UF UNIVERSITY of FLORIDA
IFAS
Department of Animal Sciences

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352-392-1916
352-392-9059 (Fax)

Welcome to the 2019 Florida Beef Cattle Short Course:

The 2019 Florida Beef Cattle Short Course Program Committee and the Department of Animal Sciences would like to welcome you to this year's Short Course. We look forward to this week every year in anticipation of delivering the premier educational event for serious beef cattle producers in the Southeast. We hope that you enjoy the program and take away some new knowledge about the beef cattle industry's future direction, additional management decision making skills, and new information about specific production and management practices that impact your beef cattle enterprise.

Planning for the Florida Beef Cattle Short Course is a year-round event. Shortly after every Short Course we review the survey comments from those participants that return them to us. The surveys are one of our key mechanisms to get your feedback about the quality and content of the Florida Beef Cattle Short Course. We appreciate the feedback that we get and would welcome all of our participants to return the surveys and voice their opinion. Late in the summer we begin evaluating subject areas and specific topics for the next year's Florida Beef Cattle Short Course. Our program committee works hard to identify important, timely topics that impact our beef cattle producers. We then work through the fall to identify the best speaker for that topic area and invite them to speak at the Florida Beef Cattle Short Course. We are privileged to get nationally recognized individuals to speak at the Florida Beef Cattle Short Course and appreciate the limited time they have in their schedules. Likewise partnering with our valuable Allied Industry partners we work to bring you a viable and diverse Tradeshow to share industry and product specific information.

Gainesville has been the home of the Florida Beef Cattle Short Course for the past 67 years. Survey responses consistently indicate that our participants prefer the Florida Beef Cattle Short Course to stay in Gainesville. Remaining in Gainesville offers certain advantages for us to deliver the excellent program that you have come to expect. We hope the Alto and Patricia Straughn Extension Professional Development Center location provides a comfortable and professional location, allowing us to provide a cost-effective, valuable learning experience for you.

The Program Committee has worked hard over the years to deliver a premier program at a reasonable cost to our participants. The Florida Beef Cattle Short Course is a self-sustaining program and receives no direct financial support from the UF/IFAS Department of Animal Sciences or UF/IFAS Extension. In as much, the Florida Beef Cattle Short Course has to meet costs associated with speakers' expense, meeting space, refreshment breaks, and material costs. Unfortunately, we have to pass those costs on to our participants. Just like the beef cattle industry, our costs of operation continue to increase in all facets.

Thank you for choosing to attend the 2019 Florida Beef Cattle Short Course. We hope that the program meets your expectations and provides you with valuable information to impact your beef cattle enterprise.

Best Regards,

Matt Hersom

Matt Hersom

Chair, 2019 Florida Beef Cattle Short Course

Florida Beef Cattle Short Course

68th Annual Florida Beef Cattle Short Course

"Connecting the Dots, Calf to Carcass"

May 8 – 10, 2019

Presented by

Department of Animal Sciences

Institute of Food and Agricultural Sciences

University of Florida, Gainesville, Florida

2019 Florida Beef Short Course Committee

Matt Hersom, Chair
Chad Carr
Bailey Harsh
Joel McQuagge
Jason Scheffler
Tracy Scheffler
Todd Thrift

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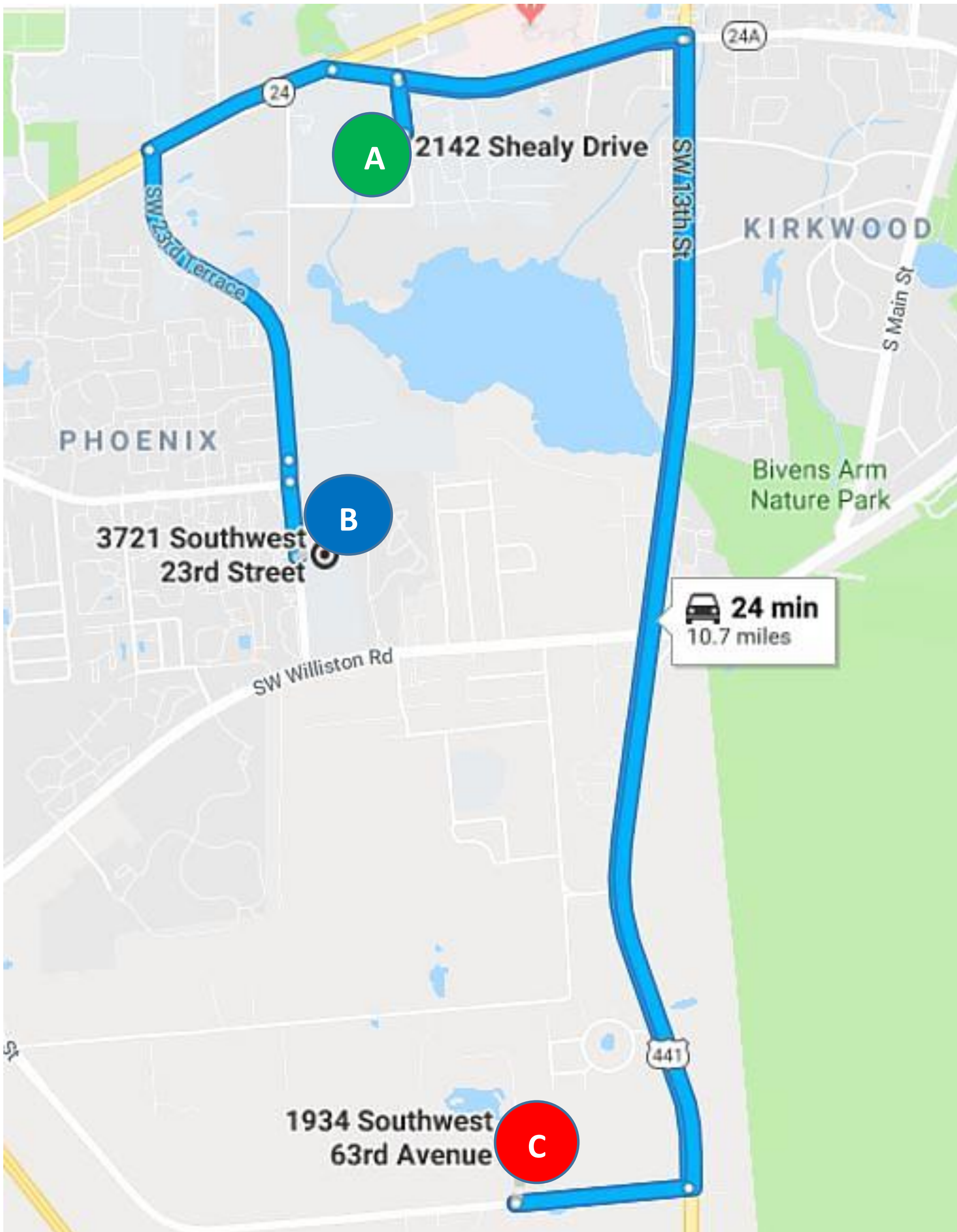

A

Wednesday, May 8: Reception

- Depart the Straughn Center, turn left unto Shealy Dr.
- Go to the stoplight and turn left onto SW 16th Ave/SR-226 W.
- Bear left unto SW Archer Rd/SR-24 W.
- Turn left on SW 23rd Terr (The road name will change to SW 23rd St).
- Go through the roundabout.
- Your destination will be on the left**.**

B **Beef Teaching Unit-S. 3721 SW 23rd St**

A

Thursday, May 9: Steakout

- Depart the Straughn Center, turn left unto Shealy Dr.
- Go to the stop light and turn right onto SW 16th Ave/SR-226 W.
- Go to SW 13th St/US-441 S/SR-25S and turn right.
- Go to SW 63rd Ave/CR 23 and turn right.
- Your destination is the right (if you reach SW 21st Terr, you have gone too far.

C **Horse Teaching Unit, 1934 SW 63rd Ave**

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Please visit our webpage-page @ http://animal.ifas.ufl.edu/beef_extension/index.shtml

Allied Industry Trade Show

UF/IFAS Beef Teaching Unit

May 8-10, 2019

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Allied Industry Trade Show

UF/IFAS Beef Teaching Unit

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Allied Industry Trade Show
UF/IFAS Beef Teaching Unit

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Allied Industry Trade Show

UF/IFAS Beef Teaching Unit

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Thank you for your continued support!

“Connecting the Dots, Calf to Carcass”

2019 Florida Beef Cattle Short Course

Straughn Extension Professional Development Center, 2142 Shealy Drive, Gainesville, FL

Follow this link to register online https://www.eventbrite.com/e/68th-florida-beef-cattle-short-course-tickets-54877220243

Wednesday, May 8, 2019

1:00 Welcome

1:15 Cattlemen’s Comments – Alex Johns, President of Florida Cattlemen’s Association

1:30 Market and Industry Trends in the Beef Business – Trey Warnock, Amarillo Brokerage Co.

2:15 Customer Satisfaction and National Tenderness Survey – Dr. Jason Scheffler, University of Florida

3:00 Break

3:30 Value and Mechanics of Meat Export – Dr. Travis Arp, Meat Export Federation

4:15 Cattle Cloning: Alpha and Omega – Dr. Ty Lawrence, West Texas A & M University

5:00 Evening Trade Show and Brisket Feed – Beef Teaching Unit-South

Thursday, May 9, 2019

8:30 Influence of Environment on Tenderness – Dr. Tracy Scheffler, University of Florida

9:15 Genetic Markers for Meat Quality – Dr. Steve Shackelford, USDA-MARC

10:00 Break

10:30 Physiology of Marbling – Dr. Susan Duckett, Clemson University

11:15 Fed Beef Challenge/How Do FL Cattle Compare – Dr. Bailey Harsh, University of Florida

11:45 Producer Panel with Experience Feeding Cattle

12:30 Lunch at Animal Sciences Building, Sponsored by Farm Credit of Florida

1:30 Afternoon Program

1. Live Animal Evaluation
2. Harvest and Processing
3. Carcass Evaluation
4. Performance and Profit(Loss)
5. Taste Panel

6:00 Cattlemen’s Steak Out – Horse Teaching Unit

Friday, May 10, 2019

8:30 Meat Quality and Thermotolerance in *Bos Indicus* Influenced Cattle – Dr. Raluca Mateescu, University of Florida

9:00 Issues in Cow Herd Health – Dr. Kelsey Arellano, University of Florida, CVM-FARMS

9:30 Mycotoxins in Forages – Dr. Ann Blount, University of Florida

10:00 Break

10:30 Using Ionophores in Cattle Production – Dr. Matt Hersom, University of Florida

11:00 Reproductive Challenges in Cow-calf Operations – Dr. Mario Binelli, University of Florida

11:30 Forage Management Application – Dr. Marcelo Wallau, University of Florida

12:00 Adjourn

Program Participants

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Speakers Biographies

68th Annual Florida Beef Cattle Short Course

John Arthington
UF/IFAS Department of Animal Sciences
When John Arthington was 11, his grandfather gave him two heifers for a 4-H project in Indiana, where he was born and raised. Arthington took those heifers and built a small herd, and that success drew him to major in animal sciences at Purdue University. Arthington excelled as an undergraduate, and his professors encouraged him to attend graduate school. Now, after 20-plus years as a premier cattle scientist and administrator, Arthington has been appointed chair of animal sciences at the University of Florida Institute of Food and Agricultural Sciences. Arthington, who started April 1, comes to his new position in Gainesville after 14 years as director of the UF/IFAS Range Cattle Research and Education Center in Ona, Florida.

Travis Arp
Senior Director, Export Services/Access
United States Meat Export Federation
Dr. Travis Arp is the Senior Director of Export Services/Access for the U.S. Meat Export Federation (USMEF), covering the Asian and Middle Eastern markets. Travis started with USMEF in October, 2012. At USMEF, he is responsible for market and trade access issues while also working with USMEF members, USMEF foreign offices, and the U.S. government to improve market access for U.S. red meat exporting companies. During his time at USMEF, Dr. Arp has worked directly and supported trade negotiations to open or expand market access for red meat products to markets like China, Saudi Arabia, Japan and Singapore. He was recognized for his work in Japan by the USDA Foreign Agriculture Services in 2016, being selected for the FAS Honor Award for Excellence in Achieving Strategic Objectives.
Dr. Arp has a Master's and Doctoral degree in Meat Science from the University of Florida and Colorado State University, respectively, and a Bachelor of Science degree in Agriculture Economics from the University of Missouri. Dr. Arp is originally from the Madison, Wisconsin area, where he grew up.

Mario Binelli
UF/IFAS Department of Animal Sciences
Dr. Binelli's overall program goal to maximize the proportion of beef cows pregnant at the end of the breeding season with particular focus on Bos indicus-based cattle operations. This goal is being pursued by conducting basic and applied research to understand and manipulate female reproductive tract functions to support embryo-conceptus development and pregnancy success. More than 50% of pregnancies of beef cows are lost during the first three weeks following insemination. Research will lead to increasing the odds of a successful conception from each insemination and methods to quickly re-inseminate after a failed insemination is detected.

Ann Blount
UF/IFAS North Florida Research and Education Center
Ann Blount is a University of Florida forage breeder and a state Forage Extension Specialist, located at the North Florida Research and Education Center at Marianna. She holds a bachelor's degree from Texas A&M University in Crop Science (1978), and a Masters (1980) and Ph.D. (1984) in forage breeding and genetics from the University of Florida. Dr. Blount has worked with Florida forages for over 30 years and has been involved in developing or co-developing over 75 cultivars of adapted sub-tropical forages including bahiagrass, perennial peanut, ryegrass, rye, oat, triticale, forage soybean, and clover cultivars that are currently grown in the southeastern U.S. and internationally. Her area of forage breeding focuses on plant photoperiod and cold response in forage production systems and disease/insect/nematode resistances. Her main forage crops include the breeding, genetics and evaluation of bahiagrass, perennial

peanut, small grains and ryegrass. Dr. Blount collaborates with regional plant breeding programs to adapt new forages, like limpograss and small grains to the southern Coastal Plain and Peninsular Florida. She has published over 362 research papers on forages and a book chapter on bahiagrass genetics with CRC Press. She is very actively involved in both research and extension activities state-wide, regionally, nationally and internationally. Dr. Blount is an active member of many professional organizations including Alpha Zeta, Gama Sigma Delta, American Forage and Grassland Council, National Cattlemen's Association, Perennial Peanut Producers Association, and has held various leadership positions in the American Society of Agronomy, Crop Science Society of America, and the Southern Pastures and Forage Crop Improvement Conference. Currently she is chairman of the USDA-ARS Crop Germplasm Advisory Committee (CGC)-Grasses and an active member of the AOSCA, National Grass Variety Review Board.

Susan K. Duckett

Clemson University, Department of Animal and Veterinary Sciences

Susan K. Duckett is currently a Professor in the Department of Animal and Veterinary Sciences at Clemson University where she holds The Ernest L. Corley, Jr. Trustees Endowed Chair. She received her B.S. degree in Animal Science from Iowa State University, and M.S. and Ph.D. degrees in Animal Science from Oklahoma State University. She held faculty positions at the University of Idaho and University of Georgia prior to her appointment at Clemson University. Dr. Duckett's research integrates ruminant nutrition and meat science to alter lipid metabolism, fatty acid composition and palatability of animal products.

Dr. Duckett's research integrates ruminant nutrition and meat science to alter lipid metabolism, fatty acid composition and palatability of animal products. Current research projects include:

Impact of Fescue Toxicosis on Fetal Development and Postnatal Growth (USDA-NIFA)

Early exposure of steers to corn grain to enhance marbling deposition

Palmitoleic acid supplementation on lipid and glucose metabolism in obese sheep

Bailey Harsh

UF/IFAS Department of Animal Sciences

Bailey Harsh is an Assistant Professor of Meat Science at the University of Florida. Originally from Radnor, Ohio, Bailey obtained her B.S. degree in Animal Science in 2013 from The Ohio State University. While at OSU, Bailey was an undergraduate employee and researcher in the meat science laboratory and a member of meat and livestock judging teams, receiving All-American honors in livestock judging.

Bailey completed her M.S. degree in Meat Science at Oklahoma State University in December 2014 where her research focused on the effects of production systems and production technologies on strip steak palatability and muscle dimensions. As a student at Oklahoma State, Bailey held leadership positions in the Animal Science Graduate Student Association and was awarded the Animal Science Distinguished Graduate Fellowship. Receiving her Ph.D. at the University of Illinois, her research focused on the effects of a beta-agonist on nitrogen excretion, nutrient digestibility, as well as expression and protein abundance of beta-receptor subtypes. She was recently recognized for her teaching and research accomplishments receiving the American Meat Science Association "Cleaver Award" for excellence in graduate student teaching and the American Society of Animal Scientists Midwest Section "Young Scholar Award" for excellence in research. Bailey's current research focuses on improving the efficiency of lean meat production and the quality of fresh and processed meat products by developing applied production strategies and technologies. Her production-systems based approach to research focuses on providing answers to questions from industry partners.

Matt Hersom

UF/IFAS Department of Animal Sciences, Gainesville, FL

Dr. Matt Hersom is an Associate Professor and Extension Beef Cattle Specialist at the University of Florida. His specific area of emphasis includes development of strategic nutritional and supplementation programs to optimize beef cattle performance utilizing forage and roughage based diets and evaluation of calf production and growing practices to improve animal performance in integrated beef production systems. Extension areas address expanding education experiences in beef cattle nutrition, implementation of optimal supplementation strategies for Florida cow-calf production, and development of increased pasture and forage utilization and management.

Alex Johns

President, Florida Cattlemen's Association

Alex Johns is the Director of Natural Resources for the Seminole Tribe of Florida, Inc. and such positions comes with quite the responsibility. The tribe has employed Alex for 23 years now working his way up the ladder from cowboy to Director. The responsibilities of Director include the day to day management of a 10,000 plus head herd of cattle that are raised ultimately for the production of beef. This cow/calf operation is a 67 member cattle co-op that Alex oversees, from the birthing to the marketing and even venturing into the branded beef market. He is involved in everyday husbandry and general welfare of cattle, this is includes the land they graze and the water they drink. The development of a central database utilized to measure performance and productivity was also developed by Alex and his staff for the tribal herds. He has had direct involvement in the certification of cattle as All Natural, Source and Age Verified, VAC Plus, NHTC, NE3, and a host of other certifications. He built a 1000 head back-grounding yard and it is a vital part of the vertically integrated beef chain that the Seminole Tribe owns. This 5 county operation has even ventured into Georgia with a large Brangus seed/stock operation.

He has served as a member of the Board of Directors for the Seminole Tribe of Florida, Inc. for four years. He has been President of the Glades County Cattleman's Association for three years. Most recently he has been Secretary, Treasurer, 2nd Vice President, 1st Vice President and currently President of the Florida Cattlemen's Association. He currently sits on the Board of Directors for Hard Rock International, a global entertainment company owned by the Seminole Tribe of Florida. He is a certified Beef Quality Assurance.

He is a proud member of the Florida Cattlemen's Association, Florida Beef council, Florida Cattlemen's Foundation, National Cattlemen's Beef Association and U.S. Roundtable for Sustainable Beef. He is also a founding member of Florida Cattle Ranchers which is a birth to plate, vertically integrated boxed beef program in Florida.

In 2018, he was awarded the Outstanding Agriculturist of the Year award on behalf of UF/IFAS. Alex was also awarded the InterTribal Agriculture Commission's Outstanding Producer of the Year Award in 2018.

Ty Lawrence

West Texas A & M University

Dr. Lawrence joined the Department of Agricultural Sciences in July 2004. He was reared on a cow-calf operation north of Dalhart, Texas before pursuing formal education in the animal sciences at West Texas A&M University (B.S. '97, M.S. '99) and Kansas State University (Ph.D. '02). Dr. Lawrence spent two years with Smithfield Foods in the position of research manager for pork harvest and processing facilities on the eastern seaboard.

Dr. Lawrence teaches undergraduate courses in food science, meat animal/carcass evaluation, anatomy and physiology of domestic farm animals, meat science and statistics. He also teaches advanced level meat science and technology and integrated animal science courses for the M.S. and Ph.D. programs.

Dr. Lawrence is the director of the University Meat Laboratory, a facility dedicated to teaching students the science and business of converting muscle to meat.

Dr. Lawrence also supervises the Livestock and Meat Judging teams.

Dr. Lawrence is the director of the Beef Carcass Research Center. He collaborates with a multitude of other universities and animal agriculture businesses in research activities that focus on improving the yield and quality of red meat products.

Raluca Mateescu
UF/IFAS Department of Animal Sciences
Dr. Raluca Mateescu is an Associate Professor of Quantitative Genetics & Genomics in the Department of Animal Sciences at the University of Florida. Her research interests focus on identification of genetic markers associated with economically important traits in beef cattle. Special interest is given to development of genetic tools to improve meat quality, nutritional and health value of beef and understanding the genetic mechanism of thermotolerance in Bos indicus influenced beef cattle. The molecular information generated through this research could lead to identification of molecular DNA markers to be incorporated into breeding decisions. Dr. Mateescu joined the faculty at Florida in 2014 after serving on the Animal Science faculty at Oklahoma State University for 7 years. She received a B.S. degree in Molecular Biology and Genetics from Bucharest University, Romania and received her M.S and Ph.D. in Animal Breeding and Genetics from Cornell University.

Jason Scheffler
UF/IFAS Department of Animal Sciences
Dr. Scheffler is an Assistant Professor in the Department of Animal Sciences at the University of Florida. He earned his M.S. from Michigan State University and a PhD from the University of Nebraska–Lincoln, both in meat science studying muscle growth and development. After a post-doc at Purdue University, Scheffler worked as a research assistant professor at Virginia Tech University and joined the University of Florida in 2014. His current extension responsibilities include coordinating HACCP and Preventive Controls for Animal Food training programs. Internationally, he has been working in Ethiopia to improve hygiene and food safety of the meat supply chain. He teaches Introduction to Animal Science and is co-instructor for HACCP Systems, and Meat Technology courses.

Tracy Scheffler
UF/IFAS Department of Animal Sciences
Tracy Scheffler received her B.S. from Michigan State University, M.S. from Purdue University, and PhD degree from Virginia Tech. She joined the Department of Animal Sciences at the University of Florida as an Assistant Professor in 2014. Her research program focuses on muscle biology and meat science. Specifically, she is interested in the effect of muscle metabolic properties on growth, composition, and efficiency of livestock, and the adaptations that occur in muscle in response to environmental and nutritional factors. Another focus is determining how these properties impact changes that occur in muscle early postmortem and during meat aging, in order to improve tenderness, color, and other traits that dictate economic value of fresh meat.

Marcelo Wallau
UF/IFAS Agronomy Department
Marcelo Wallau recently rejoined the Agronomy Department at the University of Florida as a Forage Extension Specialist (70% extension, 30% research). With an engineer and MS degree in Agronomy and PhD in Animal Sciences, his focus is on forage production and management for beef cattle, dairy cattle and horses, and on integrated crop-livestock systems. Coming from a farming background in southern Brazil, Dr. Wallau's interests are on the big picture of the production systems, searching for solutions for daily questions from our farmers with a deep scientific base and global perspective. He also has worked on grassland ecology, modeling and foraging behavior, and on feral hog management and control.

Trey Warnock
Amarillo Brokerage Company, LLC
Trey Warnock is a Florida native and graduate of the University of Florida. Trey graduated with a Bachelor of Science in Animal Sciences in 2008 and a Master of Science in Animal Sciences in 2010. He resides in Amarillo, TX now and is a partner in Amarillo Brokerage Company, LLC. Amarillo Brokerage Company facilitates commercial risk management and trading for the cattle and beef markets.

Market and Industry Trends in the Beef Business

Trey Warnock[1]

[1]Amarillo Brokerage Company, LLC, Amarillo, TX

Introduction

Cattle and beef markets have been volatile in recent years and remain dynamic. The rapid contraction and subsequent expansion of cattle numbers across the United States created an intensely volatile period. The causes of the moves mentioned here are wide ranging. The implications these factors had and have on cattle markets are diverse. Cattle numbers contracted into 2014 and created an incredibly tight market for calves, feeders and fed cattle. Market direction turned sharply higher for most of late 2013 through 2014 and most production margins were extremely positive. During fall of 2014 cattle and beef markets began transition from a contracting market with powerful leverage to an expanding market with less leverage and more fear.

Through 2015 until the present time cattle and beef markets have witnessed massive losses in futures and cash markets and more recently a collapse of feeder and fed cattle basis. Beef packing margins have seemingly remained strong while cow-calf and post-weaning profitability has been challenged to say the least. The loss of packing capacity in some key feeding regions while simultaneously increasing pen capacity and seeing some older feedyards come back online has created a startling loss of leverage between the cattle feeder and the beef packer. There are many fundamental, technical, and outside factors that either have changed or are currently changing within the beef industry. Understanding market setups and cycles is potentially key to knowing how and what decisions to make for our individual operations.

Fundamental Developments

It is no surprise that cow numbers have seen moderate year over year increases since 2014. As a result of this, there are more calves and feeders available and therefore more cattle on feed. As of the March 2019 United States Department of Agriculture (USDA) Cattle on Feed report there is an estimated 11.8 million head of cattle on feed in yards with capacity greater than 1,000 head. This is the largest number of cattle on feed in the United States in ten years and is not significantly smaller than the largest number of cattle on feed in the entire USDA database. On a related note, the increase in available calf and feeder supplies has driven placements into feedyards higher and using these data we can estimate that this number on feed will remain strong. Additionally, breaking down the weights at which these cattle have been placed into feedyards we can estimate the times those cattle will potentially be market ready. The most recent placement data would suggest that May and June 2019 market ready numbers will also be near ten year record levels. Any deviation in marketing’s that would disrupt feedyards remaining current could both alter and exacerbate the negative affect of larger summer supplies.

Carcass weights are near normal for this time of year and should bottom in the near term. Considering the winter weather events that have impacted some cattle, weights have remained seasonal. Cheaper feeding cost of gains and milder weather forecasts may cause higher third and fourth quarter weights. As a result of higher supplies, weights, and increased feeding capacity; beef production is topping recent records and is expected to continue to do so. Strong domestic demand, featuring, and export sales have offset many of the possible negative implications associated with increased production. Non-fed and fed harvest is and has been managed well by packing entities in order to effectively handle increased production and manage profitability. Non-fed harvest has challenged the ability to remain current on fed cattle marketing’s at times, but still is at or near record levels compared to recent history. Interestingly, feedyard out weights have steadily increased due to various market factors and allowances for yield grade 4-5 have also increased, further enabling longer days on feed.

Outside Influences

Agriculture markets have long been a haven for investors, producers, and market participants of all types. In the recent era of low interest rates, one could argue that capital has been allocated to various areas in hopes of any return. Ranch and farm ground across the United States as well as feeding capacity and even packing capacity is no exception to the managed money interest in an effort to capture returns or increase exposure to agricultural risk. Money flow in and out of cattle markets through futures trading can, at times, draw the attention of the industry. Late 2014, 2015 and 2016 are good examples of this in the cattle markets. These time frames brought about large changes in both the commercial users and non-commercial traders position.

Late 2014 presented us with a situation where cattle feeders were at very high percent hedged and short levels and non-commercial/managed money traders were very long. In both 2015 and 2016 we witnessed the opposite with managed money traders becoming very short on cattle markets and cattle feeders decreasing their hedged position. Additionally, in many ways the cattle and beef markets are subject to the implications of capital leverage. Indirectly, the leverage associated with trading cattle futures can impact a wide array of industry dynamics and how all the different sectors within the beef industry interact.

Beef Industry Changes

The last five years has brought about some key and interesting changes within the beef industry. In order to tease out what this might mean to any sector of the industry we need to fully understand the evolution of each factor in recent history. Quality grading has moved sharply higher in all cattle feeding areas recently. The increases in percent Choice and higher cattle has brought about much debate and discussion about the causes and implications. The reduction in cow herd numbers and the subsequent herd expansion is suggested to have increased the quality of the cow herd and thus the quality of those offspring. Additionally, the poorer quality genetics are thought to have been culled first even for those operations that may not have expanded at the same rate or at all. Instrument grading has been the topic of much discussion in recent times as a causative factor in the rapidly increasing Choice and higher grading. There have been some changes and developments in plants using instrument grading versus USDA inspectors as well as the instrument grading technology itself.

Marketing methods across the industry continues to transition from less negotiated to more committed or scheduled in nature. Negotiated marketing would be the most well-known and understood method of cash trade. Since the beginnings of large private and corporate model cattle feeding, the percentage of cattle being marketing in an alternative method has steadily increased. The most widely used alternative marketing method would be formula trade with grids and forward contracts being situationally used. Considering the increase in total supplies, the amount of negotiated cash trade has increased, but the alternative methods continue to dominate marketing method of choice for most entities within the beef industry. There are some regional differences in marketing method with the Southern plains having been and remaining much more committed to formula trade. The central feeding areas are similar and have grown more committed in recent years, but remain a solid negotiated trader due to some large custom cattle feeding operations in that area. The northern feeding regions have seen an increase in formula trading, but remain the largest negotiated cash traders in the industry. This is likely due, in part, to the operating model differences and yard sizes in those areas.

Feedyard ownership has seen material changes in the last several years. There has long since been shifts from year to year in the top feedyards, but more material shifts have occurred in feedyard and packing ownership. The most recent key shifts have been packing entities moving out of the feedyard ownership space. Feeding margins are volatile and capital requirements in a rising interest rate environment are extremely high. The corporate packers with feedyard ownership seemed to be interested in liquidating in order to allocate capital in other areas while maintaining cattle supplies through relationships and alignment. Another interesting development in cattle feeding as well as feedyard ownership is entities that formerly did not have cattle production within their operating model, now do. These entities have entered the space and seemingly changed very little of the standard operating procedures as of now. Thinking of how this might impact the industry going forward will be necessary to keep ourselves prepared. How might they operate in periods of weak basis? What changes will be made during sustained poor margin times? How could this affect calf values? What will it look like when publicly traded or managed money entities no longer wish to be in this space?

Conclusion

The cattle and beef markets have been challenging. The markets have been complicated to understand, predict and mange in recent years. The volatility of both physical and futures markets has been staggering and pushed many to believe that the markets are not operating efficiently or transparently. The truth is this has been the case many times over the years and in many agricultural markets. In general, there is no evidence that markets are not operating well and some might make the case the markets are performing very well and possibly as efficiently as they have in recent history. It would seem that making well informed and wise decisions for ourselves and our own operations is key to remaining sustainable.

The fundamental shifts are simply a response to markets signaling expansion through economic incentives. The interesting part about the beef industry is that our generation interval is long. The outside influences in our markets will change over time. Interest rates and money looking for returns will vary the amount of managed money participating in cattle and beef markets. The narrative or lack thereof will also influence non-commercial activity in our markets. As allied industry members, producers, feeders, and packers we need to be aware of several situations including, but not limited to grading percentages, marketing methods, and ownership of key industry entities. Quality grade has rapidly advanced and is beginning to impact how increased Choice and higher grading affect cattle profitability. Marketing methods within the cattle business are trending towards being completely committed and scheduled to accommodate the increasing efficiency of the modern production model. How can we maintain transparency without going backwards? How will marketing methods within the feeding sector might affect calf, feeder or fed cattle sales. Finally, we need to remain cognizant of the shifting nature of the players within the industry and how they may or may not react to different market scenarios.

Customer Satisfaction and National Tenderness Survey

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The primary end product of cattle production is beef, thus the profitability of cattle producers is dictated by the value placed on that end product. In Florida, the primary product is a weaned calf that is often headed out of the state on a truck to backgrounders, stockers, and feedlots further west. It is easy to be insulated from the market cues at the end product level. However, as consumer demand for beef increases or decreases, the change in value is passed on through the entire system and will inevitably be felt by cow-calf producers. Therefore it is important to recognize the contribution of each segment of cattle production to end consumer satisfaction.

Palatability

Palatability of beef is primarily dependent on three major factors: flavor, juiciness, and tenderness (Smith et al., 1974). For decades, the beef industry in particular, and the meat industry as a whole, have been supporting work on improving these traits to maintain or increase consumer demand. A recent meta-analysis of 11 studies including 1,500 beef samples and 1,800 consumers indicated that about 43% of the variation predicting overall palatability was attributed to flavor, 7% to juiciness, and 49% to tenderness (O'Quinn et al., 2018). Combined, those three factors account for over 99% of the variation in predicting overall palatability. Surprisingly, they did not find an interaction between those three factors nor was there appreciable error in the prediction that could be attributed to other factors.

Flavor is perhaps the most difficult target to hit as consumers have a wide variety of preference with one person's desirable flavor being another's off flavor. Perception of flavor is a complex interaction of the taste buds of the tongue (sweet, sour, bitter, salty, and umamai), perception of aroma by the olfactory bulb, and somatosensory perception by trigeminal nerves (Kerth and Miller, 2015). Flavor compounds are largely produced through degradation of lipids by heat, non-enzymatic browning or Maillard reaction, and the interaction of lipids and Maillard products (Kerth and Miller, 2015) but is certainly an oversimplified summary of all the processes contributing to perception of flavor.

Juiciness is primarily attributed to fat content (Egbert et al., 1991) and degree of doneness (O'Quinn et al., 2012). As degree of marbling increases, so too does the perception of juiciness. There is a perception that increased marbling provides "insurance" against overcooking; higher levels of marbling can be subjected to a wider range of degree of doneness and still be considered palatable. However, recent work indicates that this may not be the case. Higher degrees of doneness reduces palatability independent of marbling level; higher marbling levels did not show any protective effect (Lucherk et al., 2016). Taken together, these data indicate both improving marbling and educating consumers on cookery are needed to improve eating experience.

Improvement of beef tenderness has been an important area research for at least the last three decades. Different assessments of willingness-to-pay indicate consumers may pay an additional $1-2 per lbs if they can be assured of a more tender product (Lusk et al. 2001, Igo et al. 2013). To capture the changes in tenderness The National Beef Tenderness Survey has been conducted periodically over that period to benchmark changes in tenderness over that period (Morgan et al., 1991; Brooks et al., 2000; Voges et al., 2007; Guelker et al., 2013; Igo et al., 2015; Martinez et al., 2017). If we compare the 2015 audit with the

1998 audit (Figure 1), we see a 23-27% improvement in Warner-Bratzler shear force (WBSF) in the retail top loin, boneless ribeye, top sirloin, and bottom round (Brooks et al., 2000; Martinez et al., 2017).

Changes in how meat is sorted and distributed down different supply chains may have an influence. The 2015 audit shows top loin steaks sold to foodservice had 23% higher WBSF than those sold at retail (Martinez et al., 2017). Ribeye steaks had 44% higher WBSF. When comparing the 2015 audit to the 2006 audit (Voges et al., 2007; Martinez et al., 2017), the percentage of ribeyes, top loins, and top sirloins considered very tender (WBSF < 7.05 lbs) has decreased 15.5%, 7.1%, and 6.2%, respectively. When coupled with an observed reduction in packer and store brands, it may indicate that other branding programs may be successful in sorting more tender beef.

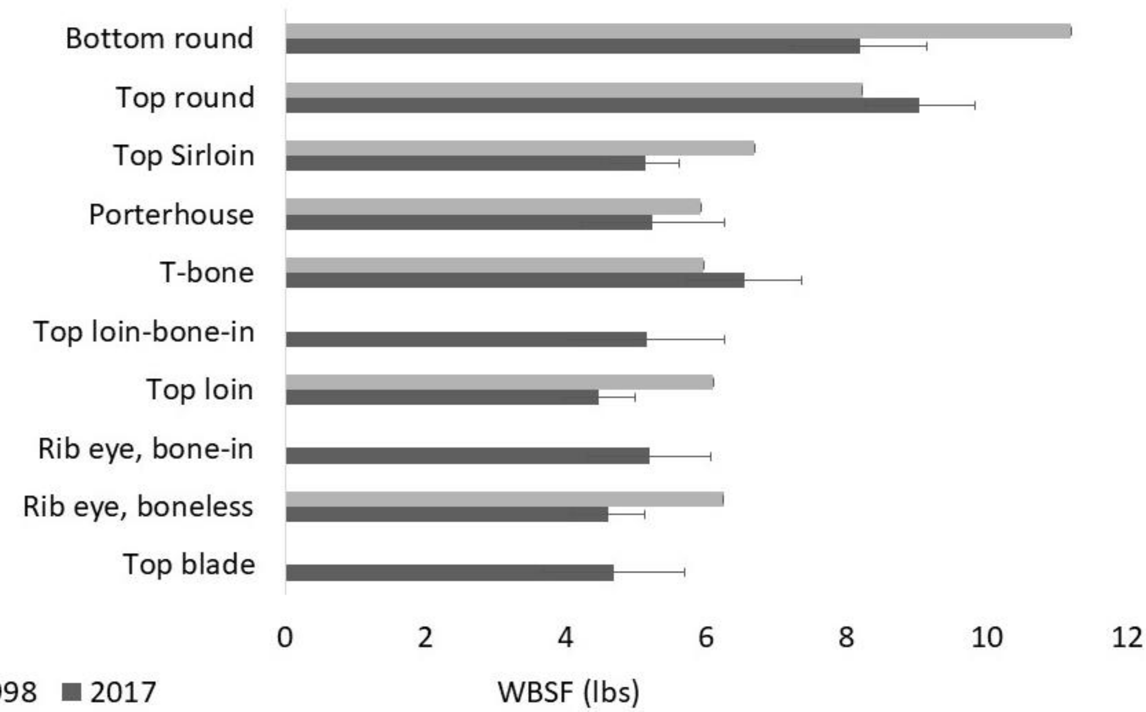

Figure 1. Warner-Bratzler shear force values of selected retail steaks. Adapted from Brooks et al. 1998 and Martinez et al. 2015. Data are presented as mean ± SEM; SEM from Martinez et al 2015 was not provided.

A common, and not surprising, observation across all the tenderness audits is differential in tenderness between muscles of the round (top and bottom round) and muscles of the rib and loin. Functional differences between muscle groups contribute to most of the difference so it is unlikely top round will ever be as tender as a top loin. However, there was still improvement, at least in the bottom round. Improved tenderness may lend that muscle to new applications which could improve carcass value.

Tenderness

While there have been some improvements in beef tenderness over the last three decades, it is possible to look at the data and be somewhat disappointed that we have not made more progress considering the resources allocated to addressing this challenge. Tenderness is very complicated trait that is the function of intramuscular fat (Duckett and Pratt, 2014), myofibrillar protein degradation (Huff Lonergan et al., 2010), and connective tissue (Purslow et al., 2011). In some cases, changes in some of those traits may be antagonistic to more economically important traits like growth and feed efficiency.

In the 1990's Olson et al (2000) tried selecting for improved WBSF in Angus bulls over several generations at the University of Florida. High and low WBSF bulls were utilized for breeding the Angus herd at the Santa Fe Ranch and Beef Research Unit expecting to demonstrate divergence in WBSF for further study. However, both high and low WBSF groups showed reduction in WBSF over five generations. However an interesting comment in the summary that selection for meat quality traits "may have unintended consequences such as losses in other traits such as growth rate, live or carcass weight, muscling (ribeye area) and even in maternal traits such as fertility and milk yield" perhaps alluding to observed issues with the study cohort.

Intramuscular fat or marbling can be improved with genetic selection, while carcasses can be sorted and valuated based on USDA quality grade. The industry had made steady progress increasing the percentage of USDA Prime and Choice carcasses as indicated by the National Beef Quality Audit (Boykin et al., 2017).

Myofibrilar degradation utilizes enzymes involved in protein degradation in the living animal. The primary enzyme associated with tenderization is the calcium-activated protease, calpain. (Goll et al., 1998; Huff Lonergan et al., 2010). This protease is activated by intracellular calcium, autolyzes, and cleaves several target proteins found to be degraded during post mortem metabolism. Myofibrillar degradation can be improved, to an extent, with carcass aging (Colle et al., 2015). An inhibitor of calpain is calpastatin. Both the abundance and activity of calpastatin appear to influence tenderness. Brahman cattle have higher calpastatin activity (Pringle et al., 1999) and content (Wright et al., 2018) that may partly explain the variation in tenderness, but with aging, calpastatatin in both Brahman and Angus cattle is degraded. Perhaps the biggest challenge is the recognition that caplains and calpastatin have activity in the living animal. Protein accretion is the net result of synthesis and breakdown. Increased calpain activity may result in more protein turnover in the living animal resulting in slower, less efficient growth. The value of more tender product will likely not offset increased feed costs or fewer pounds of salable product. We simply cannot just select for more calpain or less calpastatin without recognizing the ramifications on animal growth.

Connective tissue is found in the extracellular matrix (ECM), a complex network of proteins that provide structural support to the muscle fibers. Collagen is the primary protein of the ECM and is often the target of research investigating muscle tenderness. As the animal ages, the amount of collagen increases, as does the amount crosslinks between collagen fibers (McCormick, 1999). More mature collagen cross-links are more heat stable and less likely to solubilize during cooking (McCormick, 1994). The challenges with connective tissue include no genetic selection markers, very broad sorting parameters like carcass maturity, no improvement with aging (Purslow, 2005; Nishimura, 2015).

Conclusions

Improving beef palatability continues to be an important endeavor that will contribute to the profitiability of beef producers. Consumers have indicated they would be willing to pay more for products with an assurance of being more tender. Current efforts in improving tenderness are producing slow, but steady progress. Advances in beef tenderness need to be balanced against other economically important traits to ensure a net gain.

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Opportunities and Challenges for U.S. Beef Exports

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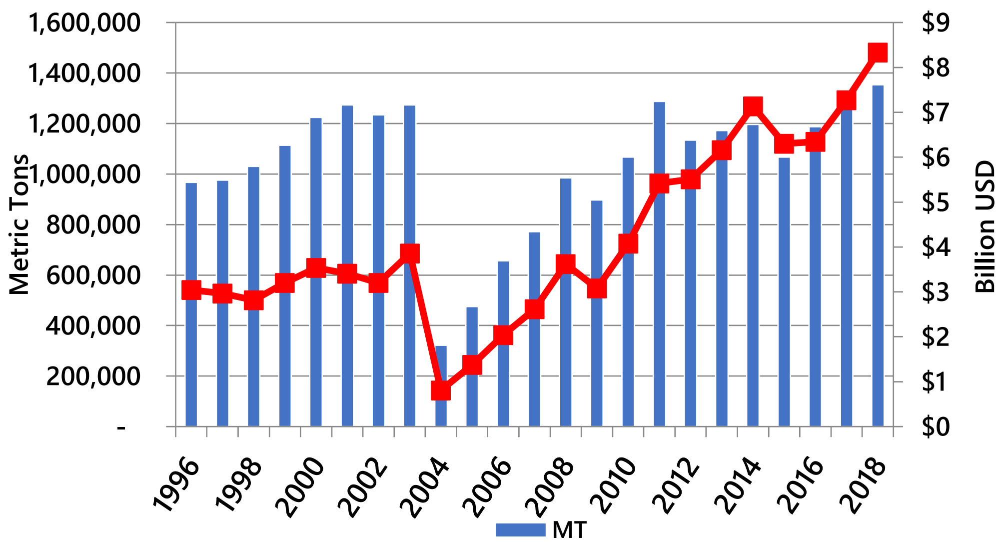
Export markets for U.S. beef products have grown in importance for the bottom line of the beef industry over the past several decades. While exports of beef only represent 13.5 percent of the total volume of beef produced in the U.S., export markets are critical for adding value to various cuts across the beef carcass as well as offal and by-products.

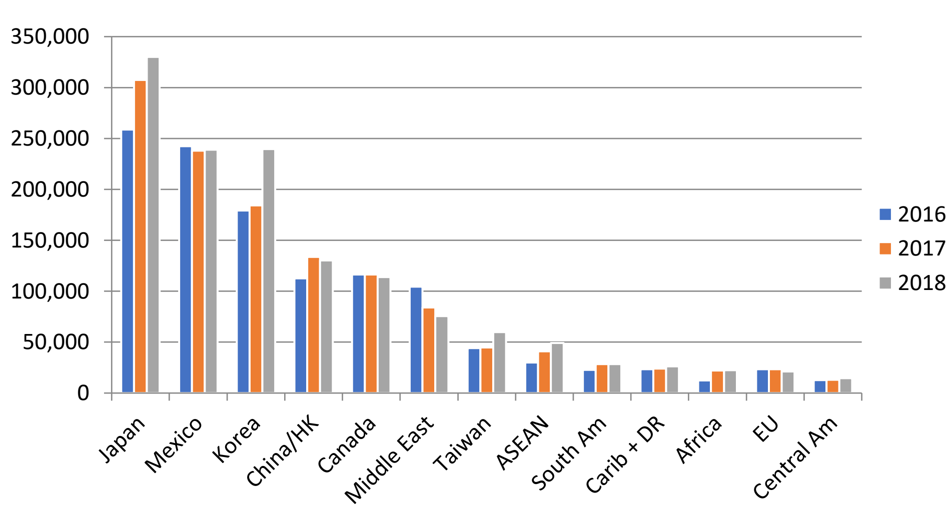
In 2018, beef exports set both value and volume records never seen before in the industry, valued at $8.332 billion and totaling over 2.982 billion pounds (1.353 million metric tons); an increase of 15 and 7 percent over 2017 levels, respectively (Figure 1).

Figure 1. Historical Volume and Value of U.S. Beef and Beef Variety Meat Exports



Japan was a primary driver of both volume and value for U.S. beef exports, and was followed by Mexico, South Korea, China/Hong Kong, and Canada as the top 5 export markets (Figure 2). South Korea finished 2018 as a banner market for U.S. beef, with growth of over 30 percent from 2017 and finishing as the second largest value market for U.S. beef globally.

Figure 2. Top Markets for U.S. Beef and Beef Variety Meat Exports



While only 13.5 percent of the total volume of beef and beef variety meats are exported, certain cuts from the beef carcasses are destined for exports at a much higher rate. For example, over 70 percent of beef short ribs and short plates are exported to markets like Japan, Korea, Taiwan, and Hong Kong; while offal products like livers, hearts, and kidneys are exported at a rate in excess of 90 percent to regions like the Middle East and South America. In total, essentially one piece from every animal will find its way to an export market and underscores the importance of how exports add value to the entire carcass complex.

As the industry moves forward in 2019, there are several factors that could provide tremendous opportunities for the beef industry, but also could stand as hurdles to future success. The political landscape and pending trade agreements with major trade partners loom large over the industry and will have significant impacts on the beef industry's trade potential in the near future.

The beef industry stands to gain from a trade agreement with China that resolves the many sanitary and phytosanitary (SPS) issues that restrict U.S. beef exports today. The current beef agreement with China requires additional cattle traceability and for beef to be free from synthetic hormones and beta agonist residues, which has capped expansion of U.S. beef exports to the largest beef importing country in the world. In addition to the requirements that places U.S. beef at an extreme cost disadvantage to its competitors (Australia, Brazil, Uruguay, etc.), beef products from the U.S. are also sold with an additional 25 percent retaliatory tariff stemming from the U.S.'s 301 investigation on Chinese forced technology transfer and intellectual property issues. These SPS requirements combined with the 25 percent additional tariff (37 percent in total) have greatly restricted the U.S.'s access to the Chinese market and a resolution within the broader trade discussions could stand to greatly benefit U.S. beef exports.

The U.S. beef industry was also poised to improve their position in the Japanese market via the Trans-Pacific Partnership until the U.S. withdrew from the agreement in 2016. Since that time, all major beef export competitors have moved forward with trade agreements with Japan and have already started to realize decreases in the tariff rates relative to the U.S. Beef from the U.S. continues to be successful due to its unique quality attributes and consumer preference for well-marbled beef; however, as beef from Australia, Canada, Mexico, and New Zealand continues to become more competitive with reduced tariff rates, it has and will continue to erode the U.S.'s majority market share. Thus, negotiating and finalizing a bilateral trade agreement between the U.S. and Japan has to be a top trade priority for the beef industry in 2019 to maintain our competitive position in the Japanese market.

In addition to trade agreement and tariff barriers, technical regulations and SPS barriers have hindered U.S. beef exports in markets around the world. Countries continue to exercise the European Union's precautionary principle as it relates to new technologies and veterinary drugs, which has restricted U.S. beef access in various markets around the world. While the restrictions in the EU and China are well publicized, importing countries like Egypt, Thailand, and Singapore have restricted beef exports from issues ranging from vet drug residues to the use of food safety interventions. The U.S. must continue to be a champion for science-based standard setting around the world not only to maintain the U.S.'s ability to export to these countries, but also uphold the role of science and technology innovation in production agriculture.

U.S. beef exports face tremendous opportunity for continued growth. Beef production continues to expand in the U.S., largely from strong export demand. Global economic expansion will continue to create opportunities for U.S. beef both in our larger established markets (i.e. Mexico, Japan, Korea) and create more opportunities in developing markets (i.e. Central America, Southeast Asia). Growing incomes and increases in middle class population in developing countries will help drive global consumers towards upgraded food choices; a trend which U.S. beef is poised to take advantage of. The superior taste and quality of U.S. beef will be a defining factor in differentiating it from our global competition and provide further opportunities for the U.S. export business to grow.

WTAMU PrimeOne

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Throughout history, animal breeding choices have predominantly utilized phenotypic selection. We have undertaken a unique crossbreeding project beginning with rare carcasses that exhibit highly desirable yet antagonistic traits – USDA Prime and yield grade 1. We utilized cloning technology to produce five live animals from three beef carcasses that were USDA Prime and yield grade 1. We have conducted 3 experiments to date to evaluate the carcass outcomes of progeny produced from direct clones and their offspring. In experiment 1, seven Alpha x Gamma steer calves were fed a standard commercial feedlot ration at the WT Research Feedlot for 182 days. Steer carcasses exhibited 45% more marbling concomitant with 29% lower yield grades as compared to the average U.S. beef carcass. In experiment 2, Alpha was compared to 3 reference sires in a terminal sire study. Steer and heifer calves (n = 424) were fed (176 to 257 days on feed) according to standard industry practice at a commercial feedlot and harvested at a commercial beef processor. Alpha progeny performed similar to high performing reference sires for terminal sire production traits. In experiment 3, AxG1 was compared to 4 reference sires in a terminal sire study. Steer and heifer calves (n = 392) were fed according to standard industry practice at a commercial feedlot and harvested at a commercial beef processor. AxG1 outperformed his sire and the other high performing reference sires for terminal sire production traits. This project has allowed us to highlight the role of technology in animal production, develop genetics to simultaneously improve quality and yield, and provide our students with unique learning opportunities.

West Texas A&M University

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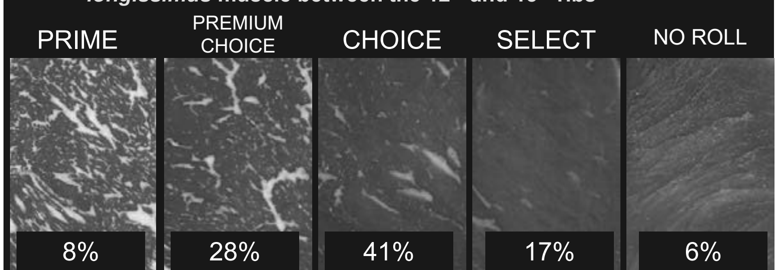
- WTAMU
  - Beef Carcass Research Center
  - Nance Ranch
  - Research Feedlot
- Timber Creek Veterinary Clinic
- Mendota Ranch
- Viagen and TransOva
- Cactus Feeders

Quality Grading

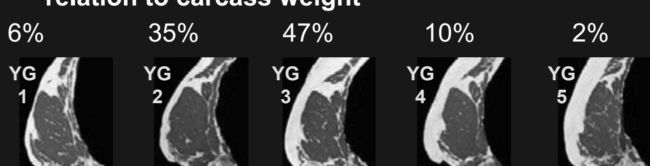
- **Marbling**
  - **subjective evaluation of the quantity of intramuscular fat in the *longissimus* muscle between the 12th and 13th ribs**



- **Maturity**
  - **Number of permanent incisors present at harvest**
  - **Subjective evaluation of the extent of ossification (conversion of cartilage to bone) of the vertebral column**

Yield Grading

- **Fat Thickness**
  - **Linear measure of backfat**
- **Rib eye Area**
  - **Cross-section area of *longissimus* muscle**
- **Hot Carcass Weight**
  - **Weight of the freshly dressed carcass immediately prior to chilling**
- **Estimated % of Kidney Pelvic and Heart Fat**
  - **Subjective evaluation of weight of internal fat in relation to carcass weight**



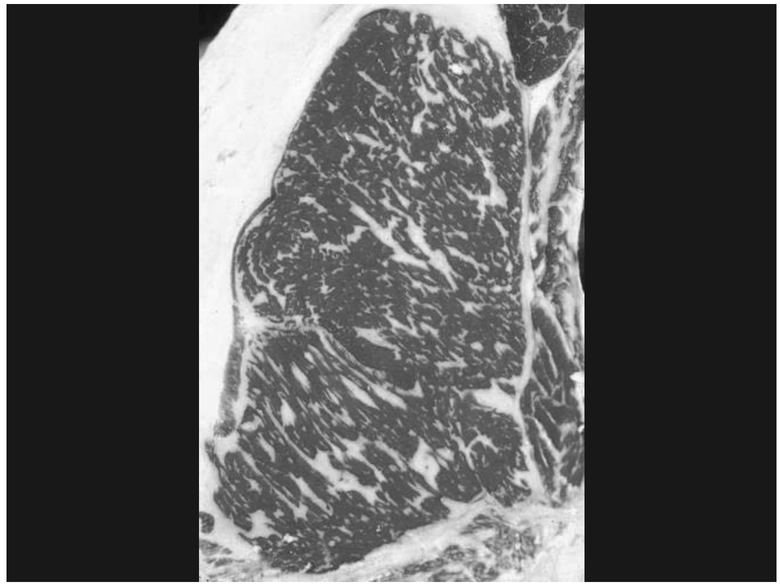
Distribution matrix of USDA QG x YG

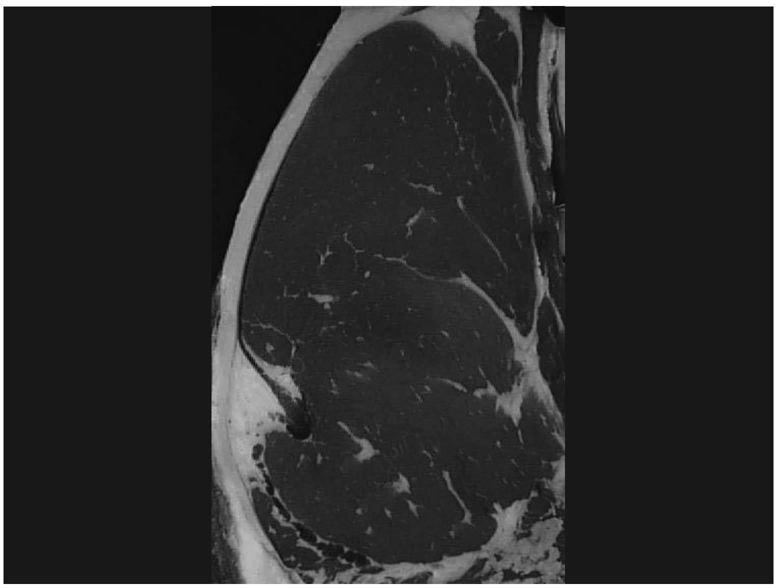
Cumulative = 100%

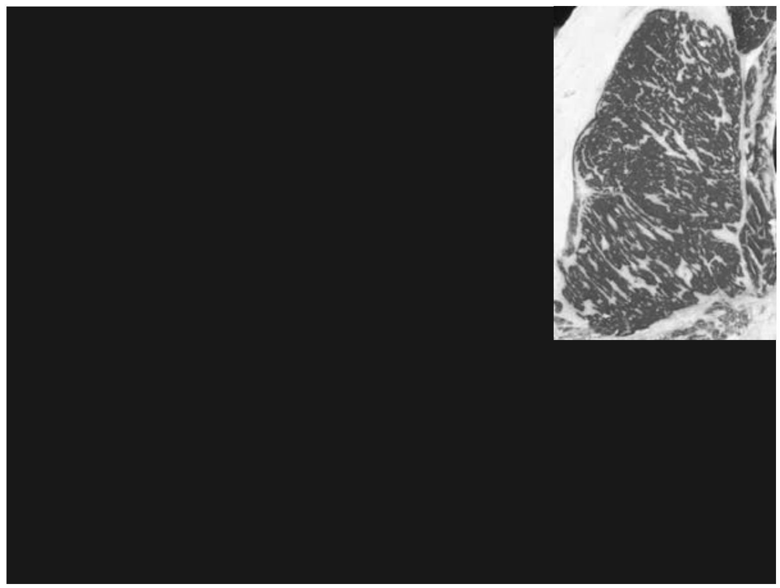
	Prime	Choice	Select	Standard	Commercial	Utility
YG 1	0.06	2.46	2.89	0.00	0.00	0.00
YG 2	1.45	24.18	9.10	0.00	0.01	0.13
YG 3	5.33	36.82	5.02	0.00	0.05	0.34
YG 4	1.76	7.81	0.55	0.00	0.04	0.14
YG 5	0.48	1.24	0.08	0.00	0.01	0.03

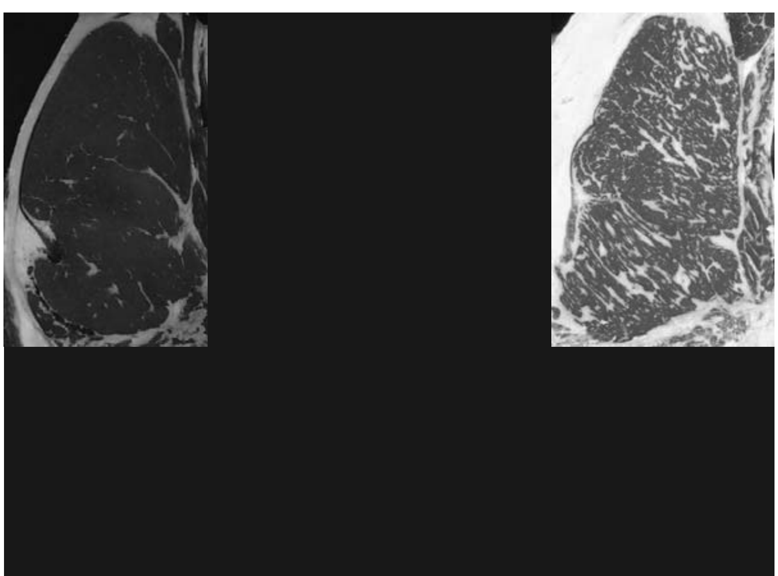
The Problem:

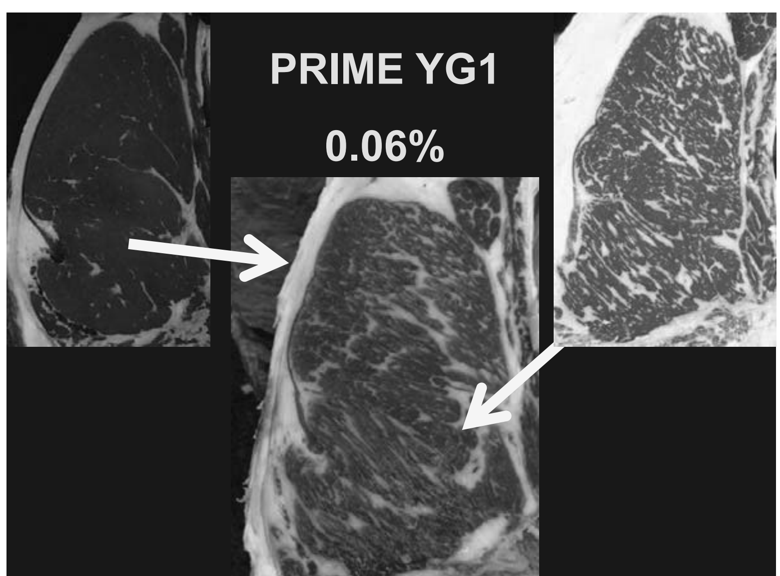
QUALITY
AND
YIELD
ARE
ANTAGONISTS











Our Hypothesis:

CROSSBREEDING PRIMEONE ANIMALS WILL IMPROVE QUALITY AND YIELD

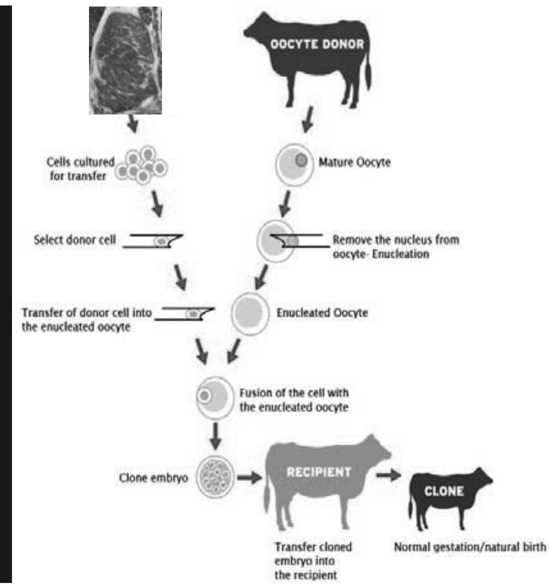
Carcasses Found

n=45

Further DNA-based selection

- Tissue sample from clone candidates are sent to a lab that processes DNA looking for growth, quality, and palatability traits

- **Phenotype**
  - **Prime-YG1**
    - **1 per 1,667**
- **Genotype**
  - **Refine**
    - **1 per 15,555**

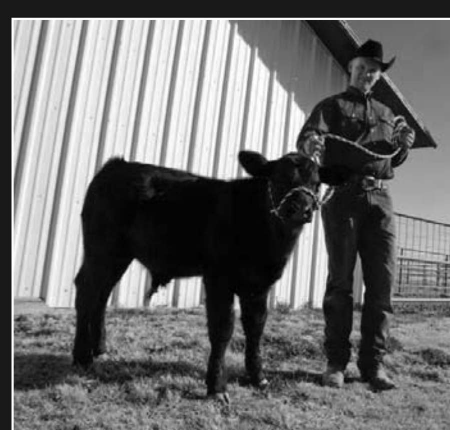


What is a Clone?

- An animal that is genetically identical to its donor, having developed from a single donated cell
- An <u>**identical twin**</u> from different points in time

WT

Alpha 2012



Alpha 2013

PHENOTYPIC

Sex:	Steer
HCW:	782
12th rib fat:	0.44
REA:	15.9
REA/HCW:	2.03
YG:	1.98
Marbling:	Slab^{70}
Hide:	51% Blk

86% Angus

14% Zebu

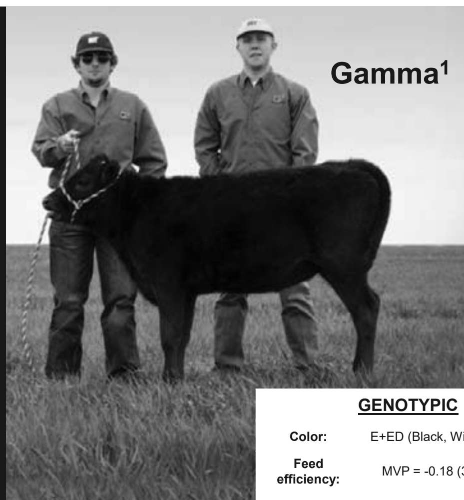
GENOTYPIC

Color:	EDED (Homozygous black)
Feed efficiency:	MVP = -0.76 (10 percentile)
Marbling:	MVP = +0.15 (30 percentile)
Tenderness:	MVP = -0.59 (6 percentile)
Palatability:	MVP = 429 (8 percentile)

Alpha 2016

Photo by David Lust

Gamma[1]



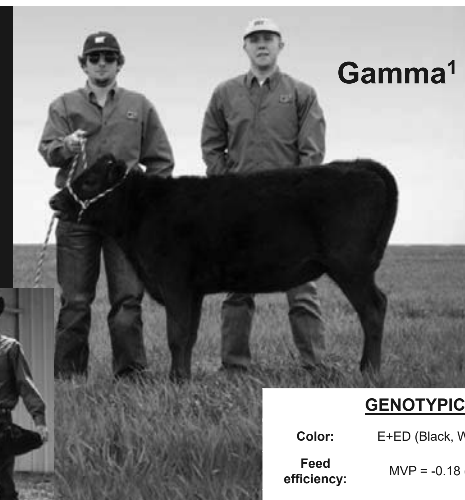
PHENOTYPIC

Sex:	Heifer
HCW:	708
12th rib fat:	0.16
REA:	15.5
REA/HCW:	2.19
YG:	1.03
Marbling:	Slab^{10}
Hide:	51% Blk

GENOTYPIC

Color:	E+ED (Black, Wild type carrier)
Feed efficiency:	MVP = -0.18 (30 percentile)
Marbling:	MVP = +0.41 (5 percentile)
Tenderness:	MVP = -0.28 (30 percentile)
Palatability:	MVP = 454 (6 percentile)

Gamma[1]



PHENOTYPIC

Sex:	Heifer
HCW:	708
12th rib fat:	0.16
REA:	15.5
REA/HCW:	2.19
YG:	1.03
Marbling:	Slab^{10}
Hide:	51% Blk

Gamma[2,3]

GENOTYPIC

Color:	E+ED (Black, Wild type carrier)
Feed efficiency:	MVP = -0.18 (30 percentile)
Marbling:	MVP = +0.41 (5 percentile)
Tenderness:	MVP = -0.28 (30 percentile)
Palatability:	MVP = 454 (6 percentile)

Experiment 1: Alpha x Gamma[123]

Alpha x Gamma calves

9 bulls
(7 steers)
4 heifers

WTAMU Research Feedlot

Alpha x Gamma Calves

7 steers

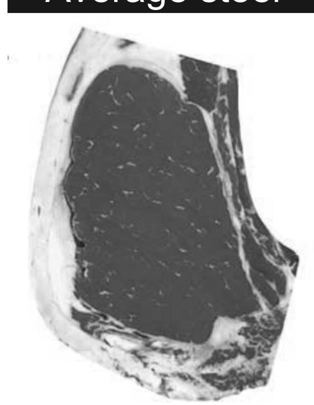
Alpha x Gamma Calves

7 steers

DOF	BW	Backfat	IMF	Prime	REA
77	916	0.34	8.2%	3/7	12.0
137	1095	0.42	8.7%	4/7	12.9
180	1222	0.50	8.9%	5/7	14.1

MARBLING SCORE

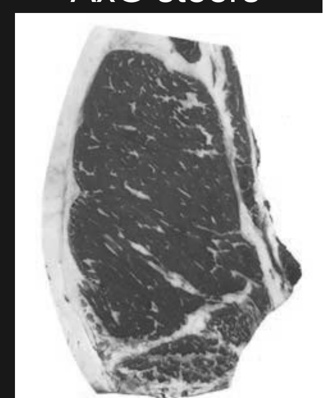
Average steer



Small40

\+ 45%

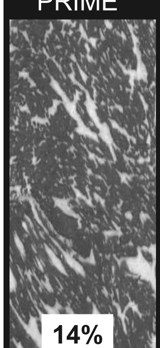
AxG steers



Moderate30

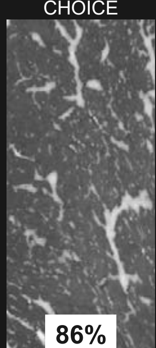
AxG Quality Grades

PRIME

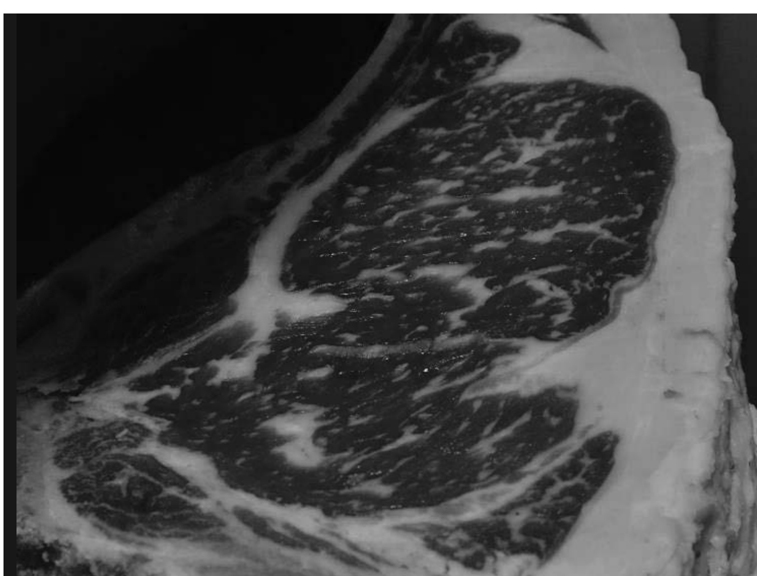


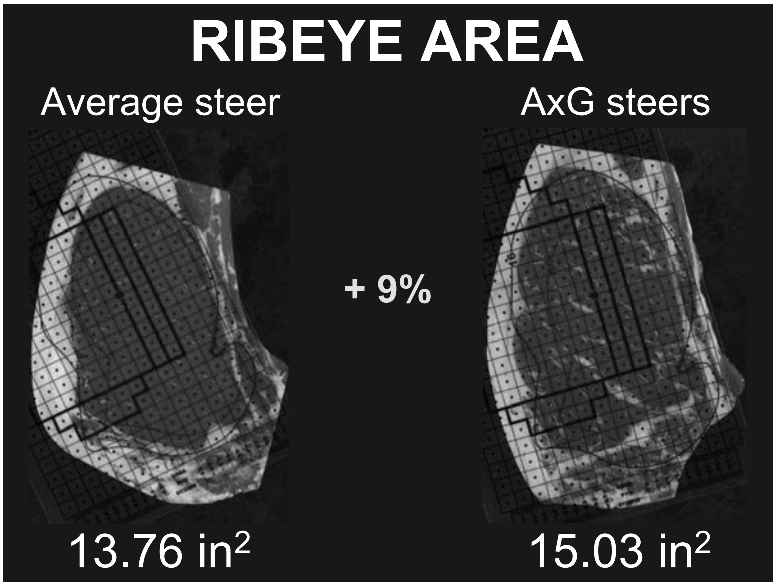
14%

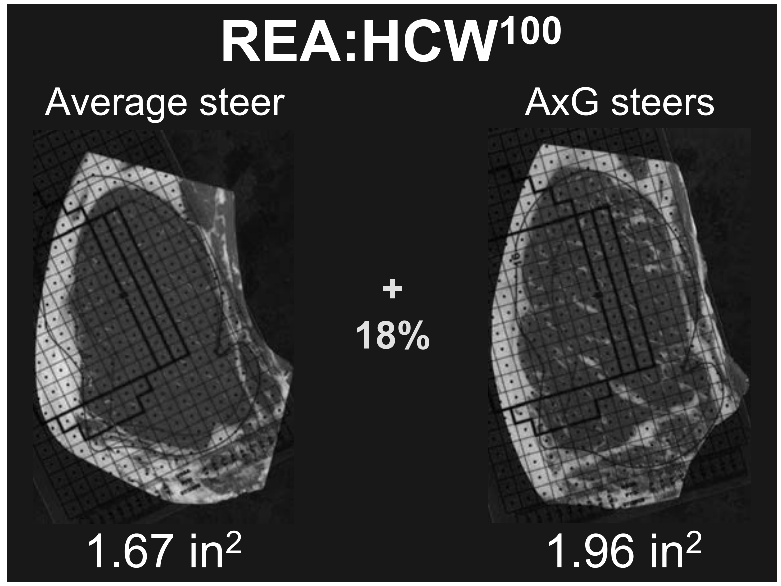
PREMIUM CHOICE

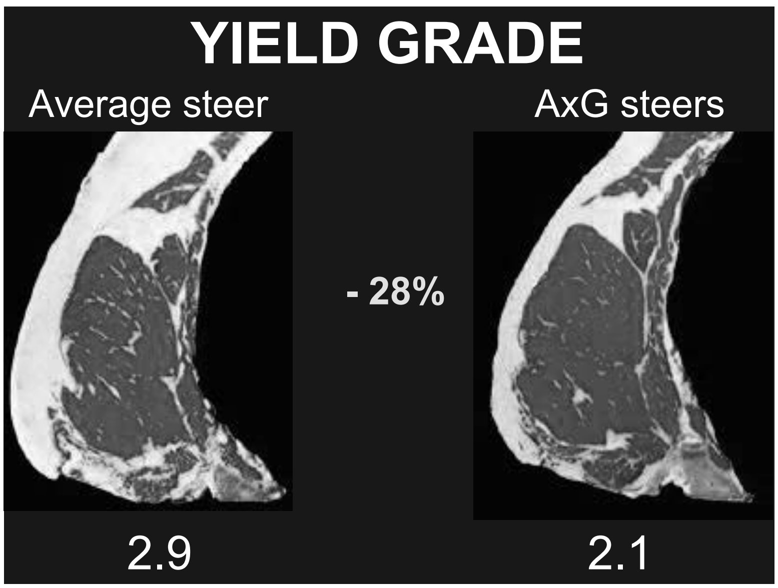


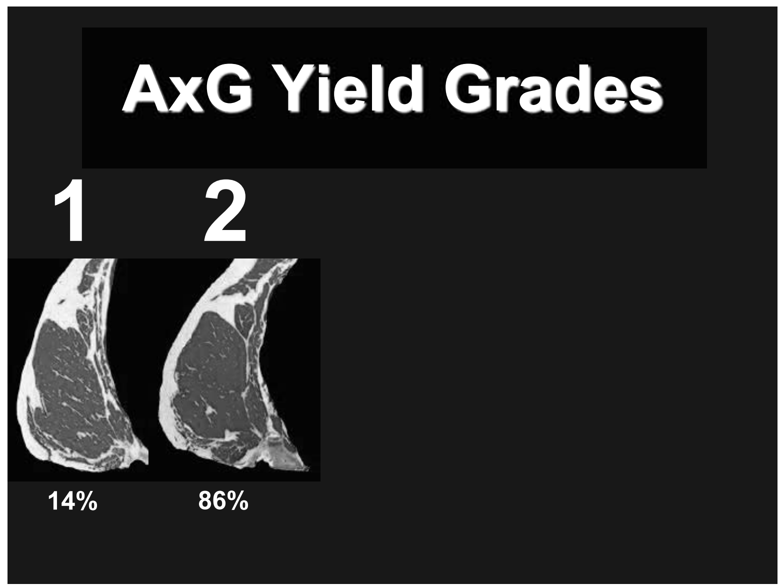
86%

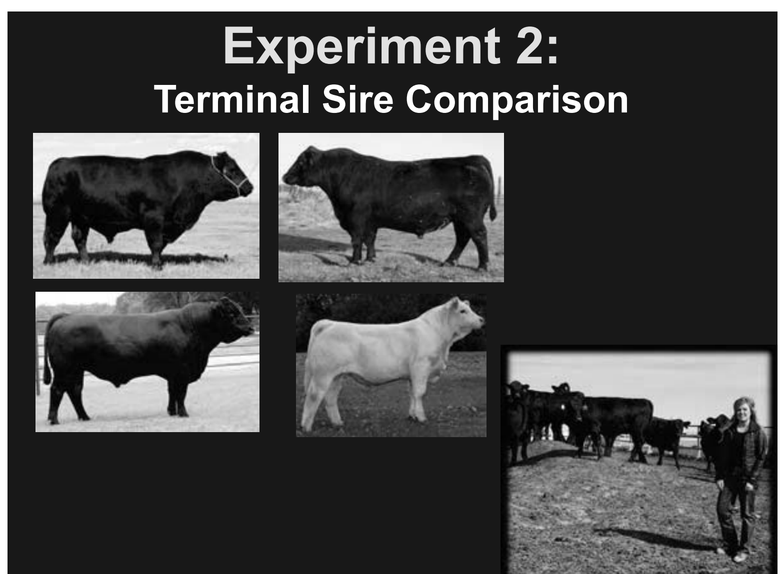



RIBEYE AREA
Average steer
AxG steers
+ 9%
13.76 in2
15.03 in2


REA:HCW100
Average steer
AxG steers
+ 18%
1.67 in2
1.96 in2


YIELD GRADE
Average steer
AxG steers
- 28%
2.9
2.1


AxG Yield Grades
1
2
14%
86%


Experiment 2:
Terminal Sire Comparison

Alpha

WTAMU "Alpha" clone of USDA P1 Carcass

Angus

29AN1688 RIT0 REVENUE

CW	Marb	REA	FAT
+29	+1.53	+.42	+.062
.80	.78	.75	.78
65%	1%	50%	95%

ABS Global, 2018

Simmental

29SM0390 SURE BET

CW	YG	Marb	BF	REA
+16.6	-.49	+.36	-.109	+.78
.84	.62	.83	.78	.82
95%	40%	2%	65%	65%

ABS Global, 2018

Charolais

ANJOU PURE POWER 184Y

CW	REA	FAT	MARB
26	1.01	-0.011	0.07
0.10	0.10	0.08	0.05
15	4	25	60

AICA, 2018

Cow Facility

Feeding Facility

Table 1. Heifer carcass metrics for all sires in study

Outcome	Alpha	Angus	Charolais	Simmental	SEM	*P* - Value
n	41	58	74	50	-	-
Feedlot arrival weight, kg	270.8	259.9	269.9	269.0	15.5	0.07
Hot carcass weight, kg	368.5	369.0	373.1	370.4	6.9	0.82
Fat, cm	1.5^{b}	1.8^{a}	1.1^{c}	1.5^{b}	0.1	<0.01
Longissimus muscle area, cm^2	95.2^{b}	90.2^{c}	99.9^{a}	93.3^{bc}	1.5	<0.01
Calculated yield grade	2.82^{b}	3.44^{a}	2.22^{c}	2.99^{b}	0.1	<0.01
Marbling score[1]	509^{b}	587^{a}	446^{c}	492^{b}	11.6	<0.01
Empty body fat[2], %	30.4^{b}	33.2^{a}	27.8^{c}	30.7^{b}	0.3	<0.01
Total carcass value	1562.90	1565.71	1583.00	1571.66	29.7	0.81
Carcass value per cwt	192.66	192.55	192.47	192.61	0.1	0.47

[1]Marbling score: 400 = small^{00}, minimum required for U.S. Low Choice; 500 = modest^{00}, minimum required for U.S. Premium Choice.
[2]17.76207 + (4.68142 x 12th rib fat, cm) + (0.01945 x HCW, kg) + (0.81855 X quality grade; 4 = Select, 5 = Choice-, 6 = Choice, 7 = Choice+, 8 = Prime) - (0.06754 x longissimus muscle area, cm^2); Guiroy et al. (2002).
No difference (*P*> 0.05) was detected between sire groups for liver and lung health.

Table 2. Steer carcass metrics for all sires in study

Outcome	Alpha	Angus	Charolais	Simmental	SEM	*P* - Value
n	42	50	50	59	-	-
Feedlot arrival weight, kg	293.6^{a}	284.3^{b}	296.9^{a}	297.4^{a}	14.6	<0.01
Hot carcass weight, kg	413.8^{b}	420.6^{ab}	431.3^{a}	426.2^{a}	7.6	0.05
Fat, cm	1.5^{b}	2.0^{a}	1.1^{c}	1.6^{b}	0.08	<0.01
Longissimus muscle area, cm^2	96.8^{b}	90.7^{c}	102.6^{a}	96.2^{b}	1.1	<0.01
Calculated yield grade	3.16^{b}	4.05^{a}	2.59^{c}	3.40^{b}	0.1	<0.01
Marbling score[1]	504^{b}	586^{a}	420^{c}	489^{b}	14.1	<0.01
Empty body fat[2], %	31.4^{b}	35.0^{a}	28.5^{c}	32.0^{b}	0.5	<0.01
Total carcass value	1757.91^{b}	1787.41^{ab}	1831.42^{a}	1816.22^{a}	31.8	0.04
Carcass value per cwt	192.47^{a}	191.92^{b}	191.82^{b}	192.10^{b}	0.1	<0.01

[1]Marbling score: 400 = small^{00}, minimum required for U.S. Low Choice; 500 = modest^{00}, minimum required for U.S. Premium Choice.
[2]17.76207 + (4.68142 x 12th rib fat, cm) + (0.01945 x HCW, kg) + (0.81855 X quality grade; 4 = Select, 5 = Choice-, 6 = Choice, 7 = Choice+, 8 = Prime) - (0.06754 x longissimus muscle area, cm^2); Guiroy et al. (2002).
No difference (P > 0.05) was detected between sire groups for liver and lung health.

Table 3. USDA carcass yield and quality grades of heifers

Outcome	Alpha	Angus	Charolais	Simmental	*P* - Value
n	41	58	74	50	-
Quality grade, %					
Prime	2.4	19.0	0	0	0.25
CAB[1]	42.9^{a}	43.1^{a}	1.4^{b}	48.1^{a}	<0.01
Choice	47.6^{b}	31.0^{b}	79.7^{a}	50.0^{b}	<0.01
Select	7.1	6.9	18.9	1.9	0.06
Yield grade, %					
1	2.4^{b}	1.7^{b}	47.3^{a}	7.7^{b}	<0.01
2	71.4^{a}	31.0^{c}	47.3^{bc}	57.7^{ab}	<0.01
3	26.2^{ab}	46.6^{a}	5.4^{c}	23.1^{b}	<0.01
4	0	20.7	0	0	0.66
5	0	0	0	0	1.0

Table 4. USDA carcass yield and quality grades of steers

Outcome	Alpha	Angus	Charolais	Simmental	*P* - Value
n	42	50	50	59	-
Quality grade, %					
Prime	2.4	22.5	0	0	0.19
CAB[1]	35.7	42.9	0	35.1	0.85
Choice	59.5^{a}	32.7^{b}	70.0^{a}	54.4^{a}	0.02
Select	2.4^{b}	2.0^{b}	28.0^{a}	10.5^{b}	0.01
Yield grade, %					
1	2.4	0	20.0	3.5	0.06
2	35.7^{ab}	2.0^{c}	56.0^{a}	29.8^{b}	<0.01
3	57.1^{a}	44.9^{a}	22.0^{b}	54.4^{a}	0.02
4	4.8^{b}	46.9^{a}	0^{b}	12.3^{b}	<0.01
5	0	6.1	0	0	1.00

Genetic Evaluation -EPDs

Sire	CW	YG	Mrb	BF	REA
Surebet	16.2	-0.47	0.29	-0.105	0.75
Rito Revenue	30.2	0.33	1.32	0.118	0.17
PurePower	19.9	-1.02	-0.38	-0.256	1.32
ALPHA	**16.2**	**-0.3**	**0.56**	**-0.031**	**0.78**

Experiment 3:
Terminal Sire Comparison

Alpha x Gamma[1] Bull


Photo by Jessica Sperber

Preliminary Results

Carcass characteristics for steer and heifer progeny

Outcome	Alpha	AxG1	Rampage	Surebet	Protege
n	79	105	72	91	45
HCW, kg	381	387	404	388	396
12th rib fat, cm	1.62	1.55	1.66	1.60	1.65
LM area, cm^2	90.9	93.6	92.7	93.2	89.8
Yield grade	3.29	3.14	3.44	3.23	3.51
Marbling score	Mt 61	Md 10	Mt 46	Mt 32	Mt 28
Prime, %	11.4	23.5	4.1	2.2	4.4
CAB, %	54.4	53.9	42.3	53.9	37.8
Choice, %	34.2	21.6	46.6	42.9	48.9
Select , %	0	1.0	6.9	1.1	8.9
YG 1, %	1.3	6.9	2.7	2.2	4.4
YG 2, %	36.7	30.4	23.3	33.0	15.6
YG 3, %	44.3	53.9	52.1	50.6	51.1
YG 4, %	16.5	8.8	20.6	14.3	28.9
YG 5, %	1.3	0	1.4	0	0

Summary

- Alpha progeny performed comparably to high performing reference sires for terminal sire production traits
- AxG1 progeny outperformed high performing reference sires for terminal sire production traits

Our Goals

- Develop genetic opportunities to improve beef quality and yield
- Improve beef production efficiency
- Highlight the role of technology in agriculture
- Provide unique learning opportunities for students

For More Information

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West Texas A&M University

Heat Adaptability and Tenderness

Tracy Scheffler[1]

[1]UF/IFAS Department of Animal Sciences, Gainesville, FL

Beef from *Bos indicus* cattle is associated with more variation in toughness compared to *Bos taurus* breeds, indicating there is antagonism between thermotolerance and beef palatability. However, the physiological connections between heat tolerance and tenderness are poorly understood. By virtue of its contribution to body weight, muscle may play an important role in defining the thermoregulatory capacity of *Bos indicus* cattle. Ultimately, defining relationships between muscle metabolism and heat tolerance are necessary in order to optimize growth and tenderness, without sacrificing the heat tolerance of *Bos indicus* breeds.

What Factors Affect Heat Tolerance?

Compared to *Bos taurus* cattle, *Bos indicus* cattle have an improved ability to regulate body temperature in response to heat stress. Heat tolerance is a function of the capacity for heat loss, and the heat production from metabolic processes. Heat transfer between the animal and the environment is dependent on surface area of the animal per unit weight, the temperature gradient between the animal and the air, and the properties of the hair coat. For example, Brahman possess smooth, slick, light-colored hair coats that reflect solar radiation, thereby preventing heat absorption by the animal. Additionally, heat loss can occur through evaporative mechanisms, such as sweating or panting.

Conversely, heat tolerance is also influenced by metabolic rate or heat production of the animal. In turn, metabolic rates determine the nutrient or energy requirements, and growth rates of livestock. A portion of the nutrients an animal consumes is lost through feces, urine, and methane. The remaining metabolizable energy is allocated for basal energy expenditure, which is the energy needed for maintenance of cellular functions within the animal; and for the energy required to do work. Specifically, once the energy requirements for digestion of food and physical activity are met, the 'leftover' energy can be dedicated to production (e.g., growth or milk). Accordingly, higher producing animals have greater nutrient requirements and metabolic rates, and thus possess a reduced capacity to adapt to environmental heat stress. While Brahman clearly have properties to enhance heat loss, there is also evidence to support that decreased heat production contributes to their heat tolerance.

Are Metabolic Rate, Growth, and Tenderness Related?

Reductions in basal metabolism and growth rate appear to contribute to decreased metabolic rate of *Bos indicus* breeds. Metabolic rate is determined by heat production of different organs and tissues of the animal. Some organs, such as the brain or liver, represent a low percentage of body weight, but exhibit high metabolic activity. In contrast, muscle is not particularly active on a per unit basis, but contributes significantly to metabolic rate since it represents roughly 40% of body weight.

On a cellular level, nutrients from the diet are metabolized to accomplish vital functions, including protein synthesis, muscular contraction, and the maintenance of ion gradients across membranes. However, the energy demand does not come from these processes; rather the additional energy required for cellular maintenance is due to processes that oppose these functions (reviewed by Rolfe & Brown, 1997). These opposing or uncoupling processes include protein degradation, muscle relaxation, and ion leaks. Consequently, decreasing any of these uncoupling processes would be expected to decrease the animal's metabolic rate and energy requirements. Accordingly, the decrease in metabolic rate would be dictated by which organs are impacted, as well as the extent to which uncoupling processes are reduced.

Interestingly, there is evidence that *Bos indicus* cattle have lower protein degradation in muscle, which would help explain not only reduced growth rates and metabolic rates, but also tougher beef. Muscle growth is an energetically demanding process; in order to increase muscle mass, proteins must be synthesized as well as degraded, which is also known as protein turnover. The net balance of synthesis and degradation dictates the gain in muscle mass. In living muscle, several systems contribute to protein degradation; of these, the major player in postmortem muscle is the calpain-calpastatin system. Calpain cuts proteins into fragments, which disrupts the structure of muscle cells and contributes to the tenderization of beef. Calpastatin, on the other hand, is the only known inhibitor of calpain (reviewed by Goll et al., 2003). *Bos indicus* cattle are well-documented to possess elevated calpastatin activity in postmortem muscle, consequently decreasing degradation and limiting tenderization (Wheeler et al., 1990; Whipple et al., 1990; Pringle et al., 1997). Thus the greater calpastatin observed in muscle of Brahman and *Bos indicus* breeds may be a mechanism for limiting protein turnover in the animal, in order to restrict metabolic heat production; in postmortem muscle this manifests as tougher beef. Certainly, it is possible that other organs of *Bos indicus* cattle also contain greater calpastatin or that other mechanisms to prevent protein degradation are upregulated, but these data have not been reported.

Besides protein degradation, changing cell size may be another mechanism for reducing metabolic cost. Increasing cell size reduces the surface area to volume ratio, which decreases the cost of maintaining the membrane potential (Jimenez et al., 2013). This affects the activity and distribution of ion pumps at the membrane, thereby reducing the energy required for cell maintenance. Increasing percentage of Brahman genetics was associated with larger type IIx muscle fibers (Wright et al., 2018). Greater toughness may be related to larger fiber size (Chriki et al., 2012). Yet, as protein degradation increases during aging, the effect of fiber size on tenderness is less pronounced (Crouse et al., 1990).

Basal metabolic rate is also affected by proton leak in the mitochondria, the energy producing organelles of cells. Proton leak in mitochondria increases metabolic rate and heat production, but uncouples fuel oxidation from energy production. Reducing proton leak in mitochondria may be another mechanism to restrain heat production in *Bos indicus* cattle. The connection between mitochondria and meat quality development is less clear, but this is an active area of investigation. Disruption of mitochondria early postmortem is associated with initiation of proteolysis and greater tenderization. Some have suggested that disruption of mitochondria stimulates cell death pathways, which, in turn, activates enzymes capable of degrading calpastatin (Kemp et al., 2010). This is an attractive concept because enhancing calpastatin breakdown would hasten tenderization. However, this is a controversial topic as others have reported that there is no evidence that this process occurs in muscle postmortem (Mohrhauser et al., 2011; Underwood et al., 2008).

Furthermore, *Bos indicus* breeds may have acquired other mechanisms to protect against cellular stress. In response to elevated temperatures, cells produce heat shock proteins to help stabilize and protect cellular structures. In postmortem muscle, structural protection by heat shock proteins may hinder the breakdown of muscle, thereby limiting tenderization. Along these lines, loin muscle of Brahman cattle exhibit greater resistance to metabolic changes postmortem, demonstrated by slower pH and energy decline (Ramos et al., submitted). Additional work is ongoing to determine underlying mechanisms.

Conclusions

Bos indicus cattle impart heat tolerance, but have garnered a reputation for slow growth and variation in palatability. Certainly, there is tremendous economic incentive to increase growth performance and improve product consistency. Because muscle represents a significant portion of body weight, shifts in metabolism may contribute to heat production and thus affect the thermoregulatory capacity of *Bos indicus* cattle. On a cellular level, there are several possible connections between heat tolerance and tenderness, including but not limited to, calpastatin, mitochondrial function, and heat shock proteins. Defining the relationships between muscle characteristics and heat tolerance are critical to developing strategies that optimize growth and tenderness without sacrificing heat tolerance of *Bos indicus* breeds.

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Physiology of Marbling in Beef Cattle

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Introduction

Marbling or intramuscular fat deposition in beef is a major determinant of carcass quality and value in the US. According to the National Beef Quality Audits (NBQA; Lorenzen et al., 1993; McKenna et al., 2000; Moore et al., 2012; McKenna et al., 2000) from 1993 to 2016, marbling and quality grades have increased during this time period (Fig 1). The percentage of carcasses grading Prime has increased by 64% and upper Choice (CAB) by 75%. The percentage of carcasses grading Select or Standard is 35% or 86% lower. These changes are likely related to two major factors: 1) carcass discounts and premiums based on quality grades and 2) availability of genetic information to improve carcass traits.

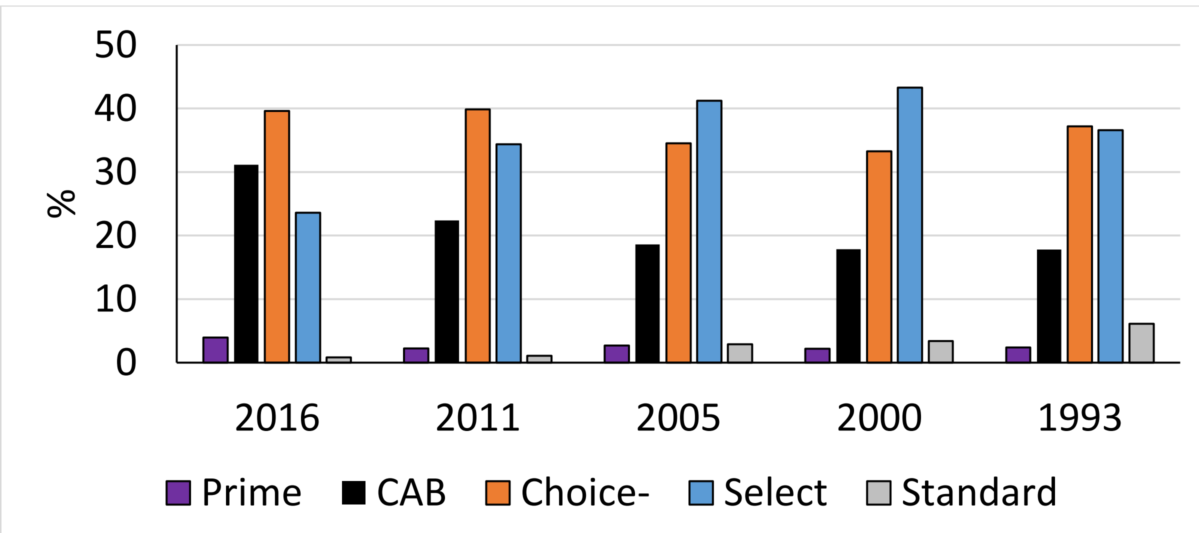

Figure 1. Percentage of Prime, Certified Angus Beef (CAB), Choice-, Select and Standard carcasses in US fed beef carcasses according to the National Beef Quality Audits (NBQA) from 1993-2016.

The Choice-Select spread can range from $2 to $25/cwt depending on the time of year. Premiums for Certified Angus Beef (CAB; Upper Choice) range from $4 to $14/cwt and for Prime range from $9-26/cwt depending on time of year. Traditionally, the largest differentials between Choice and Select and premiums reach a peak in summer months (June/July) and again at the end of the year (Dec.). These discounts and premiums can have a significant impact on value of beef carcasses and provide incentives for improving genetic potential and altering finishing systems for greater marbling deposition.

Carcass traits like marbling are highly heritable ($h2 = 0.48$; Angus Assoc., 2019), which means that genetic improvement can be made. Indeed if we look at the genetic change in marbling EPDs for Angus bulls, you can see the increase that has occurred during the last 20 years. Marbling score is determined on the carcass longissimus muscle at the 12/13th rib and has a strong correlation ($r = 0.79$; Wilson et al.,

1998) with chemical total fat measures. The use of real-time ultrasound has been instrumental in assisting with identification of bulls and their progeny with superior abilities to deposit intramuscular fat. Currently the average marbling EPD in the Angus breed is + 0.41 and has a range from -0.77 to +2.15. Today we have cattle with superior genetic ability to deposit marbling but we may need to rethink our traditional approach to finishing beef systems.

Accelerating Marbling Deposition

Early research (Moody and Cassens, 1968; Hood and Allen, 1973; Cianzio et al., 1982, 1985) described intramuscular fat deposition as a late developing depot compared to other adipose depots. Moody and Cassens (1968) traced marbling depots and concluded that both hyperplasia and hypertrophy were important to marbling score. Hood and Allen (1973) evaluated changes in adipocyte cell number and size in perirenal, subcutaneous, and intramuscular depots in Angus-Hereford and Holstein steers at 14 mo of age and Hereford steers at 8 mo of age. Subcutaneous and perirenal adipocytes increased in size indicating the hypertrophy was primarily responsible; however, intramuscular adipocytes were smaller in size and number of cells was positively correlated to intramuscular lipid content within and across the muscles. Cianzio et al. (1985) compared adipose cellularity and lipid concentration from 11 to 19 mo of age in steers fed a grower diet. They reported that adipocyte diameter and adipose tissue amounts in the carcasses both increased with advanced animal age indicating that adipocyte hypertrophy was primarily involved in adipose tissue deposition. However, marbling score was positively correlated to both cell diameter and total cell number suggesting that both hyperplasia and hypertrophy was important for intramuscular lipid deposition. Most of us have learned in the classroom that marbling is deposited last and the first to be mobilized in times of energy need.

Current research examining fetal programming is increasing our knowledge and understanding of muscle and adipose tissue development. Muscle and adipose tissues originate from the same mesodermal germ layer of the embryo. Muscle development begins early with primary myogenesis and followed by secondary myogenesis. In cattle, it is estimated that primary myogenesis is complete by 100 d of gestation and secondary myogenesis is complete by 180 d of gestation (Albrecht et al, 2013). Therefore, muscle fiber number is set before birth and postnatal growth is the result of hypertrophy or enlargement of existing muscle fibers. Adipose development is also occurring during this early time period but less is known regarding timing and whether hyperplasia is ever really complete. Robelin (1981) has shown that the fattening process occurred with an estimated 70% attributed to hypertrophy and 30% to hyperplasia in various adipose depots. Robelin (1981) reported that when subcutaneous adipocytes were filled with lipids that this stimulated another wave of hyperplasia to provide more adipocytes for additional lipid filling. Du et al. (2015) hypothesized that a critical window between late gestation and 250 d of age occurs for hyperplasia of intramuscular adipocytes which is followed by hypertrophy. If there are important stages of development for adipocytes, then our early management systems for calves need further examination.

Deutscher and Slyter (1978) reported higher quality grades for calves that had access to creep feed (50-50% corn and oats) in the drylot cow-calf system and then finished on concentrates. Faulkner et al. (1994) showed linear increases in quality grade of calves that received unlimited or limited creep feed prior to weaning when cows were grazing endophyte-infected fescue. In addition, Faulkner et al. (1994) found that quality grades were higher when calves were offered creep feed containing corn compared with soybean hulls in either limited or unlimited amounts prior to weaning. In contrast, Myers et al. (1999) found no difference in marbling scores or percentage grading Choice, upper Choice, or Prime when normal weaned calves were creep fed ground corn ad libitum for 55 d with dams grazing endophyte-infected tall fescue and red clover, and then finished on concentrates for 213 d.

Many researchers have evaluated early weaning (63-150 d of age) as a strategy to improve overall herd performance and potentially alter marbling deposition in calves. Early weaning of calves followed by feeding of high concentrate diets increased marbling scores and external fat thickness compared to normal weaned calves (Myer et al., 1999; Story et al., 2000; Shike et al. 2007; Meteer et al., 2013; Scheffler et al., 2014). In contrast, others reported no change in marbling score or fat thickness when early weaned calves grazed forage with supplement (1% BW; Arthington et al., 2005), fed transition diets (75% whole corn; Fluharty et al., 2000) or drylot period followed by grazing (Wiseman et al., 1019) after early weaning before entering the feedlot. Duckett et al. (2007) found that higher stocker growth rates increased marbling deposition in steers finished on concentrates. These results suggest that exposure to high concentrate diets after early or normal weaning may have the most impact on marbling deposition.

Serial slaughter studies indicate that marbling deposition occurs after 120 d on a high concentrate based diet (Greene et al., 1989; Duckett et al., 1993; Bruns et al. 2004, 2005). Early weaning and exposure to a high concentrate diet has been reported to increase marbling deposition in finished cattle (Scheffler et al., 2014); whereas carcass weights are often decreased in turn. Koch et al. (2018) reported that exposure to high concentrates for 110 d post normal weaning followed by forage finishing produced carcasses with similar marbling scores to steers fed high concentrates early and late in the finishing phase. High concentrate, corn based diets up-regulate expression of lipogenic enzymes and down-regulate expression of lipolytic genes in subcutaneous tissue (Duckett et al., 2009; Key et al., 2013; Koch et al., 2018). In contrast, corn supplementation (< 1% of body weight) on pasture (Pavan and Duckett, 2008; Greenwood et al., 2015; Wright et al. 2015) does not appear to alter marbling deposition. Researchers (McGilchrist et al., 2011; Fitzsimmons et al., 2014) have suggested that marbling deposition may be related to development of insulin resistance. Kitessa and Abeywardena (2016) reported that localization of glucose transporter (GLUT4) and fatty acid translocase (CD36) to the plasma membrane are altered in high plasma insulin states during insulin resistance. During insulin resistance, the fatty acid translocase moves to the plasma membrane creating an open gate that allows fatty acid to enter the cell; whereas glucose transporter remains inside the cytosol to limit glucose uptake into the cell and thereby elevating plasma glucose levels. A consequence of type II diabetes is heightened accumulation of intramyocellular fat in skeletal muscle of humans (Gemmick et al., 2017). More research is needed to develop a better understanding of how intramuscular lipid deposition is regulated in skeletal muscle in order to stimulate deposition earlier at the expense of excess subcutaneous fat.

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Growth Promoting Technologies – Strengthening Your Bottom-line While Preserving Meat Quality

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Introduction

Modern beef production economics and small returns relative to input costs demand that producers capture incremental improvements in animal productivity to improve profitability. Anabolic implants and beta-adrenergic agonists are two such growth-promoting technologies the beef industry has used for many years to do just that, improving performance and reducing production costs.

Indicated for increased rate of gate and feed efficiency, beef implants have been developed for use in heifers and steers at multiple stages of production from feedlot cattle to calves on pasture prior to weaning. Anabolic implants have been designed to steadily release active ingredients such as estrogenic and androgenic hormone over a set period and are delivered through hormone pellets administered under the skin of the ear. With similar indications, beta-agonists such as Optaflexx and Actogain are demonstrated to increase performance, feed efficiency, and carcass leanness when delivered in a complete feed. Approved for use in both steers and heifers, beta-agonists are intended to be used for only the last 28-42 days of the finishing period.

While these technologies improve the economics and sustainability of beef production, as well as improve beef's price competitiveness compared to other proteins, these technologies also have the potential to erode marbling scores and negatively affect beef palatability if not used appropriately. Since tenderness, juiciness, and beef flavor are major components of consumer eating satisfaction, it's important for producers to understand effective usage and timing of these technologies as well as their effects on meat quality.

Implants

To a producer new to beef implanting, the number of different implants commercially available may be a little overwhelming. The variety of available implants is a result of multiple implant strategies designed to maximize benefits of exposure while reducing negative impacts and most commonly focus on targeted finish date, price spread, genetic potential for marbling, nutritional plane and feeding programs (Holt, 2009). While many implants are similar, they may have slightly different characteristics such as active hormone, dosage, and hormone release duration. It is these characteristics that provide producers the flexibility to use implants in multiple stages of beef production.

Beef production has historically been a highly segmented industry. This segmented nature has led to implanting decisions being dictated by phase of production in which cattle are to be marketed (Duckett and Andrae, 2001). Historical wisdom has been to implant when entering the finishing stage. With the greatest increase in animal value associated with implant use being tied to the finishing phase ($51.34/hd), some feedlots offer premiums for unimplanted calves (Duckett and Andrae, 2001). However, research has reported carryover effects of implanting suckling and stocker calves are minimal relative to feedlot performance.

The same characteristics that provide usage flexibility, have a major impact on potency (or "aggressiveness") and effects on meat quality characteristics. Timing of implant administration and frequency of reimplantation (administering an implant at multiple stages of beef production) has been shown to affect beef quality grade and objective tenderness (Platter et al., 2003). On average, the use of implants may decrease marbling scores by 4 to 11% (Duckett and Pratt, 2014). In extremes, Platter et al. (2003) demonstrated almost a full quality grade reduction in carcasses from cattle implanted five times compared to nonimplanted steers, although five implants is well above the industry average of 1-2 implants per animal. Flavor and juiciness are other traits of consumer importance. Platter et al. (2003) reported an additive effect of implants on consumer palatability with little change observed in steaks from cattle implanted 1-2 times, and greater negative effects observed in steaks from cattle implanted 3, 4, or even 5 times.

Beta-agonists
Limited to the last 28-42 days of the finishing period, it would appear there are fewer usage considerations associated with beta-agonist use. However, several factors including dosage, sex, and breed type can influence effects of beta-agonists on meat quality.

In a summary of 45 research studies, Lean et al. (2014) reported an average increase of 13.6 lbs in hot carcass weight, 0.29 square-inch increase in ribeye area, and a 0.23% unit increase in dressing percentage compared with carcass characteristics of control-fed cattle. However, steaks from beta-agonist fed cattle demonstrate a modest decrease in objective tenderness. Studies where steers and heifers were fed a beta-agonist at a low-dosage for shorter feeding periods demonstrate smaller negative effects on tenderness values when compared with control cattle, whereas in studies where cattle were fed greater doses for longer periods prior to slaughter, marked decreases in tenderness were observed. Nonetheless, classical postmortem aging strategies (14-21 days) have been proven effective in reducing detrimental effects of beta-agonists on objective tenderness (Boler et al., 2012) although postmortem aging did not change the proportion of steaks classified as "tender" according to USDA guidelines (Martin et al., 2014).

Sex is another important factor when considering beta-agonist responsiveness. Quinn et al. (2008) reported feeding heifers a beta-agonist less effect on carcass weight, ribeye area, 12th-rib fat thickness, yield- or quality grade than observed in steers. Despite the smaller response in carcass effects, beta-agonists did improve feed efficiency of finishing heifers (Quinn et al., 2008).

Another consideration is the effect of beta-agonists in Bos taurus- vs. Bos indicus-type cattle. Gruber et al. (2008) reported that beta-agonist usage had a more detrimental effect on tenderness values of steaks from Brahman-cross steers than British-breed steers, with Continental-cross steers intermediate. However, these effects were mitigated when Brahman-cross steers were fed a beta-agonist at a lower dosage.

Conclusion
Anabolic implants and beta-agonists have had a crucial role in helping cattle feeders to be profitable in the face of an ever-shrinking U.S. cattle inventory, fluctuating corn prices and high beef demand. In the later stages of feeding, when cattle start to deposit more fat than muscle, the use of growth-promoting technologies can help to increase muscle synthesis, ultimately increasing feed efficiency and pounds of lean beef produced. Nonetheless, if not managed properly detrimental effects on quality grade made be observed, negatively impacting the price feeders may be willing to pay for calves as well as the bottom-line for producers choosing to retain ownership.

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Meat Quality and Thermotolerance in *Bos Indicus* Influenced Cattle

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Meat Quality

Beef product quality is a top priority for beef industry - because it has a great power to influence demand and also because the beef industry has the ability to improve it. Great effort was dedicated to understanding how consumers perceive beef quality and all studies point out that the strongest quality attributes are tenderness, juiciness, and flavor, followed by healthiness and nutritional value. These issues are of particular importance for Brahman crosses as they are routinely penalized for inadequate tenderness and relatively low marbling score.

The relationship between the USDA quality grade and tenderness is an important one, because the beef industry is using the USDA grading system to determine premium and discounts, to predict the palatability of the meat from a beef carcass and to communicate it to the consumers. However, we believe that the system has a limited ability to predict eating quality, and substantial variation in the degree of tenderness exists within each quality grade. This relationship is even more important to characterize in crossbred cattle, which are routinely penalized for inadequate tenderness and relatively low marbling score. A dataset of 1,360 animals spanning the range from 100% Angus to 100% Brahman with Warner-Bratzler shear force (WBSF) and USDA quality grade was used to investigate this relationship. The WBSF is an objective measure of tenderness and it measures the force required to shear a cooked steak (in kg) – the lower the number, the less force is required indicating a more tender steak. The USDA - Agricultural Marketing Service is engaged in designing standards to indicate the degree of tenderness for beef. In this program, a steak with a WBSF < 4.2 kg is considered tender and a steak with WBSF < 3.7 kg is considered very tender. The average WBSF for the population used in this study was 3.98 kg and, using the USDA-AMS standard, 37% of our animals would be considered tough, 15% tender and 48% would qualify as very tender.

Based on USDA grading system, cattle in our data were classified as *Standard* (5.6%), *Select* (47.1%), *Choice*- (32.1%), *Choice* (10.8%), *Choice+* (3.4%) and *Prime* (1.2%). The scatterplot in Figure 1 shows the distribution of our cattle across these quality grades and their respective toughness/tenderness measured by WBSF. There are three important points to take from this figure:

1. There is considerable variation in the degree of tenderness across all quality grades. There is a small trend in the average tenderness across quality grades, described by the solid line, indicating that on average steaks from higher quality grades tend to be more tender (lower WBSF). However, it is also clear that, most of the variability in tenderness is within a quality grades and not between grades. The tenderness of steaks from carcasses graded *Select* or *Choice* (the majority of our animals) varied from very tender to very tough. This highlights the limitation of the USDA grading system to predict eating quality or tenderness.

2. On the right side of the graph, for steaks graded higher (*Choice* and *Choice+*), about 34% are in fact "tough" based on WBSF. Consumers buying these steaks are paying a premium and they expect a high-quality product, but 34% of the time, they will end up with a tough steak and therefore a less then desirable eating experience. This in the long run will translate into decreased beef demand negatively impacting all sectors of the beef industry.

3. On the left side of the graph, 58% of the steaks from carcasses graded *Standard* or *Select* are in fact tender or very tender. Consumers buying these steaks are paying a lower price purchasing a very tender steak that will provide a very positive eating experience. This is great from the consumer and will help increase beef demand, but this is an opportunity loss for the producers as they are selling a high-quality product for a lower (or even discounted) price.

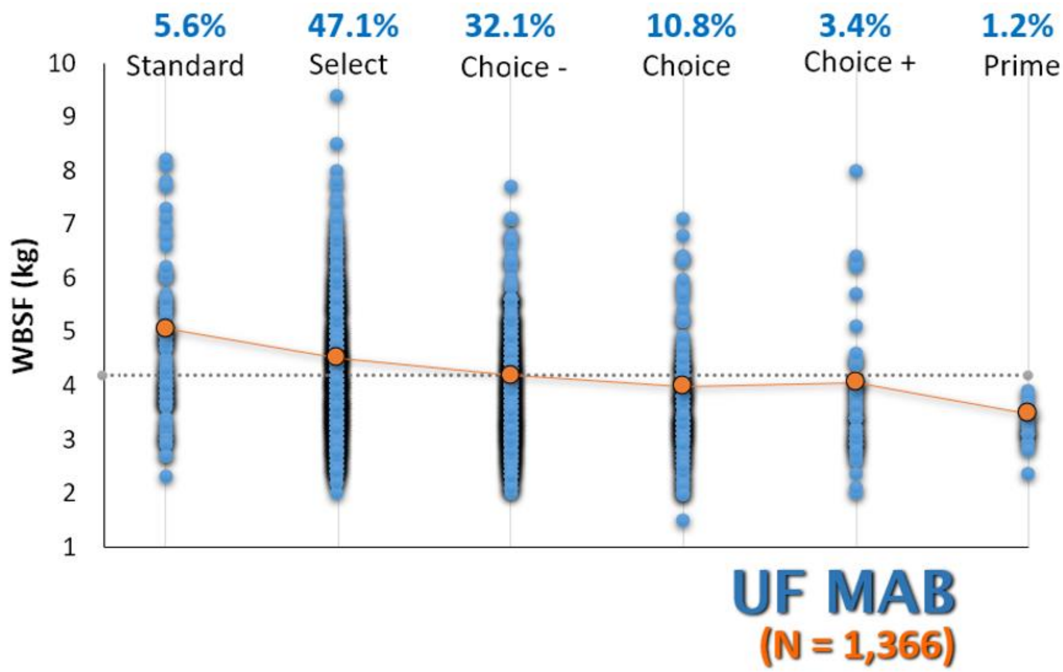


Figure 1. Cattle (n = 1,366; from 100% Brahman to 100% Angus) classified USDA quality grade and WBSF (low WBSF = tender meat, high WBSF = tough meat). High level of variation in tenderness is present within each quality grade indicating that marbling accounts for just a small portion of the variation in tenderness. The orange dot in each quality grade is the average WBSF for that quality grade and the horizontal line represents the threshold for a steak to be considered tender (steaks below the threshold are tender and very tender steaks, steaks above the threshold would be qualified as tough).

Although no errors are desirable, from the consumer and marketing point of view errors may have different consequences. We could speculate that misclassification errors for moderately tender group have relatively small market consequences because, if the price of the product reflects eating quality (as it would with a "certified tender" program), the consumer is paying and expecting average eating quality and this expectation is most likely met. On the other hand, misclassifications of a product with "tough" or "tender" quality may have a greater negative impact on consumers. Again, if we assume the eating quality is positively associated with the price of the product, not meeting quality expectations leads to dissatisfied consumers. This could have important consequences as past experience is a critical factor regarding attitude toward food. A report (SMART, 1994) evaluating the factors contributing to the intent of consumers to repurchase a product concluded that eating quality was the most important factor (65%), followed by price (28%). Unfulfilled eating quality expectations lead to consumers' dissatisfaction, reduced future beef purchases and lower demand. The negative consequences associated with misclassifications of carcasses with "tender" into "moderately tender" or "tough" groups are of different nature. These errors represent opportunity losses for the industry, as the product is undervalued.

Programs to improve eating experience when consuming beef and the ability to better predict the eating quality level for marketing purposes are critical to increase consumers' confidence and, subsequently, improve the economic position of the beef industry through increased demand for beef products.

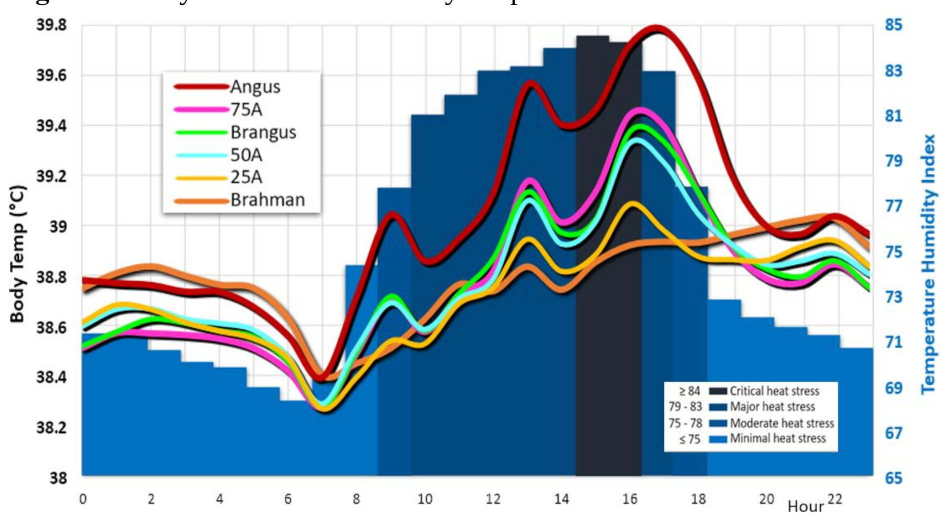
Thermotolerance

Climatic stress is a major limiting factor of production efficiency in beef cattle in tropical and subtropical environments and in dairy cattle throughout most of the world. This stress is expected to increase due to climate change. More than half of the cattle in the world are maintained in hot and humid environments, including about 40% of beef cows in the US. Substantial differences in thermal tolerance exist among breeds and among animals within breeds indicative of opportunities for selective improvement. Use of genomic tools to produce an animal with superior ability for both thermal adaptation and food production represents an energy-efficient sustainable approach to meet the challenge of global climate change.

Core body temperature was measured every 15 minutes over a 5-day period using an iButton temperature measuring device implanted in a blank CIDR in heifers from the University of Florida multibreed herd (ranging from 100% Angus to 100% Brahman) and two-year old Brangus heifers from the Seminole Tribe of Florida. Hair samples were collected and measured for length and diameter. Skin biopsies were used for histological measurement of several skin properties including sweat gland number and size.

Figure 2 shows the pattern of hourly variation in core body temperature for Angus, 3/4Angus x 1/4Brahman (3/4A, 1/4B), Brangus, 1/2Angus x 1/2Brahman (1/2A, 1/2B), 1/4Angus x 3/4Brahman (1/4A, 3/4B) and Brahman cows. Brahman cattle were the only ones able to maintain a lower core body temperature throughout the 24h-day during high heat stress conditions. Coat score had a significant effect on body temperature, where cows with shorter and slicker hair maintain lower body temperatures. Brahman cattle had larger sweat glands closer to the surface of the skin (Figure 3).

Figure 2. Daily variation in core body temperature



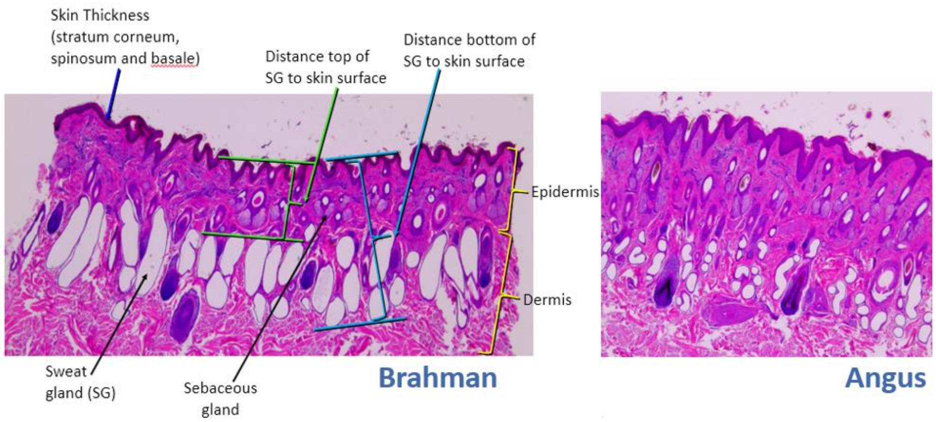


Figure 3. Skin histology showing the difference in sweat gland size and sweat gland proximity to the skin surface in Brahman versus Angus cows.

Improvements in production, such as increased growth rate, lead to increased metabolic heat production, and exacerbate the problem of thermoregulation and a good example is the negative genetic correlation between milk yield and ability to regulate body temperature during heat stress in dairy cattle. Unless accompanied by changes that increase heat loss capacity, improvements in production make animals more susceptible to hyperthermia during heat stress.

Presence of Grass Endophytes and Mycotoxins in Florida Pastures?

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Several livestock ranchers in Florida have reported concerns that their pasture forages are causing animal health issues in cattle, equine and endangered wildlife. A team of researchers and extension faculty are collaborating on a statewide sampling of predominant forage grasses to examine pastures for the presence or absence of endophytes and mycotoxins of concern to animal health.

Beginning in February 2018, we began sampling bahiagrass, bermudagrass, limpograss and smutgrass pastures on approximately 14 ranch sites. These ranches are strategically located across the state, and over a period of 1 year, we plan to evaluate endophyte and mycotoxin presence in those specific grass species.

Over the past two years, on a very limited scale, we have been examining endophyte populations in our Florida pasture grasses and have been testing for the presence of mycotoxin activity in these forages. Working jointly with the Oregon State University School of Veterinarian Medicine Toxicology Department and Endophyte Service Laboratory (OSU), we have identified the presence of fungal endophytes and various mycotoxins occurring in several of our popular forage grass species, including bahiagrass, bermudagrass and limpograss. We have confirmed from this small sample set the identification of several fungal genera living endophytically in these grasses, such as *Fusarium*, *Balansia* and *Myriogenospora*. Additionally, we have found seasonal mycotoxin activity in the forages that are of interest to us concerning animal health. To date, we have identified and quantified the presence of zearalenone, ZEAR-4-sulfate Q1, beauvericin, and 15-AcetylDON, as well as several other mycotoxins that are potentially deleterious to animal health.

What the mycotoxin concentrations are in these forage plants and at what level these harmful to animal health are important questions. However, the first step is to increase our sampling size with additional locations throughout Florida. All plant samples evaluated were either collected under grazing or fed as hay or silage to cattle, equine, and endangered wildlife. We will test all samples for the presence or absence of endophytes and mycotoxins, and if found, what is their seasonal occurrence and the environmental conditions under which they occur.

To date, we have nearly completed collecting forage and hay samples from the fourteen locations around the state. We have also cultured leaf portions of each grass to determine the presence of endophytes and begun the DNA sequencing to identify those endophytes present in the grasses.

The Florida Cattlemen Association has provided initial funding for the purchase of a freeze-dryer and heavy-duty coolers to expedite sample collection and processing. Those funds have aided us to begin our ranch sampling in early 2018. We have collected over 300 forage samples and are presently analyzing them at Oregon State University.

This research should provide preliminary information on forage sampling procedures for successful endophyte and mycotoxin analyses, DNA profiling of fungal endophytes, and mycotoxin type and quantification. We hope to provide the Florida Cattlemen with unbiased information about endophyte and mycotoxin presence in Florida forages and how it relates, if found, to animal health and performance.

Collaborators

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Application of Ionophores in Cattle Diets

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Introduction

Ionophores are feed additives that are used in the diets of cattle to increase feed efficiency and body weight gain. Ionophores are compounds that alter rumen fermentation patterns. Ionophores can be fed to any class of cattle and can be used in any segment of the beef cattle industry. Similar to many other feed additives, ionophores are fed in very small amounts and supplied via another feedstuff as carrier for intake. Ionophores decrease the incidences of coccidiosis, bloat, and acidosis in cattle.

Mode of Action

Commercially available ionophores include monensin (Rumensin®), lasalocid (Bovatec®), and laidlomycin propionate (Cattlyst®). Ionophores are classified as carboxylic polyether antibiotics and they disrupt the ion concentration gradient (Ca^{2+}, K^+, H^+, Na^+) across microorganisms membranes causing them to enter a futile ion cycle. The distruption of the ion concentration prevents the microorganism from maintaining normal metabolism and causes the microorganism to expend extra energy. Ionophores function by selecting against or negatively affecting the metabolism of gram-positive bacteria and protozoa in the rumen. The affected bacteria are those that decrease efficient rumen digestive physiology and the energy supplied from the ruminal digestion of feedstuffs. By controlling certain protozoa and bacteria in the rumen, less waste products (methane) are generated (Guan et al. 2006) and ruminal protein breakdown is decreased which results in a decreased ammonia production. The shift in ruminal bacteria population and metabolism allows beneficial bacteria to be more efficient through an increase in the amount of propionic acid and decrease acetic acid and lactic acid produced. Therefore, cattle experience an increase in the overall energy status and utilize feed resources more efficiently.

Even though ionophores are classified as an antibiotic they are not therapeutic antibiotics. Anitbiotic resistance is an increasing concern within the public discourse. However, the increase in antibiotic resistant bacteria as a result of ionophore use is not well supported for a number of reasons: 1) ionophores have never been (nor are likely to be) used as antimicrobials for humans, 2) ionophores have a very different mode of action from therapeutic antibiotics, 3) ionophore resistance in bacteria seems to be an adaptation rather than a mutation or acquisition of foreign genes (Russell and Houlihan, 2003), 4) ionophores can translocate across cell membranes of animals which limits their use as therapeutic antibiotics, 5) the complexity and high degree of specificity of ionophore resistance in targeted bacteria (Callaway et al., 2003).

Applications

Ionophores have feeding applications in a number of different manners. Most frequently, ionphores are included in either dry or liquid manufactured supplements. Inclusion of ionophores in manufactured supplements allows for specific formulations of ionophore concentrations and the option for controlled intake of the supplement. Ionophores can also be included in loose mineral mixtures. Inclusion of ionophores in mineral mixtures can be used to limit intake of the mineral, particularly when monensin is utilized because of palatability characteristics associated with monensin in loose form. Ionophores are included in small amounts when mixed in formulated supplements. Additionally, ionophores are a medicated ingredient and as such, the government regulates the manufacture of ionophore containing feeds. Thus, ranch mixing is not allowed for feed or mineral supplements. Ionophores have no withdrawal time relative to sale or slaughter of cattle. This means that cattle can consume ionophore-containing feedstuffs up to the day of sale or slaughter.

Ionophores are used in a variety of cattle production scenarios. Growing cattle consume the majority of ionophores; however mature cows can benefit from the consumption of ionophores. Table 1 demonstrates the variety of feeding scenarios in which ionophores have been offered in forage-based nutrition for cattle. Application of ionophores is appropriate in nearly every forage type and quality encountered by cattle. The carrier or supplement that contains the ionophore should complement the forage base and cattle requirements. However, cattle that consume ionophores may not be eligible to enter natural and are not eligible for organic market production chains.

Table 1. Effect of the concentration of ionophores during supplementation on growing calf gain offered different diets.

Diet	Ionophore	Concentration, mg/day	Calf body weight, lb	Control suppl. gain, lb/day	Ionophore suppl. gain, lb/day	Ionophore gain differential, lb/day
Bermudagrass	Monensin	200	550	0.93	1.04	+0.11
		200	573	1.15	1.50	+0.35
Bermudagrass	Monensin	25	343 to 518	1.24	1.55	+0.31
		50			1.61	+0.37
		100			1.72	+0.48
		200			1.56	+0.32
Bermuda-Bahiagrass	Monensin	180	457	0.76	0.52	-0.24
Bahiagrass	Lasalocid	50	480	0.76	0.66	-0.10
		100			1.02	+0.26
		200			0.71	-0.05
		300			0.82	+0.06
	Monensin	200	480	0.76	0.91	+0.15
Stargrass	Lasalocid	50	480	1.25	1.34	+0.09
		100			1.35	+0.10
		200			1.27	+0.02
		300			1.33	+0.08
	Monensin	200	480	1.25	1.50	+0.25
Wheat pasture	Monensin	180	542	2.31	2.87	+0.56
Prairie hay	Monensin	200	460	0.55	0.55	0.0
Dormant range	Monensin	150	474	0.64	0.92	+0.28
Feedlot receiving	Monensin	48	268	2.08	2.02	-0.06
		96			2.21	+0.13
		143			2.17	+0.09

Equines should not consume ionophores or feeds containing ionophores. Equine are incapable of metabolizing ionophores in the concentrations that are formulated for cattle diets. In cattle, sheep, chickens, dogs, and other animals the ionophores can be absorbed across the small intestine, transported to the liver, metabolized, and excreted in bile with the ultimate elimination through feces.

Animal Response

Reviews of numerous grazing trials using steers and heifers indicate that supplementation with 155 mg/day of monensin results in an improvement in average daily gain of 0.18 lb/day or 13.5% increase compared to non-supplemented control cattle (Kunkle et al., 2000). When the amount of monensin increased to 200 mg/day, cattle gained an additional 0.20 lb/day or 16% improvement compared to cattle not offered an ionophore. Offering supplements containing monensin at 200 or 400 mg/day on alternate days can increase growing calf gain by 0.17 and 0.18 lb/day, respectively (Muller et al., 1986). The preceding responses were collected over a variety of pasture forage qualities. Cattle grazing bermudagrass and supplemented 200 mg/d of monensin in the summer have been reported to increase daily gain by 0.22 to 0.46 lb/d, a 24 to 44% increase over cattle consuming supplement without monensin (Rouquette et al., 1980; Oliver, 1975). Table 1 provides a summary of growing cattle performance when offered an ionophore.

Ionophores have been utilized to positively affect reproductive processes in the beef cow herd. The post-partum interval can be decreased in cows that are gaining body weight and body condition score as a result of improved nutritional status associated with ionophore supplementation. However, cow body weight and condition score change during the supplementation period strongly influenced overall post-partum interval response (Sprott et al., 1988). Onset of puberty in growing heifers can be hastened by supplementation with ionophores. Research has demonstrated that in growing heifers gaining at acceptable growth rates (0.75 to 1.32 lb/day) age at puberty can be decreased and the percentage of heifers pubertal at target breeding body weight is increased.

Economics of Performance Response

In the stocker cattle segment and replacement heifers, the use of ionophores increases average daily gain by 5 to 15% and improves feed efficiency by 8 to 12% (Lawrence and Ibaruru 2008; Elam and Preston 2004). The economic effect on stocker cattle contributes an impact of 1.46% on the breakeven price, and $11.51 effect on the cost of production (Table 2). In the feedlot, ionophores improve average daily gain by 1 to 6% and improve feed efficiency by 3.5 to 8% (Lawrence and Ibaruru, 2008; Elam and Preston, 2004). Similar to the stocker sector, ionophores in the feedlot contribute a smaller but significant effect on breakeven price and production cost per head differential (1.18% and $12.43, respectively) compared to not using ionophore technology. Production practices that combine the use of ionophores and implants likely result in a synergetic effect (Elam and Preston 2004) on growth performance of cattle. Ionophores increase the amount of energy available from the diet and the application of implants stimulate lean tissue growth which utilizes the increased available energy.

Table 2. Effect of ionophore technology on average daily gain (ADG) and estimated cost of production in the stocker and feedlot segment compared to no use.[1]

Industry section	ADG, %	Breakeven price, %	Cost per head, $
Stocker	7.74	1.46	11.51
Feedlot	2.90	1.18	12.43

[1] Adapted from Lawrence and Ibarburu (2008).

Conclusions

Incorporation of ionophores into supplements and the diets of beef cattle elicit a positive increase in growing cattle performance. Ionphores should be considered for use by beef cattle producers to increase calf gain and gain efficiency in a cost effective manner. The response to ionophores is related to forage availability, forage quality, and concentration of ionophore used.

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Reproductive Challenges in Cow-calf Operations

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Introduction
The ultimate goal of cow-calf operations is to produce calves, preferably early in the calving season. Such an obvious statement hides the complexity of what it takes to attain this goal. Success in achieving pregnancy, birth and development of calves to weaning relies on adequate application and integration of principles of animal husbandry, nutrition, health, genetics, economics, among others. At the core of a successful beef cow-calf operation is reproduction. For the purpose of this paper, we will discuss reproduction in the context of the reproductive life-cycle of a female in the herd, from birth to recurring annual pregnancies (Figure 1). Progressing from each stage of the reproductive life cycle to the next, on itself represents a challenge that is measurable and usually manageable. For example, progressing from birth to puberty can be measured as the proportion of heifers on a year’s crop that achieve puberty as yearlings. Existing genetic, nutritional, management and reproductive tools may be applied to influence with that proportion, according to the goals of the producer. On the present report, we focused on four reproductive challenges that are critical to cow-calf operations: delayed puberty, poor control of timing of ovulation, early and late embryonic mortality, delayed return to cyclicity after parturition. Interestingly, each of these challenges is associated with growth and ovulation of the ovarian follicle. In the context of beef cow-calf operations, addressing these challenges must be viewed in the context of the breeding season. Specifically, management efforts must be put in place so that females become pregnant early in the breeding season.

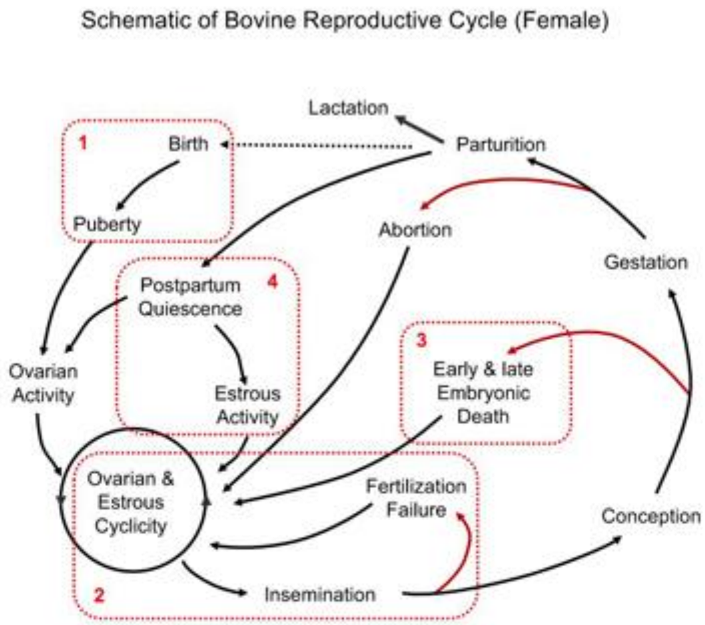

Figure 1: Schematic of the reproductive cycle of a bovine female. Challenges addressed in this report are: (1) delayed puberty, (2) poor control of timing of ovulation, (3) early and late embryonic mortality and (4) delayed return to cyclicity after parturition.

Delayed puberty
Puberty is defined as the first fertile ovulation. Ovulation occurs approximately 28-30 hours after the beginning of estrous behavior (i.e., standing to be mounted). Ovulation of an ovarian follicle is the process of release of the oocyte (a.k.a., egg) so that it may be fertilized by natural service or artificial

insemination. Thus, attainment of puberty is a pre-requisite for pregnancy. Heifers that fail to attain puberty within the time limits of a breeding season will either be maintained on the ranch until the next breeding season or will be culled. Both outcomes will have economic impacts in the operation.

The best current method to determine the pubertal status of a heifer is to conduct an ultrasound-assisted exam of the reproductive tract and assigning a Reproductive Tract Score (RTS). RTS is attributed after evaluating the development of the uterus and determining the ovarian status for size of follicles and presence of a corpus luteum (i.e., sign of an ovulation). RTS ranges from 1 to 5, 1 being an infantile reproductive tract and 5 a pubertal heifer. An experienced technician, usually a veterinarian, is needed to perform this evaluation. Evaluation of RTS is a tool to direct reproductive management of heifers and should be conducted just prior to the beginning of the breeding season. Heifers with RTS 2 and 3 may not develop in time to enter the breeding season. Our group is conducting tests currently to evaluate response to supplemental progesterone (i.e., CIDR) as a mean to induce puberty. Preliminary results indicate that exposure to supplemental progesterone increases the proportion of heifers bred in the beginning of the breeding season.

As expected, there are both genetic and environmental components of attainment of puberty. In general Brahman and Brahman-influenced cross-bred cattle tend to achieve puberty later than Bos taurus type cattle. However, traditional and genomics-based marker-assisted selection has been used to select populations of Bos indicus heifers that cycle earlier. Nutrition plays a determining role in puberty attainment. Cost-effective feeding strategies are necessary to promote growth rates compatible with puberty.

In summary, work is under way to select and manage for puberty. Evaluation of RTS prior to the breeding season will help to direct heifers to induction strategies.

Poor control of timing of ovulation

Protocols for estrous synchronization and timed-artificial insemination (TAI) consist of a strategic sequence of hormonal treatments. Protocols aim to program reproductive events in the animal, with the ultimate goal of timing the moment of ovulation**.** Protocols are very useful tools, used extensively in many production systems that achieve around 50% of pregnancies after a single insemination. In natural breeding systems, use of protocols will increase the proportion of females conceiving early in the breeding season. However, there are many different protocols and they are sometimes confusing to understand and tricky to implement. It is very common to find producers reporting poor pregnancy rates after using such protocols. Word of advice: if you are that producer, I guarantee you will get better as you try and fail a few times! There are multiple explanations for not achieving satisfactory pregnancy rates. There are reasons intrinsic and extrinsic to the protocol. For example, semen quality, inseminator skill, facilities, nutritional and health status of animals, lack of compliance with the schedule of treatments are extrinsic reasons. These must be adjusted by the producer before success is expected from a protocol! Intrinsic limitations of protocols are related to the ability to control timing of ovulation. Specifically, there is a natural dispersion among animals in the response to treatments to synchronize ovulations. Such dispersion will limit success of TAI, but will have less of an effect to AI based on heat detection. Indeed, the old-fashion heat detection became much more practical lately, with the use of heat-detector patches. Importantly, fertility to AI based on detected heat is associated with conception rates around 50-60%.

Early and late embryonic mortality

Embryonic mortality after natural breeding or artificial insemination is about 30-40% in the first 30 days. Reasons for mortality are beyond the scope of this report. Management practices to prevent mortality are an active subject of research currently. In contrast, tools to detect pregnancy losses 20 days after insemination are available. Early pregnancy tests are based on molecular analysis of blood samples and on Doppler ultrasonography. Early pregnancy diagnostics can be coupled with resynchronization strategies that allow ovulation and rebreeding by AI or natural service as early as 24 days after the first AI. Using a re-synch program, it is possible to achieve a 60-70% pregnancy rate in the first 30 days of the breeding season.

Delayed return to cyclicity after parturition

After parturition, cows need an approximately 30-day period to undergo proper involution of the reproductive tract before they are able to sustain another pregnancy. At the same time, ovulations are suppressed because of the long-term exposure to pregnancy hormones. Resumption of estrous cyclicity, and consequently ovulations, is influenced by many factors, including body condition score, milk production, nutrition and breed composition. Indeed, Bos indicus and Bos indicus-influenced cattle undergo a post-partum anestrus of longer duration than other breeds. Enrollment of cows in synchronization protocols involving progestagen supplementation (e.g., CIDR or MGA) effectively stimulates a fertile ovulation and pregnancy following AI or natural service. This practice is desirable to achieve the goal of getting cows pregnant in the beginning of the breading season.

Conclusions

Reproductive challenges must be recognized in the context of the reproductive life cycle of the female, that is, according to the female categories in the herd. Furthermore, challenges must be addressed with the objective of maximizing attainment of pregnancy early in the breeding season. Specific strategies have been developed and applied successfully to mitigate each challenge. Continuous research and extension efforts are needed to improve current knowledge, generate newer, better and more accessible technologies and ensure education and implementation by producers.

Forage Management Application

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Introduction

When we talk about improving pasture management, most may think about expensive practices, heavy fertilization, improved cultivars or rotational stocking. While some of that is important, the truth is that with some planning and small changes, we can make a lot of difference at minimum or no cost! We first need to understand some basic concepts, then take the next steps on investing on our pastures. With issues like overgrazing and lack of adequate forage, other management techniques will have minimum to no effect while still costing labor and money. Thus, we need to first work on some base concepts and do a little planning. In an analogy to animal health, we should work on the causes of the disease (organizing your pasture scheme) instead of only treating its symptoms (feeding more purchased feedstuff). The most common "symptom" we see in pastures everywhere is the lack of forage due to overgrazing, followed by excessive hay feeding during the "off season". A great advantage of Florida over Northern and Western states is the possibility to grow forage virtually year-round. If it is limpograss for the fall and winter in the South Florida or small grains and ryegrass in North Florida, we can cover most of the gaps with some creativity and good planning.

A frequent *modus operandi* is to continuously do things as they have been done in the past, even when they did not work, in hope for a better year. Then, blaming previous failures on factors that were out of our control like the weather, in hope that this year will be better. Well, hope is not a strategy and in business if we do not have a well delineated strategy then,in times of need we may find ourselves desperate trying to find remediation for our problems. And that's expensive! Even for "uncontrolled" factors there can be some yearly planning based on the goals to be achieved for the farm and herd to reduce the negative effects of unpredictable weather and market. For this to occur, first it is essential to understand and become familiar with a few concepts that can help you better manage your pastures in an attempt to sustain forage production for animal performance. Our goal is to improve pasture utilization and create a system that is less dependent on purchased or stored feed and more resilient to variations in weather and market.

Principles to Begin with

Principles are the starting point - the basis of the system. The fundamental principle of pasture management is *carrying capacity*. In simple words, it means the maximum number of animals or animal units that your pastures can support in order to achieve a targeted animal performance without compromising the pasture (Allen et al., 2011). Carrying capacity can be calculated for a pasture or a whole ranch, for a specific period. My personal advice is to calculate for all available pastures for one-year period: this way you know what your options are and how much forage you can count on during that cycle. By knowing our carrying capacity, we can determine how many animals we can have in our system, and further plan our management strategies.

Why is carrying capacity the starting point? Well, if our system is overstocked (i.e. when we have more animals than it can support), we are starting with a negative budget, requiring extra feed (hay, concentrate, etc.) to match our herd's requirements. In that case, no other pasture management practice will be able to overcome that problem (Sollenberger and Vanzant, 2011). Some may argue that fertilizing pastures might help. Yes, but only to a point. Besides, it can be very expensive and little response if the pasture is overgrazed, for example, with few leaves and roots, so plants cannot utilize that extra fertilizer properly. Thus, we need to start from the base of the system.

The second most-important concept is *herbage allowance* which refers to the amount of forage available per unit of animal. Although vital, it is a hard concept to grasp and similarly hard to apply on the real world, because it involves some effort on measuring pasture herbage mass (here we will focus only on the planning part, but for information on measuring pasture productivity, check the UF EDIS publication by Dubeux et al., 2019 - Estimating herbage mass on pastures for adjusting stocking rate). That is why people commonly use stocking rate (lb of live weight (LW)/acre or animal units per acre). However, stocking rate refers only to one side of the equation: the animal. There is no reference of how much forage you have. While one cow-calf par per acre in bahiagrass might seem much, is probably adequate for a pearl millet pasture, for example.

Herbage allowance is normally expressed as lb of herbage dry matter (DM) per lb of LW when we are measuring it on a pasture for that specific period. For planning, it is easier to think about how much the animals need, in % LW of forage available per day and use some predictions of pasture growth to calculate how much pasture you will have. Pasture growth is calculated using herbage accumulation rate (lb DM per acre per day). By calculating the herbage allowance, we can make sure that we are offering sufficient forage to our animals. And, very important: we should have two to three times more forage available than what the animals can consume. This will assure the animals can select what they are eating (i.e. with no restriction to intake) and there will be sufficient plant residual leaves for a fast regrowth. For example, let's consider a 1100-lb cow (1 animal unit - AU) with an intake of 2.5% of its LW per day (roughly between 1.8 and 3%). That means each day it will eat 27.5 lb of dry matter, so we need to offer it between 55 and 82.5 lb of DM per day, which is around 5 and 7.5% LW per day.

There are a few other important concepts that we will not get into much detail. *Resting period* will be inherent to our grazing intensity. The higher the grazing intensity the longer the resting period required for your pasture to recover. Also, a longer resting period will likely reduce total biomass production and nutritive value of the pasture. In fact, resting period can be short if grazing intensity is around 40% (i.e. graze only 40% of initial biomass or canopy height), and this can result in greater herbage production because of the large residual leaf area while also improving animal performance by grazing only the top leaves, which have higher nutritive value. Note that grazing intensity can be high or low with the same carrying capacity and stocking rate, since both parameters are calculated based on a whole area. It is just a matter of how to arrange animals in the paddocks. For example, when you divide the pasture in several paddocks for rotational stocking, the number of animals in each paddock at one time is called *stocking density*. Both, *rotational or continuous stocking* are always hot topics in pasture management discussions. Rotational stocking can improve pasture utilization, while in general animal performance is similar to continuous. But it all conveys to carrying capacity or herbage allowance. As it was mentioned before, rotational stocking will not fix overgrazing.

Planning Your Pasture Management

We often get asked "*How much pasture do I need for my herd?".* The essential question, however, is "*How much forage can I produce*?", then, we can determine how many animals we can feed. Otherwise, we are likely going to face a negative forage budget sooner than later. The first step to improve your grazing management starts before we put the boots on the pasture: it's planning and learning your inventory.

How much forage can we produce? Pasture productivity depends on multiple variables, including species and cultivar, fertilization management, grazing pressure, and climatic factors such as rainfall and temperature. Some of those, like rainfall, are beyond your control unless you have irrigation. But you can manage many other variables. For example, let's think about bahiagrass which is the backbone of our cow-calf industry in Florida. We can roughly say that bahiagrass will produce between 5,000 and 10,000 lb of DM/acre (A) in a season and use that as starting point for our carrying capacity calculation (Table 1). What determines if you are closer to the bottom or to the top range is basically fertility and grazing management (e.g. low fertility and overstocked, then you are probably even below the 5,000 lb/A). When gathering pasture productivity numbers, it is better to use local information (i.e. from research stations closest to your ranch) that have similar weather conditions. If no information is available consult your local extension agent. You can use data from other stations or even start collecting your data[1]. Always on planning, if unsure, shoot for less so there is little risk of lack of forage.

Calculating carrying capacity. On Table 1, the total biomass production of Argentine, Pensacola and UF Riata bahiagrass are presented for Gainesville and Ona, FL, under different nitrogen fertilization rates. On the study conducted by Interrante et al., (2009), forage production was measured from early-May to mid-October (~ 170-d) for three years. On our previous example, our cow eating 27.5 lb DM/d, would then need 4,675 lb/DM for that period. If we were to offer two times that value (9,350 lb DM), then the carrying capacity of our Pensacola bahiagrass (which produced 9,300 lb DM/A) in Gainesville would be around 1 AU/A. The problem, however, is that we will be overstocked both at the start and end of our growing season. Note that we are talking about a *170-d season, not a whole year*. We will also need to do the same calculation for the remaining months, accounting for stockpiled forage, winter pastures or conserved forage (hay, haylage or silage).

Table 1. Total herbage production (lb DM/A) of three bahiagrass cultivars in two sites in Florida managed under grazing with different fertilization rates.

Site	N	Cultivar: Argentine	Cultivar: Pensacola	Cultivar: UF Riata	Source
	lb N/A yr^{-1}		lb DM/A		
Gainesville	180	10,800	9,300	8,400	Interrante et al., 2009
Ona	50	4,800	4,100	4,900	Vendramini et al., 2014
Ona	100	10,000	9,200	-	Mislevy et al. 2005

It is important to understand that the total forage production *does not gives us a sense of forage distribution throughout the year*, so in order to calculate our forage budget, we need to know how much we can produce monthly. The bahiagrass production is more concentrated during the summer months (Figure 1), but, in central Florida, for example, it starts growing probably around April and goes until October or so. An early frost will cut the season short, but a mild fall can result in green grass all the way up to November (that does not mean it is growing much, though).

In Gainesville, FL, Stewart et al (2007) evaluated three management strategies for Pensacola bahiagrass: low, medium and high intensity; based on nitrogen fertilization and fixed stocking rate (Table 2). Although average herbage accumulation rate (the amount of biomass the pasture accumulates per day) for the low intensity treatment was 15 lb DM/A d^{-1}, it ranged from ranged from around 9 to almost 40 lb DM/A.d^{-1} (Figure 1). The authors also noted that for one of the four years of the trial, because of the dry spell during April and May, the grazing season only started in mid-June, when pastures achieved minimum herbage mass to support the animals (~1200 lb DM/A). Had they used the pastures prior to that, the bahiagrass would likely to be overgrazed resulting in reduction of total herbage production and delay in peak of production and reduction of carrying capacity.

[1]Check Dubeux et al. (2019) UF/IFAS EDIS publication on Estimating forage mass on pastures for adjusting stocking rate (in press)

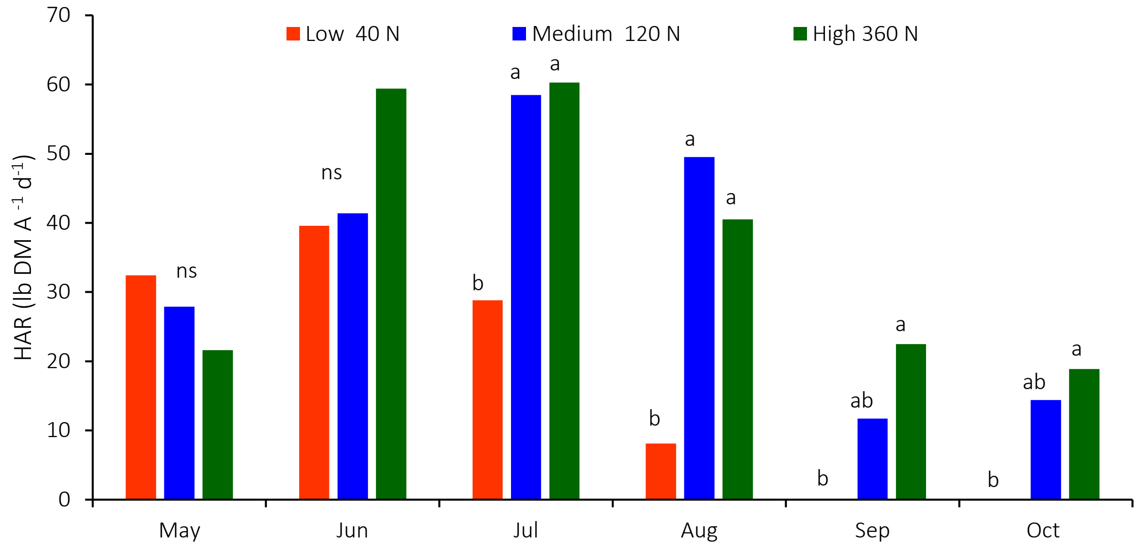

Figure 1. Herbage accumulation rate (in lb of DM A^{-1} d^{-1}) of Pensacola bahiagrass in Gainesville, FL under three management intensities: low, medium and high intensities (adapted from Stewart et al., 2007). See text and Table 1 for treatment description. Different letters on top of bars mean statistical difference between treatments at $p<0.05$; ns = no statistical difference between treatments.

In this study from Stewart et al. (2007), the low management represents the average Florida cow-calf systems while medium and high intensity represent alternative practices to increase the system's productivity. The N rates were split-applied in 3 or 4 times for medium and high management intensities. That resulted in more forage produced and longer growing season. Table 2 shows the 4-yr average of main pasture parameters and animal performance for each treatment. Note the inverse relation between stocking rate and herbage allowance: as we increase our stocking rate, there is less forage for each animal up to a point that we are then limiting intake, thus limiting performance (average daily gain). This can be justified if we are looking at the total gain per area, however, the extra gain from moderate to intensive management came at 2.6 times greater cost and was not economically viable (Stewart et al., 2007).

Table 2. Productivity of bahiagrass pastures and animal performance under different management intensity levels (nitrogen fertilization and stocking rate), in Gainesville, FL. Adapted from Stewart et al. (2007).

Management	**N rate**	**Stocking rate**	**Herbage allowance**	**Total forage mass***	**Average herbage mass**	**Herbage accumulation rate**	**Average daily gain**	**Gain per area**
	lb/A	AU/A	lb DM/lb LW	lb DM/A		lb DM/A d^{-1}	lb LW/d	lb LW/A
Low	36	0.5	4.8a§	3340	3040a	15b	0.75a	90b
Moderate	107	1.1	2.0b	6250	2550b	34a	0.77a	185a
High	320	1.7	1.4c	6840	2630b	36a	0.62b	224a

* calculated from data presented in Stewart et al. (2007)

§ different letters denotes statistical difference (p<0.05) within columns

So, after we calculate the amount of forage we can produce, then it comes the question of *how much to use*. This is called *harvesting efficiency*. It can range from 25% for rangelands up to 70% for annual forages. However, for our tropical forages a safe number is between 40 and 50%. This is similar to the concept of offering 2 times more than the animal can consume. It is important to highlight that harvesting efficiency is different than conversion efficiency: you will not necessarily produce more animal weight by harvesting more forage. Simply because by increasing grazing pressure – to increase harvesting efficiency – you are forcing animals to graze lower quality material; then as you graze closer and closer to the ground, you limit intake by limiting bite mass, while also limiting plant growth by limiting residual leaf area.

For example, let's use the value calculated for total biomass production from Stewart et al. (2007) to calculate carrying capacity, considering the average herbage accumulation rate from May to October (184-d) under the intermediate intensity management (120 lb N/A):

$$34\ lbs\ DM/A.day\ \ \times 184\ days\ =\ 6{,}256\ lbs/acre$$

then, assuming that we can use 50% of that herbage produced (*harvest efficiency*),

$$6256\ lbs\ DM/A \times\ 0.5\ grazing\ efficiency =\ 3{,}128\ lbs\ DM\ available/acre$$

so, we have available 3,128 lb DM/A. If we use that same animal unit from earlier eating 27.5 lb DM per day, during 184-d, it would require 5,060 lb DM, then we would need

$$\frac{herbage\ needed\ per\ cow}{herbage\ \ available\ per\ acre} =\ \frac{5060}{3128} = 1.6\ acres/AU$$

In other words, our carrying capacity is

$$\frac{3128\ lb\ DM/acre}{5060\ lb\ DM/AU} = 0.6\ AU/acre$$

This is already a good start, but we can fine-tune it. As we saw on Figure 1, herbage accumulation rate is variable across the season. This means that we are likely to have a shortage of forage in the edges, while an excess in the middle. In other words, we may be overgrazing in the beginning of the season, which could delay peak of pasture production, and having extra herbage accumulating in the middle of summer, which would result in decreased nutritive value for our pasture. With the same example as before (from Stewart et al., 2007), on Table 3 we have the same calculation as above but broken down by month instead of for the whole season. We multiply herbage accumulation rate by the number of days in each month to get total dry matter production. Then, we determined how much herbage is available and compare to the animal needs for the same period (intake per day times the number of days in each month).

Table 3. Monthly forage production and animal intake to calculate carrying capacity. (Data from Stewart et al., 2007).

Parameter	Unit	May	Jun	Jul	Aug	Sep	Oct
Herbage accumulation rate	lb DM/A d^{-1}	28	41	59	50	12	14
Days		31	30	31	31	30	31
Total DM production	lb DM/A	865	1242	1814	1535	351	446
DM available (50% total)	lb DM/A	432	621	907	767	176	223
1100-lb cow needs	(27.5 lb DM d^{-1})	853	825	853	853	825	853
Pasture needed	acres/AU	2.0	1.3	0.9	1.1	4.7	3.8
Carrying capacity	AU/A	0.5	0.8	1.1	0.9	0.2	0.3

Note that based on our set stocking rate of 0.6 AU/A, we are above that carrying capacity (i.e. overstocked) in May, September and October. This also means that our monthly carrying capacity is more than double in July compared to May. Then, if we stock based on May, we have excess forage in Jun through Aug, which means more dead material and lower nutritive value; but, if we stock based on July, then we are overgrazing all other months. In Table 4, we simulated a forage budget using the prior data for herbage accumulation rate and three stocking rates (0.6, 1.0 and 1.7 AU/A). This differs from the previous example because now we are calculating the balance between how much forage is produced, how much is consumed, and how much carries over to the following month. In addition to calculating the amount of forage produced in the target months, we also added an initial herbage mass of 1200 lb DM/A, which represents the pasture growth during the prior months.

There are two main ways of looking at this: one is assuring we never go below that 1200 - 1500 lb DM/A target; or we always keep at least double the forage needed (i.e. cumulative biomass should be twice as much as intake for most of the season). This exercise helps to visualize the dimension of the excess or lack of forage on pastures in each condition and understand how it will impact animal performance in each scenario. At lowest stocking rate scenario (0.6 AU/A), there is always between 3 and 9 times more biomass than our total needs. The extra herbage left over from the previous month accumulates and, consequently, the nutritive value will decrease. In this scenario, pasture utilization is low and gain per area will be affected. On the other hand, under the highest stocking rate (1.7 AU/A), the cumulative biomass is always very low (much below 1200-lb DM/A target), and gets negative towards the end of the season. This means we will not have enough forage to feed our animals.

Table 4. Detailed forage budget with estimates of forage production and animal intake.

Parameter	Unit	Initial herbage mass	May	Jun	Jul	Aug	Sep	Oct
Herbage accum. rate	lb DM/A d^{-1}		28	41	59	50	12	14
Days			31	30	31	31	30	31
Total DM production	lb DM/A		865	1242	1814	1535	351	446
Total intake 0.6 AU/A	lb DM/A		512	495	512	512	495	512
Cumulative biomass	lb DM/A	1200	1553	2300	3602	4625	4481	4416
Total intake 1 AU/A	lb DM/A		853	825	853	853	825	853
Cumulative biomass	lb DM/A	1200	1212	1629	2590	3272	2798	2392
Total intake 1.7 AU/A	lb DM/A		1449	1403	1449	1449	1403	1449
Cumulative biomass	lb DM/A	1200	616	455	819	905	-147	-1150

Dealing with Seasonality
In the previous examples we saw that as pasture production fluctuates, we need to adjust the stocking rate to better use the forage available. Easier said than done! In a research setting this is straight forward: we bring animals in from other paddocks, put them as needed in the experiments, then remove them when forage production decline. But how can we do something equivalent in the real world? There are several strategies that can help you dealing with seasonality of forage production. First and most common is by harvesting hay: you cut the excess growth form the summer to feed during the winter. On Table 4, for the 1 AU/A stocking rate simulation, if we think about maintaining a residual biomass between 1200 and 1500 lb DM/A, there is about 1000 to 1500 lb DM/A excess during July and August. Thus, we can fence off around 30% of our pasture (i.e. increase stocking density by concentrate our herd in the remaining 70%), which will increase utilization efficiency and allow us to cut hay or stockpile the remaining. The challenge is being able to dry and bale hay in the rainy Florida summer. Alternatively, that area can be stockpiled for deferred grazing (late summer and fall).

The other problem of the seasonality is the “off-season”. Most perennial warm-season forage species, as bahiagrass and bermudagrass, go dormant during the wintertime. In south Florida, mild winters might spark some early growth of bahiagrass, but it is generally not very significant. To overcome this, most producers relay on hay, but there are other alternatives such as stockpiled forage, stored feedstuffs or other supplements, depending on price and availability of them, that could also be used (Prevatt et al., 2018). Winter feeding may be 35 to 47% of annual cost of operation (Redmon, 2000) which directly impact farmer`s profit margins, however it may assure gain or maintenance of animal body condition and can be an advantage later when selling them. For this reason, adequately planning your farm forage is crucial to guarantee forage production and quality throughout the year.

Diversifying your pasture base is another important management practice. For example, in North Florida, a common practice is to overseed pastures with cool-season species to provide up to 150-d of additional grazing during the winter and spring (Fontaneli, 1999). Cool-season species are high quality feed that allow for high animal performance (Macoon et al., 2011), and can often be planted as multi-species pastures, including legumes to allow for biological nitrogen fixation and/or just optimize the peak of production throughout the season. In general, the most used species are annual ryegrass, ryegrass, oats, white clover, crimson clover, and red clover. In South Florida, limpograss has become an important alternative for farmers as stockpiled forage, due to slow decline in digestibility over maturity and growth potential during winter months (Wallau et al., 2015). Stockpiled forages tend to be low in nutritive value and will require supplement to achieve desired animal performance.

Wrapping Up
This is not an exact science, but the key message is to *plan*. Forage budgeting takes some calculation, but it is quite simple and can prevent a lot of headaches. Create different scenarios (including one where pasture productivity is reduced by half), and think about strategies to overcome the challenges that might rise. Perhaps, a way to start is just doing a simple evaluation of total pasture production, as we did in our first examples. Basically, you just need to start somewhere, but initially do not worry too much about many details. Those simple concepts will help you understanding how your system works and will facilitate your planning later. As times go by, planning becomes natural and you will be able to make adjustments based on experience and results from previous years. However, it is important to remember that even when you have laid out an adequate plan ahead, you must prepare for eventual situations you might need to overcome. So, flexibility will be essential. *Hope is not a strategy, so in hopes for a good year we can go broke. Planning can prevent it.*

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