	SEM, weight	Mean ADG, kg/ d	SEM, ADG
2007 UGA ¹	215	12.33	230.38	4.36	197.73	4.18	0.67	0.01
2007 Perry ²	247	14.16	242.50	4.25	200.83	3.97	0.65	0.01
2008 UGA	220	12.61	247.69	4.42	202.12	4.09	0.65	0.01
2008 Perry	244	13.99	252.51	4.31	205.69	3.86	0.65	0.01
2009 UGA	186	10.67	243.37	4.94	202.02	4.91	0.66	0.01
2009 Perry	216	12.39	251.50	4.51	204.80	4.38	0.65	0.01
2010 UGA	178	10.21	238.24	4.84	190.16	4.60	0.62	0.01
2010 Perry	238	13.65	246.98	3.99	197.02	3.76	0.63	0.01

¹University of Georgia Commercial Dairy Heifer Show, Athens, Georgia.

²Georgia Junior National Livestock Show, Georgia National Fairgrounds Perry, Georgia.

Table 3. Breed comparison within the Commercial Dairy Heifer Program, 2007-2010

Breed	# of Obs.	% of total Obs.	Mean Age, d	SEM, Age	Mean Weight, kg	SEM, Weight	Mean ADG, kg/ d	SEM, ADG
BS	34	1.95	231.74	13.84	174.11	10.99	0.55	0.03
HO	1485	85.15	245.98	1.70	204.28	1.61	0.66	0.00
JE	34	1.95	236.47	9.68	144.00	4.21	0.52	0.02
BS X HO	44	2.52	233.61	11.69	184.02	8.94	0.60	0.02
JE X HO	136	7.80	237.54	5.44	186.06	4.89	0.63	0.01
Other Breeds ¹	11	0.63	229.73	17.06	159.34	16.87	0.53	0.04

¹Includes all breeds and crossbreeds that n<10 from 2007-2010.

Table 4. County (first letter A-M) comparison within the Commercial Dairy Heifer Program, 2007-2010

County	Percent of total obs.	Mean age, d	SEM, age	Mean weight, kg	SEM, weight	Mean ADG, kg/d	SEM, ADG	Mean placing	SEM, placing	Mean ADG rank	SEM, ADG rank
Burke	3.73	225.7	10.16	173.6	7.67	0.58	0.02	4.95	0.39	6.0	0.46
Chattooga	2.87	249.2	8.98	189.6	7.95	0.59	0.02	4.4	0.35	7.2	0.48
Coweta	4.76	249.4	7.56	208.7	6.48	0.66	0.01	4.2	0.28	6.4	0.34
Dade	0.92	207.4	17.56	157.5	14.81	0.54	0.04	10.3	0.57	7.6	0.94
Dawson	0.80	234.2	14.83	168.4	11.31	0.54	0.03	8.3	0.68	2.2	0.77
Elbert	5.73	280.5	6.28	225.9	5.68	0.65	0.01	6.9	0.33	7.8	0.30
Greene	4.93	221.5	6.15	160.0	4.86	0.55	0.01	6.8	0.37	7.3	0.35
Hart	0.57	294.8	9.78	242.0	12.29	0.69	0.03	8.6	0.69	7.9	1.24
Houston	5.73	274.9	6.16	223.5	5.28	0.66	0.01	2.5	0.20	7.0	0.31
Jones	5.50	278.6	5.12	225.6	5.19	0.67	0.02	6.7	0.32	6.9	0.38
Lee	6.65	208.1	5.42	223.8	5.46	0.64	0.01	6.0	0.26	7.3	0.28
Macon	1.61	217.1	11.01	114.7	5.37	0.36	0.02	8.0	0.53	7.6	0.62
Madison	0.86	193.4	7.48	153.4	6.00	0.60	0.04	8.4	0.68	5.2	0.98
Morgan	12.44	234.0	4.43	196.8	3.76	0.68	0.01	7.1	0.21	5.4	0.23
Murray	0.92	307.4	7.57	271.7	7.18	0.75	0.02	1.9	0.34	6.4	0.75

Table 5. County (first letter N-Z) comparison within the Commercial Dairy Heifer Program, 2007-2010

County	Percent of total obs.	Mean age, d	SEM, age	Mean weight, kg	SEM, weight	Mean ADG, kg/d	SEM, ADG	Mean placing	SEM, placing	Mean ADG rank	SEM, ADG rank
Oconee	9.92	222.4	3.85	177.1	3.88	0.62	0.01	8.0	0.22	5.8	0.24
Oglethorpe	4.99	238.8	5.89	208.4	5.84	0.70	0.02	8.4	0.31	5.2	0.35
Peach	0.86	153.1	3.72	122.0	6.34	0.52	0.04	8.9	0.93	4.7	0.98
Perry	3.38	268.9	9.12	194.9	6.70	0.56	0.01	6.8	0.43	9.0	0.40
Putnam	6.02	243.4	7.25	216.4	7.92	0.70	0.02	3.9	0.26	5.0	0.32
Screven	1.03	183.4	9.73	161.3	8.66	0.65	0.04	6.8	0.74	4.1	0.66
White	4.64	245.0	7.26	212.1	6.93	0.68	0.01	4.3	0.32	4.8	0.32
Whitfield	1.03	185.8	9.35	171.7	10.80	0.70	0.03	6.8	0.80	3.5	0.62
Wilcox	4.07	249.7	7.47	236.4	8.17	0.77	0.02	4.6	0.37	4.2	0.34
Wilkes	4.59	214.3	4.92	190.8	6.45	0.69	0.02	7.1	0.31	5.3	0.33
Other Counties ¹	1.43	243.6	11.65	201.2	10.98	0.65	0.02	7.3	0.68	6.6	0.64

¹Combined counties with n<10 from 2007-2010.

Table 6. A detailed look at each ADG and placing rank within each class, 2007-2010

Rank	ADG Rank		Placing Rank	
	ADG, kg	Mean Placing	ADG, kg	Mean ADG Rank
1	0.82	6.31	0.65	6.02
2	0.75	6.37	0.65	5.96
3	0.72	5.89	0.65	6.21
4	0.69	6.45	0.65	6.21
5	0.66	6.16	0.64	6.51
6	0.64	5.92	0.65	6.33
7	0.62	6.14	0.64	6.32
8	0.59	6.22	0.64	6.10
9	0.57	6.07	0.64	6.24
10	0.55	5.75	0.65	5.75
11	0.53	5.82	0.66	6.06
12	0.52	6.72	0.68	5.52
13	0.50	7.04	0.63	6.72
>13	0.49	8.50	0.60	8.50

Table 7. Spearman correlation coefficients between ADG, placing, weight, and age, 2007-2010

	Placing (P-value)	Weight (P-value)	Age (P-value)
ADG (P-value)	-0.07 (0.0034)	.11 (<0.0001)	-0.89 (<0.0001)
Placing (P-value)		0.10 (<0.0001)	0.09 (0.0002)
Weight (P-value)			0.10 (<0.0001)

Table 8. Spearman correlation coefficients between ADG, placing, weight, age, wither height, hip height, hip width, jaw width, switch clearance, 2010 GJNLS¹

	Placing	Wt	Age	Wither Ht	Hip Ht	Hip W	Jaw W	Switch CLR
ADG (P-value)	-0.02 (0.76)	0.14 (0.03)	-0.87 (<0.01)	-0.15 (0.02)	-0.05 (0.42)	0.04 (0.56)	0.08 (0.22)	0.23 (<0.01)
Placing (P-value)		0.11 (0.10)	0.04 (0.55)	0.42 (<0.01)	0.32 (<0.01)	0.08 (0.22)	-0.14 (0.04)	0.17 (0.01)
Wt (P-value)			0.09 (0.17)	0.27 (<0.01)	0.26 (<0.01)	0.20 (<0.01)	0.03 (0.65)	-0.02 (0.82)
Age (P-value)				0.22 (<0.01)	0.07 (0.31)	0.02 (0.72)	0.00 (0.96)	-0.27 (<0.01)
Wither Height (P-value)					0.65 (<0.01)	0.30 (<0.01)	-0.04 (0.56)	0.17 (0.01)
Hip Height (P-value)						0.34 (<0.01)	-0.10 (0.15)	0.26 (<0.01)
Hip Width (P-value)							0.14 (0.04)	0.04 (0.53)
Jaw Width (P-value)								-0.04 (0.61)

¹Georgia Junior National Livestock Show, Perry, Georgia.

Table 9. Composition of Holstein heifers below or exceeding the Pennsylvania State Holstein Growth Spreadsheet weight guidelines

Show	# observations	# of underweight heifers ¹	% of total	# of adequate weight heifers ¹	% of total
2007 UGA ²	186	103	55	83	45
2007 Perry ³	216	143	66	73	34
2008 UGA	184	116	63	68	37
2008 Perry	207	134	65	73	35
2009 UGA	152	83	55	69	45
2009 Perry	202	131	65	71	35
2010 UGA	142	99	70	43	30
2010 Perry	200	142	71	58	29
Totals	1489	951		538	
Averages	186.12	118.88	63.75	67.25	36.25

¹Based on guidelines in Pennsylvania State Growth Spreadsheet, Pennsylvania State University.

² University of Georgia Commercial Dairy Heifer Show, Athens, Georgia.

³ Georgia Junior National Livestock Show, Perry, Georgia.

Table 10. The Pennsylvania State Holstein Growth Spreadsheet: a view of each county's performance

County	# of Observations	# of heifers underweight	% of total	# of adequate weight heifers	% of total
Burke	29	20	68.97	9	31.03
Chattooga	41	36	87.80	5	12.20
Coweta	83	59	71.08	24	28.92
Dade	16	13	81.25	3	18.75
Dawson	13	12	92.31	1	7.69
Elbert	95	64	67.37	31	32.63
Greene	62	52	83.87	10	16.13
Houston	96	66	68.75	30	31.25
Jones	91	54	59.34	37	40.66
Lee	112	81	72.32	31	27.68
Macon	22	21	95.45	1	4.55
Madison	15	9	60.00	6	40.00
Morgan	131	71	54.20	60	45.80
Murray	14	5	35.71	9	64.29
Oconee	136	96	70.59	40	29.41
Oglethorpe	79	37	46.84	42	53.16
Peach	16	13	81.25	3	18.75
Perry	58	54	93.10	4	6.90
Putnam	102	48	47.06	54	52.94
White	77	42	54.55	35	45.45
Whitfield	15	6	40.00	9	60.00
Wilcox	71	24	33.80	47	66.20
Wilkes	80	46	57.50	34	42.50
Other ¹	35	22	62.86	13	37.14

¹ Counties with n<10 total observations, 2007-2010.

Table 11. Differences in suggested weight from actual weight from the Pennsylvania State Holstein Growth Spreadsheet

Show	Underweight (Actual Weight-Suggested Weight)			Adequate Weight (Actual Weight- Suggested Weight)		
	< -50.00 kg	-25.01 to -50.00 kg	< 0 to -25.00 kg	0 to 25.00 kg	25.01 to 50.00 kg	> 50.00 kg (%)
2007 UGA	3.23 %	19.35 %	32.80 %	26.34 %	12.37 %	5.91 %
2007 Perry	9.72 %	22.69 %	33.80 %	18.52 %	11.11 %	4.17 %
2008 UGA	18.48 %	16.85 %	27.71 %	23.37 %	9.78 %	3.80 %
2008 Perry	16.43 %	19.81 %	28.50 %	24.64 %	5.80 %	4.83 %
2009 UGA	11.18 %	19.08 %	24.34 %	25.00 %	12.50 %	7.90 %
2009 Perry	17.33 %	21.29 %	26.24 %	21.29 %	7.92 %	5.94 %
2010 UGA	19.01 %	26.76 %	23.94 %	15.49 %	9.86 %	4.92 %
2010 Perry	19.50 %	29.50 %	22.00 %	19.50 %	5.00 %	4.50 %

Figure 1. Number of entries in Georgia Junior National Livestock Show, 1997-2010

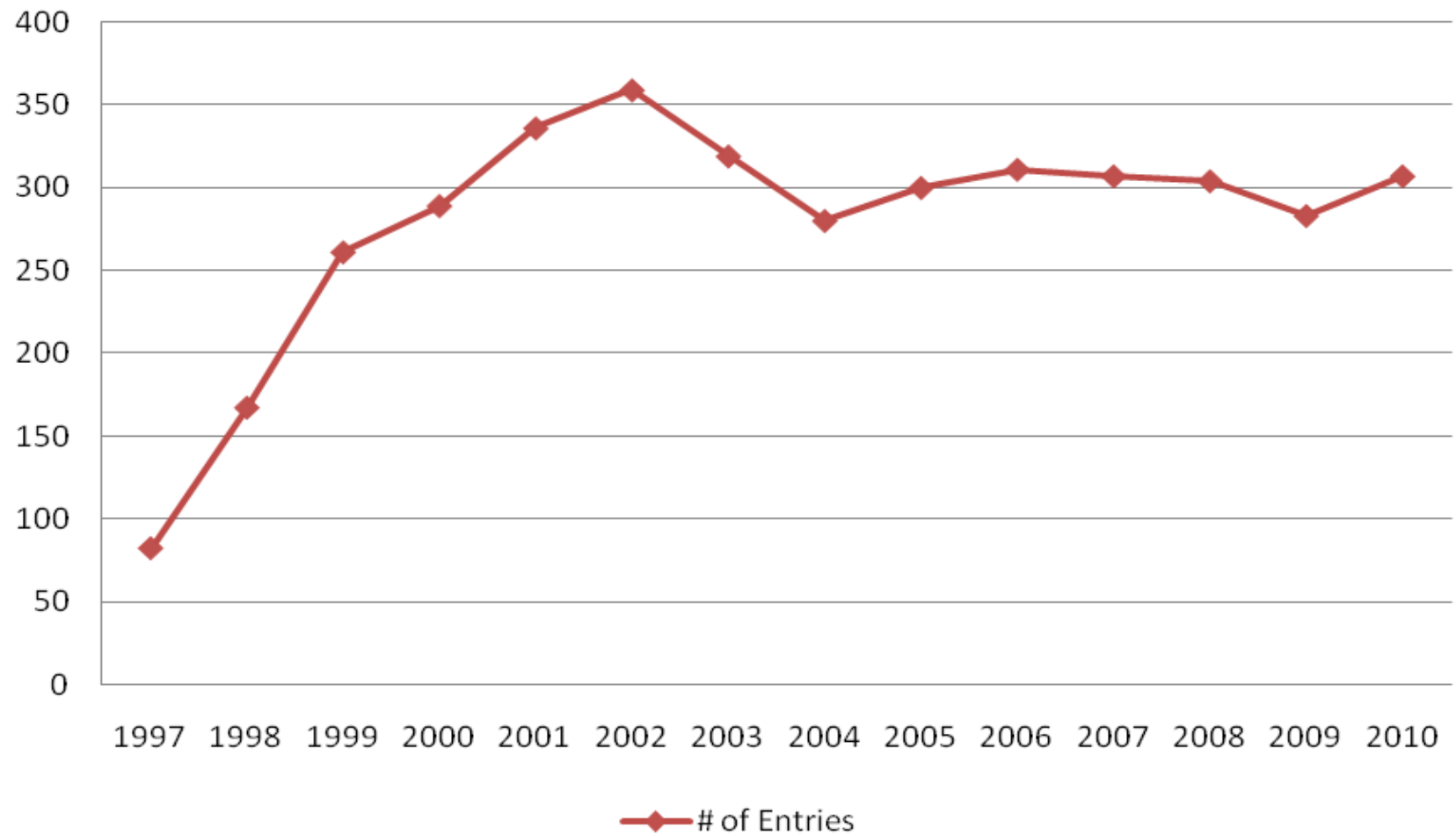
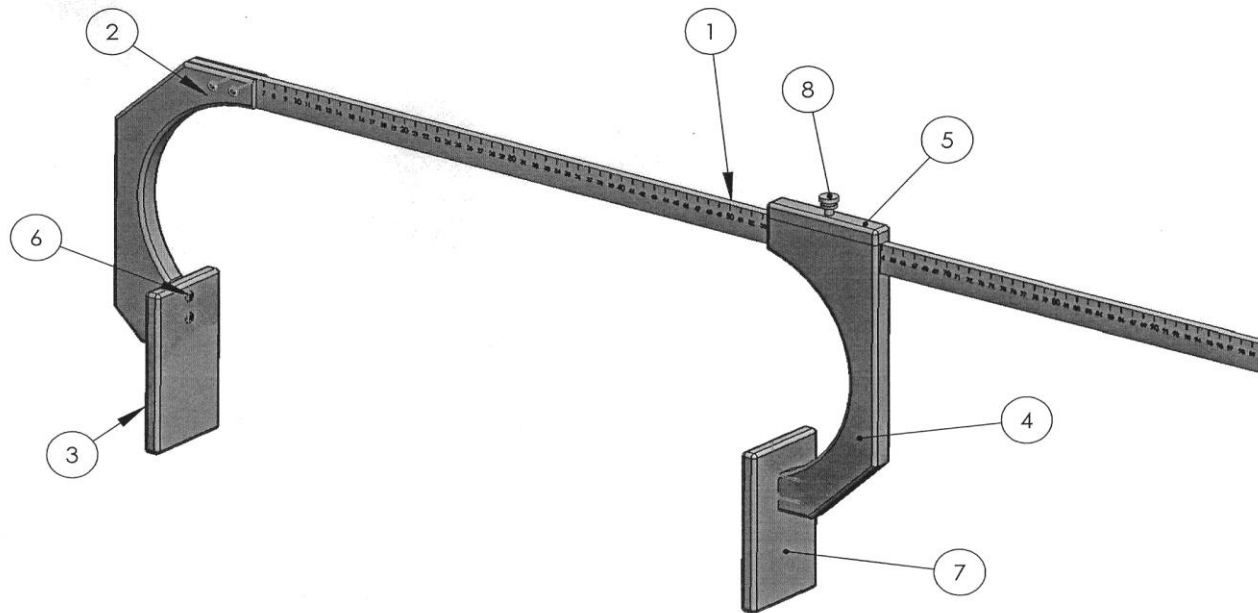


Figure 2. Custom designed heifer width measurement device, University of Georgia Instrument Shop



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Meter stick		1
2	fixed frame		1
3	fixed jaw		1
4	movable frame		1
5	movable frame cap		1
6	94629A730		6
7	movable jaw		1
8	94323A540		1

Figure 3. Holstein heifer weights compared to recommended weights, 2010 Georgia Junior National Livestock Show

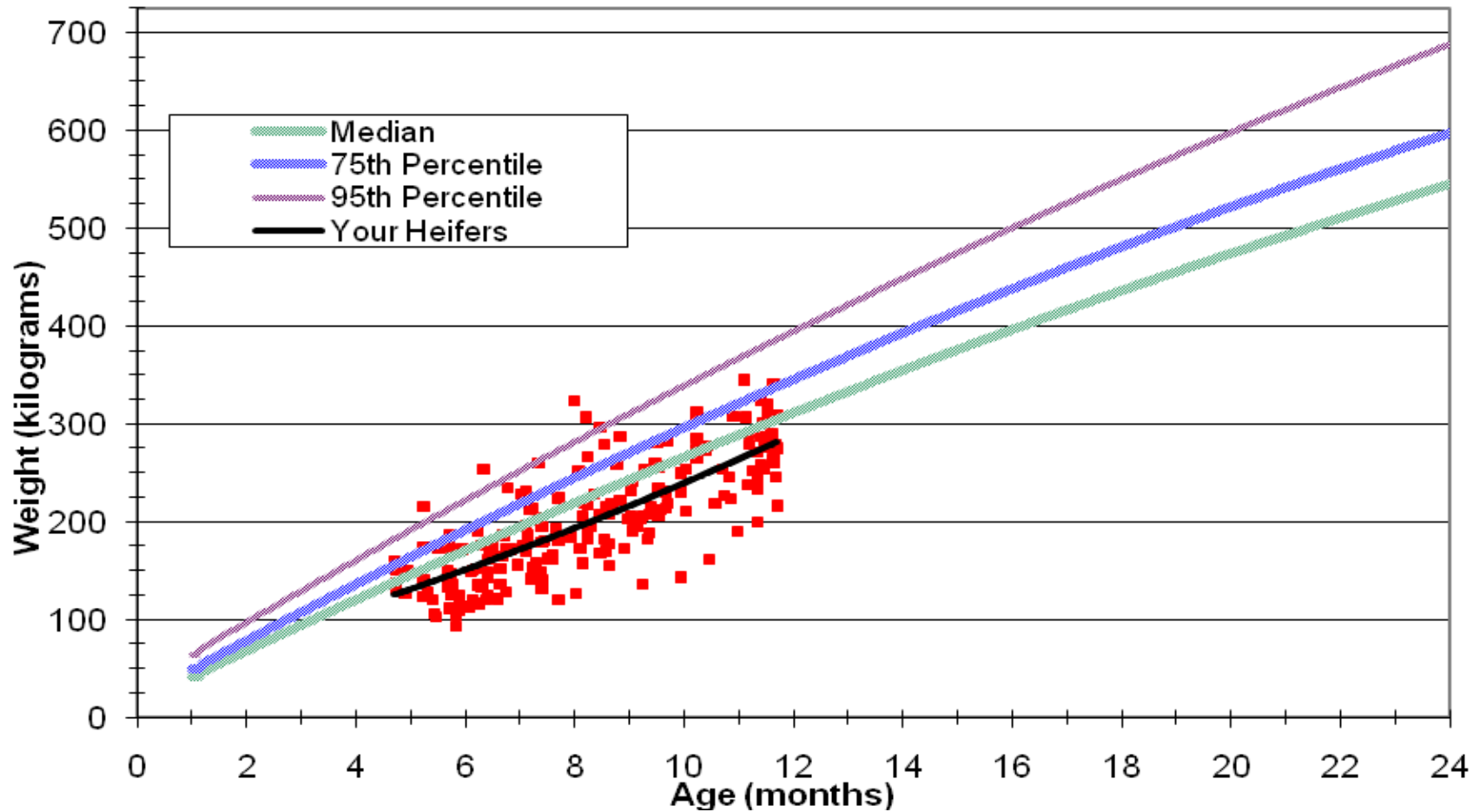


Figure 4. Holstein wither heights compared to recommended heights, 2010 Georgia Junior National Livestock Show

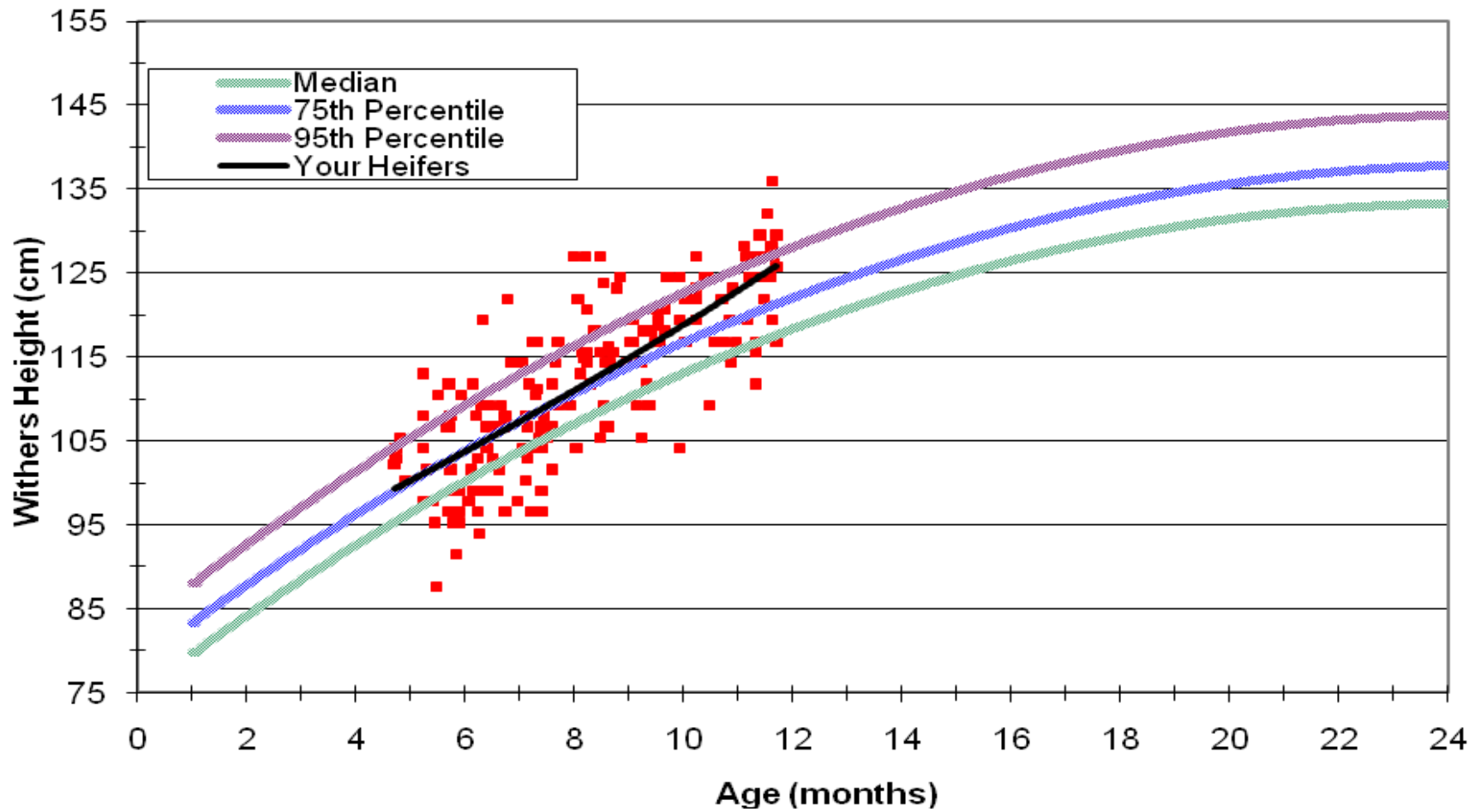


Figure 5 Holstein hip heights compared to recommended heights, 2010 Georgia Junior National Livestock Show

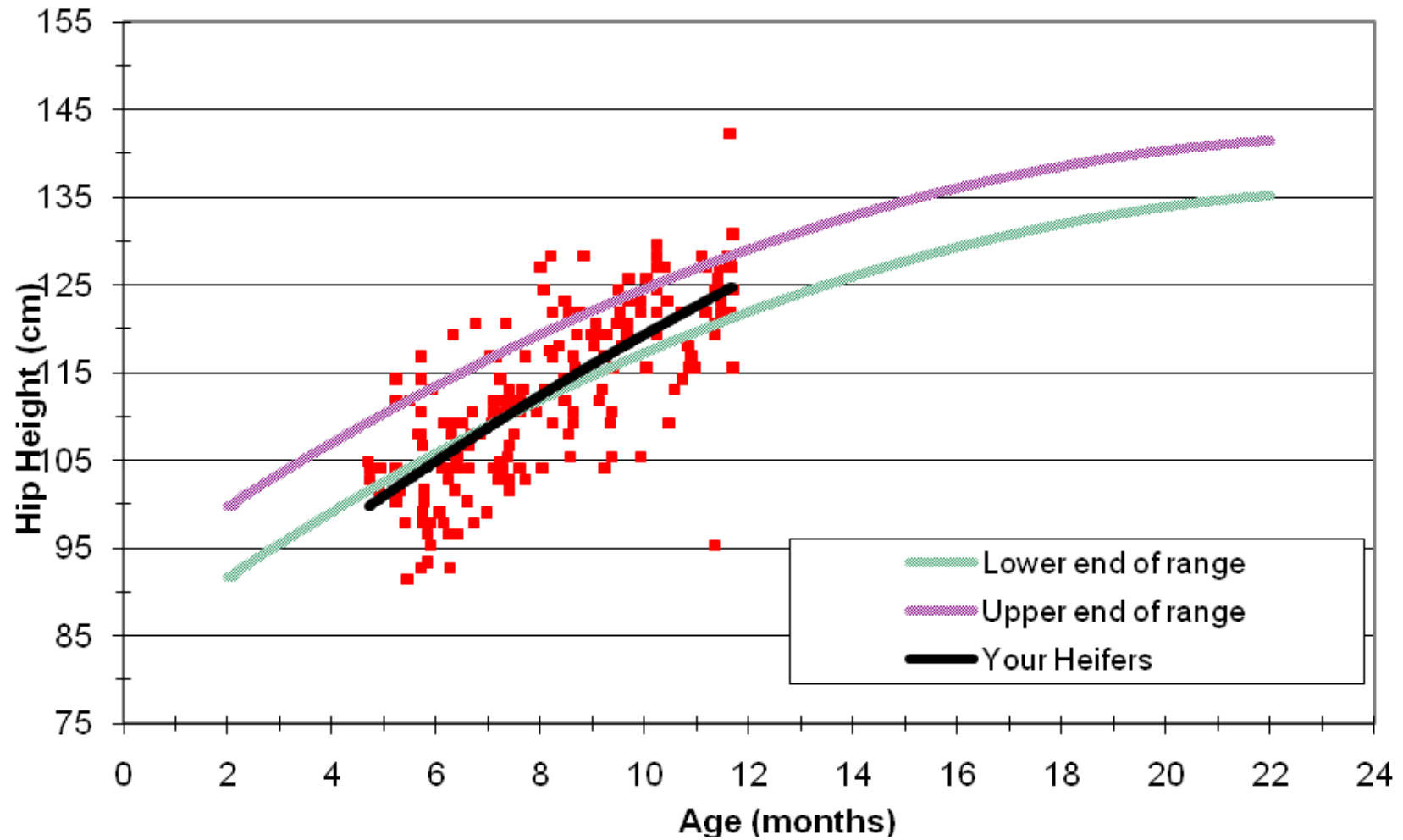


Figure 6. Holstein hip widths compared to recommended widths, 2010 Georgia Junior National Livestock Show

