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2017 Plains Nutrition Council Pre-conference Symposium and Wednesday evening reception

The 2017 Plains Nutrition Council Spring Conference

Thursday, April 13

8:30 AM - 11:30 AM **Preconference Symposium -** ***Phibro Animal Health***
11:00 AM - 7:00 PM **Graduate Research Poster Presentations**

2017 Plains Nutrition Council Spring Conference

Thursday, April 13

1:00 PM **Welcome and Introduction -** *Dr. Chris Reinhardt, Amarillo*

1:15 **Attract, Recruit & Retain Top Talent -** *Mr. Matt Schweer, Peak Solution, Ft. Collins, CO*

2:00 **Issues and Challenges in Academia - Demographics of Undergrad Population in Animal Science, Curriculum and Funding Challenges for Training Today's Undergrad -** *Dr. Maynard Hogberg, Iowa State Univ., Ames*

2:45 **Funding Sources and Challenges for Animal Science/Ruminant Nutrition Research in University Systems -** *Dr. Clint Krehbiel, Univ. Nebraska-Lincoln*

3:30 **Break and Graduate Research Poster Presentations**

4:00 **Research Update -** *Dr. Jenny Jennings, Texas A&M AgriLife Research, Amarillo*

4:30 **Price Discovery Issues and Solutions in the Fed Cattle Segment -** *Mr. Jordan Levi, Arcadia Management, Oklahoma City*

5:15 **Research Update -** *Dr. Kristin Hales, USDA MARC, Clay Center*

5:45 **Legend recognitions -** *Dr. Allen McDonald, Chr Hansen Labs, Bushland, TX*

6:00 **Reception** ***Sponsored by RAMP– Sweet Bran Cargill***

Friday, April 14

7-11:00 AM **Research Poster Presentations**

8:15 **PNC Business Meeting**

8:40 **Estimating Energy Values of Feedstuffs - Approaches and Problems** *Dr. Robbi Pritchard, South Dakota State Univ., Brookings*

9:30 **Dr. Kenneth and Caroline Eng Foundation Graduate Student Recognition -** *Dr. Kenneth Eng, San Antonio and Dr. Wade Nichols, Merck, Lubbock*

9:45 **Break and Graduate Research Poster Presentations**

10:15 **Analyzing Undegradable and Bound N fractions in Feeds -** *Dr. Evan Titgemeyer, Kansas State Univ., Manhattan*

11:05 **Predicting Gain from Intake Using the 2016 NRC Equations** *Dr. Pete Andersen, Midwest PMS, Leawood, KS*

12:00PM **Adjourn**

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Graduate Student Research Presentation Recognition

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Issues and Challenges in Academia: Demographics of undergraduate population in Animal Science, curriculum challenges for training today's undergraduate student, funding challenges

Dr. Maynard Hogberg Professor and Chair Emeritus
Departments of Animal Science
Iowa State University and Michigan State University
Ames, Iowa

World population continues to grow with little evidence of slowing down. In fact, the speed of growth is accelerating creating more challenges to produce food for the global population. Most estimates are that we are at 6.9 Billion people in the world today and this number is expected to grow to over 9 Billion by the year 2050. This will put pressure on food and water resources as food needs are expected to double. In addition, as the income of people in developing countries grows there is an increased demand for protein in their diets, especially animal proteins. This would indicate that the number of jobs in food production and food industry will grow making employment opportunities for employees strong but challenging for employers. A recent USDA study, "Employment Opportunities for College Graduates in Food, Agriculture, Natural Resources and Environment-United States, 2015-2020" indicated annual job openings of nearly 58,000 for an expected annual supply of 34,000 agriculture and related graduates. Clearly, job opportunities for graduates will be strong and promising but challenging for employers to fill their job openings.

Demographics

National demographics show that Colleges of Agriculture and Life Sciences are graduating more women in men at the bachelor degree, masters degree and DVM with women making up 52, 55 and 77% respectively for those degrees. Additionally, women now make-up 48% of PhD graduates. This has been fairly constant over the past 15 years. When comparing ethnicity from 2001-02 to 2012-13 again we see little difference in the national demographics. Minority graduates remain around 17% of all graduates for both B.S. and advanced degrees.

A very high percentage of undergraduates in colleges of agriculture and life sciences are U.S. citizens with increasing numbers of foreign students graduating with advanced degrees. This again has been fairly consistent over the last decade and one half.

Since we don't have a lot of good data on animal science departments demographics nationally I will use data we have from Iowa State University. Based on personal conversations with my colleagues in other universities, I believe that this data is similar to what is being seen in other departments of animal science.

Not only has enrollments been growing but there has been a marked shift in gender among students. Anecdotal information from the 1960's would indicate that the gender shift is even more dramatic. In the 1960's the number and percentage of females in animal science departments was quite low. Also, the trend of increasing numbers of minority students is slowly moving in a positive manner.

The background and experience that students bring to the university when they enroll is also changing. (Table3) The changing demographics of our rural farm populations has had a significant impact on the background and experience of the students enrolling in animal science. Fewer students come from a farm background and those entering have less experience with animal production. This will be a challenge to teach students animal production and animal production systems.

In summary, the demographics show that enrollments are increasing in colleges of agriculture and in animal science, there is definitely a shift to more female students, fewer students come from a farm/ranch background and have less experience with livestock prior to entering the university. Much of this has been the result of an aging and depopulation of farm communities and the consolidation and mergers of farms and agriculture industries. This has huge implications on the structure of the curriculum and how classes are taught.

There are other trends that are impact and influencing how students are being educated and prepared to work in the animal agriculture industries:

1. Increasing disconnect between universities and producers,
2. Shift from 12 month to 9 month appointments of faculty,
3. Shift toward grant supported, competitive research,
4. Fewer faculty in general,
5. Fewer faculty that understand animal production systems,
6. Increasing enrollments in animal science,
7. Shift to more urban background students with interest in companion animals,
8. Complexity of curriculum; more on environmental impacts, food safety, animal well-being in addition to animal production,
9. Difficulty in maintaining modern farms for teaching students.

Recruitment

Recruitment of students with an interest and experience working with farm animals should be a priority for animal science departments. In the past, this was taken for granted as most incoming students came from a farm and had experience working with livestock. The students that now have an interest and experience working with animals are likely those involved in 4-H, FFA or junior breed organizations where they have been involved in showing cattle, pigs or sheep. Many university faculty downplay the show ring and don't want to be a part of the show industry. However, I feel that it is very important that university faculty stay engaged to encourage these young people who have shown an interest in the animal industry to purse their education in animal science or related fields. If we can recruit them, then we have an opportunity to provide educational experiences for our feedlot and commercial livestock industries. Interesting, only 11% of incoming students have a career goal of graduate studies or research, likely because they aren't familiar. Again, an opportunity to expose students to career opportunities that fit their passion and interests.

Curricular Changes

Our data on incoming Animal Science students at Iowa State University has shown a trend of decreasing animal husbandry experiences. This is not really surprising since fewer students come from livestock farms and unless they have been involved in 4-H, FFA or youth breed organizations they haven't had the opportunity for animal husbandry experiences. With this in mind, what needs to be done and how should the curriculum change to address this critical factor. Well managed teaching farms and the employment of students at these farms can give rudimentary experiences in working around animals and a basic understanding of farm management. Specialized hands on classes that address proper animal handling can help build confidence in students with minimal or no farm animal experience. Recently our curriculum committee initiated a hands-on one week class to help naïve students gain experience in working around farm animals. One of the goals was to teach proper animal handling to students relative to animal well-being guidelines. Students with little or no background with farm animals found this to be a very positive experience. Our livestock industries have changed rapidly to the use of data to monitor operations and make management decisions. Graduates should be exposed to the use of data to manage feedlots in an advanced management class. Internships are essential to give the students insights on the livestock industry and whether they see this as a career goal. Multiple internships are better than one. Faculty offering independent study/undergraduate research options for students can also give them valuable experience working with animals as well as the livestock industry. Our experience is that when undergraduate students become involved in research projects they become excited about animal industry and animal science research. We need to have more industry personnel involved in presenting guest lectures to classes or speaking to student clubs about the career opportunities that exist within their fields. In 2016, over 50% of our incoming students indicate they have a career goal to pursue veterinary medicine and 15% a goal of working in the animal industry. Most students are not aware of the vast array of career opportunities that exist so it is imperative that departments provide this information with the goal of helping students to find their passion and define their careers. Our experience is that within several months, students already changing their career goals and direction with increasing numbers looking at animal industries and fewer considering veterinary medicine. Making them aware of the vast amount of opportunities available does make a difference.

The USDA, 2015 study indicated that almost one-half of the job opportunities in agriculture will be in business and management and 27% would be in the STEM fields. Traditionally, Animal Science programs have trained students in science and technology with minimal training in business and management. Several years ago when we surveyed our graduates in Animal Science they wished they had taken more business, microbiology, economics and management. Fortunately, we have been able to add a concurrent MBA to our program so seniors can enroll and finish the MBA in one additional year. Animal Science programs need to expand opportunities for including economics and business in their curriculums.

Placement

Placement rates continue to be strong. The robust agriculture industries and the projected shortage of people to fill projected vacancies will continue to make strong job market for new graduates. Table 4 shows entry level salary information compiled from 20 university animal science programs. Overall, the average salary was $37, 360 in 2015-16 with a low of $10,000 and a high salary of $78,000. You will notice that salaries in the agriculture sector are higher than salaries in the non-agriculture sector for graduates in animal science. This does not include those who pursued a graduate program or professional program in veterinary medicine.

The changing structure of our rural areas has created a real challenge in attracting students back to the rural areas. Even in Iowa, this has been a topic of concern with no real solution identified. Some of the solutions is to make sure the amenities found around campuses and more urban areas are available in our rural areas. These amenities can include:

- high speed internet
- quality schools
- fitness centers
- having a cohort of similar age people that can form social groups
- allow flexibility in work schedules to handle parent responsibilities
- promote the quality of life that exists in the rural areas

Employers can help by making sure new hires moving into the community are welcomed and hire a cluster of similar age employees that would have the opportunity to bond. Don't forget that keeping the spouse happy is as/or more important than creating a positive work environment for the employee. Internships also give potential employees an opportunity to experience living and working in a rural community and whether this fits into their lifestyle.

Many students from rural areas would like to live in rural areas if they can. 70% of our graduates in the ISU College of Agriculture and Life Sciences remain in Iowa for their first job. Obviously, our best opportunity for students to be willing to return work in rural areas is with students who grew up there. We also need to increase the diversity of our work force in the future. It will be important that we encourage more members of minority groups who live in rural areas to pursue a degree in higher education. Businesses could be active in recruiting, financially supporting and hiring these potential employees of the future.

The future is bright for students who want to work in animal agriculture. The students coming out of college today in animal science are quite different than they were several decades ago. Can we change our curriculum and approach to meet the educational need? We need to understand what we need to do to make jobs, opportunities and life styles appealing to millenniums if we are to be successful.

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Personal Communication. M. D. Kenealy and J. A. Sterle. Department of Animal Science. Iowa State University, Ames, IA

Table 1. Characteristics of Graduates from Colleges of Agriculture and Life Sciences

	Gender,%		Ethnicity,%		US Citizenship,%	
	2001-21	2012-13	2001-02	2012-13	2001-02	2012-13
B.S.	47M, 53F	48M, 52F	80C, 16M	79C, 17M	98	98
M.S.	45M, 55F	41M, 56F	81C, 14M	76C, 17M	85	83
PhD	59M, 41F	52M, 48F	78C, 17M	74C, 17M	65	60

USDA Study, 2015

Table 2. Characteristics of Animal Science Students at Iowa State University

Item	1989	2009	2016
Number of students	489	823	1129
Gender, %			
Male	61	27	22
Female	39	73	78
Minority, %	4.5	5.8	13.5

Table 3. Background and Experience of Students Entering Animal Science at Iowa State University

Background	1981	2010	2016
Farm/ranch	71%	46%	51%
Small town	14%	26%	31%
Urban/City	15%	28%	18%
Experience			
None	5%	11%	NA
Limited	13%	18%	NA
Crop farm	10%	12%	NA
One species	39%	35%	NA
Multi-species	33%	24%	NA

Table 4. Entry Level Salaries of Animal Science Graduates

Overall Ave. Salary-	$37,360	Low - $10,000	Hi - $78,000
Ave. Ag Salaries	$41,129	Ave. Low- $26,298	Ave. Hi - $57,260
Ave. Non-Ag Salaries	$26,655	Ave. Low- $14,994	Ave. Hi- $39,533

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Funding Sources and Challenges for Animal Science/Ruminant Nutrition Research in the Land-Grant System

C. R. Krehbiel
Department of Animal Science, University of Nebraska
Lincoln

Introduction

Animal Science research will continue to be essential for addressing the global challenge of food (in)security. The demand for meat, milk and eggs is anticipated to double by the year 2050. Increased demand will result from a predicted increase in the world population from 7.2 billion to between 9 and 10 billion people in 2050 (United Nations, 2015). The increased population will place additional strains on the availability of land, water, and energy needed for animal and crop production. Per capita meat consumption will increase as a result of increasing urbanization and a rise in the middle class in developing countries. Global climate variability and the growing threat of disease transmission to and from livestock and poultry provide additional challenges to meeting the demand for animal protein in the future. Unequal distribution of calories from consumption of animal products across the globe and the need to respond to changing consumer preferences provides an opportunity to integrate social science with animal science research. Without an investment in research, U.S. animal agricultural will have difficulty meeting the expected increased demand for animal products for human consumption.

The Food and Agriculture Organization (FAO) estimated a 73 percent increase in meat and egg consumption and a 58 percent increase in dairy consumption by the year 2050 (McLeod, 2011). North America and Europe will likely see little growth in animal protein consumption, whereas consumption in Asia and Africa is predicted to more than double. In addition, consumption of animal products are expected to increase significantly in Latin America and the Caribbean (Rosegrant et al., 2009). Although rates of return on an investment in agricultural research continues to be between 30 and 75 percent, agricultural research and development has been neglected (FAO, 2009a). The remarkable advances in animal agriculture in the past 50 years have been a result of research and development and the adoption of new technologies in areas such as food safety, genetics and breeding, reproduction, nutrition, and disease control (Roberts et al., 2009). Investments in research, infrastructure, and training of the next generation of animal scientists will need to continue in order to meet future animal protein needs.

Funding Needs and Sources

Animal protein provides 13 percent of the calorie consumption by humans globally, and represents 26 percent of the world’s dietary protein needs (Fraser, 2014). In the U.S., 133.9 lb of animal protein were consumed per person in 2012 (37.8 lb of beef/person in 2009), and animal products accounted for over half of the value of agricultural production (USDA ERS, 2014). More than 37 million tons of meat are consumed in the

U.S. on an annual basis (U.S. Census Bureau, 2011). The U.S. is the world's largest producer of high-quality, grain-fed beef, with the largest fed-cattle industry in the world. Cash receipts from milk production is second to beef and equal to corn. The U.S. swine industry has become vertically integrated with an adoption of technology and an evolving industry structure. Pork production in the U.S. accounts for approximately 10 percent of the world's supply and has been among the world's largest pork exporters since 2005 (America's Pork Checkoff, 2009). The U.S. is the world's largest producer and second largest exporter of poultry meat, and is a major egg producer. From 1998 to 2010, the sale of livestock (cattle, sheep, goats, swine, horses, and poultry) and livestock products earned $1.50 trillion (Webb et al., 2012). Crop commodities grossed over $1.61 trillion, with non-animal feed crops and animal feed crops (defined as barley, corn, hay, oats, sorghum grain, corn silage, and millet) bringing $1.25 and $0.36 trillion of total sales, respectively. Total U.S. Gross Domestic Product (GDP) contribution by the agricultural sector ($1.70 trillion) corresponded to 54.6% of the value of livestock and crops cash receipts ($3.11 trillion) from 1998 to 2010 (Webb et al., 2012). In 2014, the value of U.S. food animal production was projected to be approximately $185 billion and the value of crop production was projected to be $195 billion, representing 42 and 44 percent of the total agricultural sector value, respectively (USDA ERS, 2014). Despite the large contribution to our economy, the U.S. is allocating less than 0.20 percent of the value of U.S. food animal production back into publicly funded animal science research through agencies such as the National Institute of Food and Agriculture (NIFA) and USDA Agricultural Research Service (ARS) appropriations.

Heisey et al. (2011) evaluated the impact of future public agricultural research spending on overall U.S. agriculture productivity growth from 2010 to 2050. If funding for agricultural research continued at the current rate, a 50 percent decline in the rate of increase in U.S. agricultural productivity was predicted. In contrast, if funding would meet the rate of research cost inflation a 73 percent increase in productivity could occur between now and 2050. If one assumes a 1 percent increase in inflation-adjusted spending, an 83 percent increase was projected (Heisey et al., 2011). One challenge with our current structure and limited funding is that academic institutions have limited input in setting overall future directions for animal agriculture research. Decisions by administrators have often been made unrelated to any vision of a future for animal agriculture. We have examples of several Departments of Animal Science, including dairy and poultry sciences, that were either eliminated or combined with other departments in well-known U.S. land-grant universities (Roberts et al., 2009). A vision forward and reinvigoration of animal science research are needed to sustainably meet future animal protein demands (NRC, 2015).

From a funding perspective, there are several important points to consider for the future of animal science research. In general, government agencies (e.g., USDA NIFA) and private industry tend to support different kinds of research. A review of the roles of public and private sectors in animal research was discussed by Fuglie et al. (2008). Funding from the public sector is the source of most basic research (i.e., innovative research that advances scientific knowledge but might not have immediate application), while private industry in general focuses more on market-oriented applied and developmental research (Fuglie et al., 1996). Over the past 20 years, federal and state governments have continued to reduce spending for research infrastructure development and graduate training (Green, 2009), despite the fact that costs of large-animal research have increased. In addition, there has been an imbalance among agricultural commodities, with funding for animal agriculture falling behind funding for plants and other life science research. As a fraction of total federal funding for life sciences research, which includes agricultural commodities, natural resources, food science, policy and market analysis, nutrition, food safety, community studies, and administration, animal and plant sciences received 53.1% of funds and other life sciences received 46.9% from 1998 to 2010 (Webb et al., 2012). The federal government provided 22.6% of life science funding to animal science research, 30.5% to plant science research, and 46.9% to other life sciences research. Industry partnerships have been essential for sustaining research productivity in many disciplines including ruminant nutrition and feedlot cattle health and management.

The National Research Council warned about the consequences of underfunding the basic sciences of agriculture in 1972 (NRC, 1972), 1989 (NRC, 1989), and again in 2000 (NRC, 2000). Congress has failed to act in a significant way as overall funding has decreased for animal systems from 1998 to 2011 (NRC, 2015). Overall funding for animal systems has shown large annual fluctuations mainly due to variations in funding received from other federal (i.e., non-USDA) funding sources. NIFA investment in animal science research was essentially stagnant in real dollars between 2003 and 2012, with a mean of $114,584,000 per year (NRC, 2015). The highest priority was dairy production (17 percent of the funding), followed by aquaculture (16 percent), beef production (16 percent), poultry production (12 percent) and swine production (11 percent). Despite the lack of Congressional priority and the declining role that USDA funding has played for agricultural research (NRC, 2014), it should be noted that USDA has funded and continues to fund important research which has resulted in advancements in animal health, food safety, genetics, reproductive efficiencies, nutrient utilization, and animal production systems.

Infrastructure

As indicated, federal (and state) funding for agricultural research has declined significantly in the past 20 years, significantly impacting research and the infrastructure needed to support research. In addition, USDA competitive funding for research, as well as ARS funding, has shown a decreasing trend in real dollars during the last decade. Underfunding animal science research will have long lasting consequences, including a decrease in faculty, post-doctoral and graduate student positions, continued loss or consolidation of many animal, dairy and poultry science units and departments, and the lagging of improvement/enhancement of other essential infrastructure that is critical to the development of innovations to advance animal agriculture in the future. Recovery from these funding trends and associated consequences will require a greater investment with a longer time lag before productive research levels can continue.
The Hatch Act of 1887 transformed the Bureau of Agriculture into the USDA, with its primary emphasis on agricultural research. Interestingly, the Hatch Act mandated that USDA sponsor extramural agricultural research to solve the food challenges that the

country was, and would be, facing. It provided funding to federal laboratories and land-grant colleges for agricultural research through a formula based on each state's share of the rural and farm populations (FA/RM, 2014). Formula funds provided the backbone on which research in animal agriculture was based by focusing on applied, mission-oriented programs, teaching and extension (Roberts et al., 2009). Formula funding (in constant dollars) for agricultural research and extension has decreased 57 percent from 1980 to 2003 (Huffman and Evenson, 2006). Overall revenue to state agricultural experiment stations increased by approximately 21 percent during this same period, mainly due to increased funding from other federal (i.e., non-USDA) and state funding sources, contracts and grants, as well as commodity group and foundation funding. Hatch funding declined in constant dollars from 2003 to 2008, increased in 2007 and 2008, and thereafter declined to levels similar to 2003 (USDA NIFA, 2014). Huffman and Evenson (2006) suggested that formula funding has a greater impact on agricultural research productivity than competitive grant funding. Advantages of formula funding are that it can provide steady support for core research and be used to address issues that are important to individual states. In addition, given that formula funds are not subject to university facility and administrative costs, they have greater purchasing power, and can be used to support improvements in infrastructure. Maintaining animal facilities on university campuses, while critical to our mission, is becoming a greater challenge for Departments and Animal Science.

Graduate Students

Undergraduate enrollments in animal science disciplines (e.g., general animal science; animal breeding, health, and nutrition; dairy science; food animal management; and poultry science) have been steadily increasing since 1987, with 5,000 undergraduate animal science degrees conferred in 2012 (NRC, 2015). In 2012, animal science students made up approximately 7 percent of all students enrolled in food and agriculture departments (FAEIS, 2014). However, a significant shift in demographics has occurred (more students from urban backgrounds) and the majority of students in many departments are interested in veterinary or non-agriculturally related careers. The traditional animal science curriculum structure has evolved to meet the interests and needs of these students, due to the changing face of animal agriculture and basic research needs in animal biology, public interest in the food system, changes in the job market, and evolving interests of students (and consequently future faculty) pursuing animal science degrees.

In contrast to undergraduate student numbers, the number of masters and doctoral degrees conferred in animal sciences appears to be decreasing (NRC, 2015). A decrease in number of PH.D. students could significantly impact future faculty capacity and technical support for allied industries. Departments of Animal Science conferred from approximately 600 M.S. and 200 Ph.D. graduates in 1987 down to 450 M.S. and 200 Ph.D. graduates in 2012, respectively (NRC, 2015). It is difficult to determine what these figures reflect about the current numbers of graduate students with expertise or emphasis in the animal sciences, because some universities also confer disciplinary (e.g., physiology, immunology, animal behavior and nutrition) or interdisciplinary (e.g., agricultural sustainability) advanced degrees, with students trained by animal science faculty members. Despite an 8 percent increase in undergraduate enrollments from 2007 until 2010, faculty headcount in Departments of Animal Science have remained flat (FAEIS, 2012). Similar to the undergraduate curriculum, graduate course offerings have expanded into less traditional animal science disciplines and areas such as animal behavior, animal ethics, contemporary issues, biotechnology and molecular biology. Student interest in veterinary medicine has also lead to more courses on topics like animal health and the human-animal bond (Britt et al., 2008). Research opportunities for undergraduate students are increasing with hopes of recruiting some of the pre-veterinary students into M.S. and Ph.D. programs.

While higher education is evolving, academia and private industry must maintain and advance research in food animal production over the entire production cycle from conception to consumption due to the world's demand for higher quality, more efficiently produced and safer food. Therefore, maintenance of funding for traditional graduate programs is essential to our future. In addition, although education and training for students in U.S. Departments of Animal Science are generally of high quality, these students may lack sufficient knowledge to cope with the necessary requirements and tasks of private industry. For example, employment opportunities within the poultry industry have shifted from primary production to processing, largely due to increases in on-farm production efficiencies that have reduced labor needs (Thaxton et al., 2003). In addition, the poultry industry views technical competence in poultry science as a less-important attribute for employment than good business and communication skills (Pardue, 1997). While training needs for employees might vary greatly among livestock species, communication between industry and academia is essential to determine employer needs for our students. A systems-based approach to both undergraduate and graduate education might help to prevent a mismatch between industry needs and traditional animal science curricula. Ensuring that animal science graduates continue to be employed in the agricultural industries is critical for the future of animal science research, because these graduates are able to recognize and communicate industry research needs and opportunities to academic scientists.

Conclusions

Animal science research has improved animal production and efficiency, decreased the costs of animal products to consumers, increased food safety and security, decreased environmental impacts of livestock production, and is addressing public concerns about animal well-being. Despite the demonstrated importance of animal agricultural research to global food security, there are challenges that could limit the ability of animal scientists to sustainably increase productivity to meet the future global demand. Along with academia, private industry will continue to play a critical role in conducting research and providing research outreach as a part of their technical service teams. In addition, there is a need for communication and partnership building between academia and private industry for the future of animal science research, outreach, and training. Due to the challenges ahead, there has never been a more exciting time to be an animal scientist. Students we are training at the present time will have an incredible opportunity to impact animal agriculture over the next 35 years.

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Research Update – Texas A&M AgriLife Research, Amarillo
Evaluating dietary roughage inclusion rate and particle size in beef cattle finishing diets

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Effects of roughage inclusion and particle size on performance and rumination behavior of finishing beef steers. Roughage is typically mechanically processed to increase digestibility and improve handling and mixing characteristics in beef cattle finishing diets. Roughage is fed to promote ruminal health and decrease digestive upset, but inclusion in finishing diets is limited due to the cost per unit of energy. Rumination behavior may be a means to standardize roughage in beef cattle finishing diets, and increasing particle size of roughage may allow a decrease in roughage inclusion without sacrificing animal performance. Therefore, the objectives of this study were to quantify rumination time for a finishing beef animal and to evaluate the effects of corn stalk (CS) inclusion rate and particle size on rumination behavior, animal performance, and carcass characteristics. Fifty-one individually fed steers (385 ± 3.6 kg initial BW) were used in a randomized complete block design feeding study. Corn stalks were passed through a tub grinder equipped with a 7.62-cm screen once to generate long grind CS (LG-CS) or twice to generate short-grind CS (SG-CS). Dietary treatments were based on steam-flaked corn and included, on a DM basis, 30% wet corn gluten feed (WCGF) with 5% SG-CS (5SG), 30% WCGF with 5% LG-CS (5LG), and 25% WCGF with 10% SG-CS (10SG). The Penn State Particle Separator was used to separate ingredients and treatment diets and to estimate physically effective NDF (peNDF). On d 70, each steer was fitted with a collar (HR Tag;SCR Dairy, Netanya, Isreal), which continuously measured rumination minutes via a sensory microphone. Long-grind CS contained more ($P < 0.01$) peNDF than SG-CS, and the 10SG diet contained more ($P = 0.03$) peNDF than the 5LG and 5SG diets. Dry matter intake was greatest ($P = 0.03$) for steers consuming 5LG and least for steers consuming 10SG, with cattle consuming 5SG being intermediate. Carcass-adjusted ADG and G:F were greatest ($P \leq 0.03$) for steers consuming 5LG and 5SG compared with steers consuming 10SG. Hot carcass weight tended ($P = 0.10$) to be greatest for steers consuming 5LG and least for steers consuming 10SG, with steers consuming 5SG being intermediate. Dressing percent was greater ($P = 0.01$) for steers consuming 5LG and 5SG than for steers consuming 10SG. A significant interaction ($P < 0.01$) occurred for rumination minutes × day. Rumination (min/day) were greatest ($P = 0.01$) for steers consuming 10SG followed by steers consuming 5LG and was lowest for steers consuming 5SG. Increasing particle size of roughage may be a means to decrease roughage inclusion rate while maintaining rumination and performance.

Effects of roughage inclusion and particle size on digestion and ruminal fermentation characteristics of beef steers. Roughage is fed in finishing diets to promote ruminal health and decrease digestive upset, but the inclusion rate is limited because of the cost per unit of energy and feed management issues. Rumination behavior of cattle may be a means to standardize roughage in beef cattle finishing diets, and increasing the particle size of roughage could modulate the ruminal environment and aid in maintaining ruminal pH. Therefore, this experiment was conducted to determine the effects of corn stalk (CS) inclusion rate and particle size in finishing diets on digestibility, rumination, and ruminal fermentation characteristics of beef steers. Four ruminally cannulated steers were used in a 4 × 4 Latin square experiment. Treatments were arranged as a 2 × 2 factorial with treatments consisting of 5% inclusion of a short-grind roughage (5SG), 10% inclusion of a short-grind roughage (10SG), 5% inclusion of a long-grind roughage (5LG), and 10% inclusion of a long-grind roughage (10LG). Differences in particle size were obtained by grinding corn stalks once (LG) or twice (SG) using a commercial tub grinder equipped with a 7.6-cm screen and quantified using the Penn State Particle Separator (PSPS) to estimate physically effective NDF (peNDF). Each period included 14 d for adaptation and 4 d for diet, fecal, and ruminal fluid collections. Animals were outfitted with rumination monitoring collars to continuously measure rumination activity. The 10LG treatment had a greater ($P < 0.01$) percentage of large particles (retained on the top 3 sieves of the PSPS) compared to the other treatments. This resulted in a greater ($P < 0.01$) percentage of estimated peNDF for the 10LG diet compared to the others. Feeding diets containing 5% roughage tended to increase ($P \leq 0.09$) DM, NDF, and starch total tract digestibility compared to diets containing 10% roughage. Cattle consuming LG treatments had greater ($P < 0.01$) rumination time and greater ($P < 0.01$) ruminal pH than cattle consuming diets containing SG roughage. Cattle receiving the 5% inclusion rate of roughage tended to have greater ($P = 0.09$) time (h/d) under a ruminal pH of 5.6 and a larger ($P = 0.03$) area under the threshold compared to cattle receiving the 10% roughage treatments. Overall, feeding a lower inclusion of roughage with a larger particle size may stimulate rumination and aid in ruminal buffering similar to that of a higher inclusion of roughage with a smaller particle size, without negatively impacting digestibility and fermentation.

Isolation of *Fusobacterium necrophorum*, *Trueperella pyogenes*, and *Salmonella enterica* from ruminal, ileal, and colonic epithelial tissues of finishing beef steers receiving different levels of dietary roughage with and without tylosin. To improve our ability to prevent liver abscesses in finishing beef steers, we must evaluate the possibility of pathogens originating from the hind gut as well as the rumen. We hypothesized that pathogens promoting liver abscess formation are located throughout the gut. Furthermore, the increased dietary roughage levels could improve gut integrity overtime. This experiment was conducted to isolate specific pathogens within the ruminal, ileal, and colonic epithelial tissues. Treatment diets were steam-flaked corn-based with 5 or 15% corn stalk inclusion (DM basis) with (5T and 15T) or without (5NT and 15NT) tylosin. Two hundred sixty-four crossbred beef steers (BW = 257 ± 18 kg) were used in a randomized complete block design with 8 hd/pen (8 pens/treatment). Half of the pens for each treatment were designated for serial slaughter while the other half remained on feed the entire experiment for performance evaluation. Steers were fed each day at 0730 h for an average of 220 d (heavy block = 205 d, light block = 234 d). At trial initiation, 8 steers were slaughtered for initial tissue sampling and 1 pen/treatment was slaughtered every 56 d thereafter. During serial slaughter, a dorsal and ventral sample of the rumen was taken for histopathological evaluation along with ruminal, ileal, and colonic tissue for bacterial isolation. Performance data were analyzed using the MIXED procedure of SAS and pen was the experimental unit. Bacterial isolation data were analyzed using the GLMMIX procedure of SAS and animal was the experimental unit. Means were separated using LSMEANS with PDIFF option. There were no differences between treatments for final BW ($P = 0.93$) and feed conversion ($P = 0.17$). The 15NT treatment had the greatest ($P = 0.04$) ADG and 5NT the lowest, with 15T and 5T intermediate. None of the cattle, except one, had abscessed livers. There were no differences in the prevalence of *Fusobacterium necrophorum*, *Trueperella pyogenes*, and *Salmonella enterica* in ruminal, ileal, and colonic epithelial tissues ($P \geq 0.35$). However, this experiment was the first to isolate *F. necrophorum* in ileal and colonic epithelial tissues of finishing beef steers, which suggests that post-ruminal gut tissue could be a source of *F. necrophorum*. With limited efficacy of tylosin in the hind gut, further research is warranted to explore post-ruminal acidosis and its effects on gut epithelial integrity, pathogen prevalence, and liver abscess formation.

Publications

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Research Update - U.S. Meat Animal Research Center

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Introduction

Typically cattle convert less than 20% of the energy in the feed they consume into edible products, but there is variation within populations in the efficiency of nutrient utilization. Thus, the single largest opportunity for improving the efficiency of livestock production is to optimize the animal's ability to convert feedstuffs to a marketable product through improved feed efficiency. There is genetic variation in the efficiency with which cattle use feed (Koch et al., 1963; Rolfe et al., 2011). Dietary factors can also have a large effect on efficiency of growth and nutrient utilization in beef cattle. Additionally, the importance of the rumen microbial community on utilization of forages has been known (Hungate, 1960), yet one of the challenges in studying and quantifying differences in microbial communities in the gastrointestinal tract has been the difficulty in culturing the strict anaerobes. The absence or poor growth of a given bacteria or archaea may be a reflection of the difficulty to culture rather than its abundance. Using DNA sequencing will allow us to infer abundance of microbial groups. Differences in gut microbiota have been associated with obesity (Ley et al., 2005, 2006) suggesting that differences in feed efficiency in cattle may be impacted by the microbiota.

Therefore, recent beef cattle research conducted at the U.S. Meat Animal Research Center has evaluated: 1) long-term breed evaluations of feed efficiency, 2) nutrient and energy balance in drylot cows fed at maintenance, and 3) the influence of the rumen microbiome on feed efficiency in beef cattle.

Long-Term Breed Evaluations

Feed costs are a major economic expense in growing and finishing cattle; however, collection of feed intake data is also costly. Examining relationships among measures of growth performance and dry matter intake (**DMI**), including breed differences, could facilitate selection for efficient cattle while reducing measurement cost. Objectives of this study were to estimate genetic parameters for growth performance and DMI traits and compare alternative indices for feed efficiency to accelerate selection response. Dry matter intake, average daily gain (**ADG**), and postweaning gain (**PWG**) records for 5,606 finishing steers and growing replacement heifers were collected.

Descriptive statistics are presented in Table 1. Dry matter intake and ADG data were recorded over 62 to 148-day testing periods. Individual quadratic regressions were fitted for body weight on time, and ADG was predicted from the resulting equations. Postweaning gain was calculated by dividing gain from weaning weight to yearling weight by the number of days between the weights. Genetic parameters were estimated using multiple-trait animal models with DMI, ADG, and PWG for both sexes as dependent variables. Fixed effects included PWG and feed intake contemporary groups. Covariates included animal age, age of dam, direct heterosis, and breed composition. Breed differences among PWG, ADG and DMI for the 18 artificial insemination (**AI**) sire breeds were estimated and expressed as contrasts between each of the other 17 breed solutions and Angus for each of the 6 traits. In addition, breed differences between feed efficiency indices were also expressed relative to the Angus population for steers and heifers. Breed differences with standard errors are given in Tables 2 and 3 with across-breed comparisons and standard errors represented for 18 AI sire breeds relative to Angus. Breed differences were seen among the 18 AI sired breeds and were statistically significant (17 *df* test; $P < 0.05$) for both steers and heifers for all 3 traits (DMI, ADG and PWG). The Angus breed effect for both steers and heifers was greater for DMI when compared to the other 17 breeds involved, suggesting Angus may have the largest appetite. Similarly, relative to the other breeds for steer ADG (Table 2), Angus, Beefmaster, and Santa Gertrudis breed effects were largest for ADG and the Angus effect was only slightly overcome by Simmental for PWG.

In the heifer ADG traits (Table 3), the Angus breed effect was greatest for PWG while the South Devon breed effect was largest for ADG. Breed differences for the feed efficiency index for both steers and heifers relative to the Angus breed effects are presented in Table 4. Greater values indicate greater efficiency or gain to feed ratio. For the steer unrestricted index including ADG with DMI, Red Angus and Brangus were less efficient relative to Angus while Beefmaster and Limousin had the greatest feed efficiency among all breeds. Red Angus, South Devon, Beefmaster, Brangus, Brahman, Santa Gertrudis, and Salers steers were less feed efficient than Angus steers when comparing the PWG and DMI index while Hereford were most feed efficient and Brahman were the least. When using the ADG and DMI index, less feed efficient heifer breeds, relative to Angus, were Red Angus, Brahman, Brangus, Braunvieh, Gelbvieh, Simmental, and Tarentaise. The same breeds were less feed efficient as heifers relative to Angus, using the PWG and DMI index with the addition of Santa Gertrudis and Salers. South Devon was the most feed efficient heifer breed for each index.

Using a combination of DMI and ADG data, both found to be moderately heritable, should allow for the genetic selection of feed efficiency. The correlations between steer PWG and ADG were moderate and correlations between heifer PWG and ADG were strong. Further research including on-test ADG on shortened intervals used in conjunction with PWG data could lead to shortened feed intake data collection standards. Postweaning gain data could supplement ADG data to derive feed efficiency selection tools. This study is the first of its kind to dissect breed differences in feed efficiency in such a diverse population. Breed differences for feed efficiency were observed and significant in this population confirming variation amongst breeds. These breed differences can be used by commercial producers to select more feed efficient breeds for their production systems.

The Effects of Feeding Monensin to Bred Heifers Fed in a Dry Lot on Nutrient and Energy balance

Intensification of beef cow systems is considered to be a viable alternative production method in times of limited forage availability. Confined cows receiving a limit-fed diet containing monensin may benefit from a decrease in methane production, increased feed efficiency, and greater nutrient utilization. In this study, 16 pregnant MARC III (¼ Angus, ¼ Hereford, ¼Red Poll, ¼Pinzgauer) composite heifers (482 kg initial BW) were used in a 161 day completely randomized design. Heifers were randomly assigned to one of two treatments, monensin (MON) and no monensin (CON). Diets consisted of corn stalks (80% on a dry matter basis), corn silage (10% on a dry matter), and wet distillers grains with solubles (7% dry matter basis). Monensin was delivered daily at 250 mg/heifer in a pellet supplement that was top-dressed at 3% of the diet. Pellets not containing monensin were fed to CON at 3% of the diet. Heifers were limit-fed to provide 100% of estimated metabolizable energy required for maintenance for the first, second, and third trimesters of gestation, respectively. Total fecal and urine collections were conducted over 96 hours to determine nutrient and energy balance. Collection periods occurred on days 14, 42, and 161 of feeding monensin, corresponding to the first, second, and third trimesters of gestation, respectively. Gas exchange was measured on days 0, 3, 14, 28, 42, and 161 using portable headbox calorimeters. Individual heifer oxygen consumption, carbon dioxide production, and methane production were determined over a 24 hour period. By design, there were no differences ($P > 0.05$) in DMI (6.60 kg/d vs 6.61 kg/d; CON and MON, respectively). On day 42 there was a tendency ($P = 0.09$) for MON heifers to consume 1.12 Mcal/day more digestible energy and 1.19 Mcal/day more metabolizable energy ($P = 0.06$) compared to CON heifers. Diet digestibility did not differ between treatments, averaging 44%. Feeding monensin resulted in a reduction ($P < 0.01$) in methane production from 1.58 liters/kg MBW for CON to 1.47 liters/kg metabolic body weight for MON (Figure 1). The magnitude of methane reduction was consistent across time, suggesting monensin is a viable production option for reducing methanogenesis long-term.

Rumen Microbiome Influences Feed Efficiency in Beef Cattle

The ruminant animal harbors a consortium of microbial communities across the gastrointestinal tract that vary in composition and function (Mao *et al.*, 2015). The rumen microbial community is composed of bacteria, protozoa, fungi, and viruses. Bacteria are predominant (10^{11} viable cells/gram rumen content; Mackie *et al.*, 2001) and outnumber the animal host genes by approximately 100-fold (Attwood *et al.*, 2008). This additional bacterial genome provides the animal with metabolic capabilities that influence performance responses.

Data used in this study were collected from a cohort of heifers (n = 125) during 2009 and a cohort of steers (n = 122) during 2014. Animals used were from the Germplasm Evaluation project (**GPE**) from U.S. MARC that included composite animals with varying percentages of: Angus, Beefmaster, Brahman, Brangus, Braunveih, Charolais, Chiangus, Gelbvieh, Hereford, Limousin, Maine Anjou, MARC II (composite of ¼

Simmental, ¼ Gelbvieh, ¼ Hereford, and ¼ Angus), MARC III (composite of ¼ Pinzgauer, ¼ Red Poll, ¼ Hereford, and ¼ Angus), Red Angus, Red Angus × Simmental, Romosinuano, Salers, Santa Gertrudis, Shorthorn, and Simmental. Heifers were fed a growing diet for 84 d comprised of 70% corn silage and 30% alfalfa hay (dry-matter basis) and steers were fed a finishing diet for 78 d comprised of 57.6% dry-rolled corn, 30% wet distillers grains with solubles, 8% alfalfa hay, and 4.4% vitamin and mineral supplement (dry-matter basis). For each animal, individual intake was measured daily using an Insentec Feeding System (Marknesse, The Netherlands). Rumen fluid samples were collected via esophageal tubing approximately 30 days prior to the end of the study. Following collection, rumen samples were snap frozen in liquid nitrogen and then stored at – 80° C until DNA extractions were performed.

Genomic DNA was mechanically extracted from the rumen samples using a commercial DNA isolation kit according to the manufacturer's manual with slight modifications. Amplicon library preparation of the V4 region of the 16S rRNA gene and library sequencing using the Illumina Miseq system (Illumina, San Diego, CA, USA). Sequence reads were processed using standard bioinformatic protocols.

Bacteriodetes, Firmicutes, and Proteobacteria were the dominating phyla and accounted for 85.9 and 94.8% of the total reads for heifers and steers, respectively. Additional main (relative abundance > 1%) phyla included Fibrobacteres, Tenericutes, and Verrucomicrobia for heifers and phylum Spirochaetes for both heifers and steers. Substantial inter-animal variation in the rumen microbiome composition (Jami and Mizrahi, 2012; Hernandez-Sanabria *et al.*, 2010) represents a challenge to identify relationships between the rumen microbiome and host phenotype. Principle coordinate analyses were conducted and steers fed a concentrate-based diet have a more diverse microbiome than replacement heifers fed a forage-based diet (Figure 2). The purpose of this non-parametric analysis is to evaluate how the population structure of bacteria differs or are similar because of diet or management and evaluate extreme differences within the microbiota. Within the rumen microbiome, *Prevotella* is a dominant bacterial genus (Stevenson and Weimer, 2007) and it represented ~28.5% of the total reads in both heifers and steers and it involved in the digestion of polysaccharides (Matsui et al., 2000) and protein (Wallace, 1996). *Prevotella* species have been observed to have both positive (Hernandez-Sanabria *et al.*, 2012) and negative (McCann *et al.*, 2014; Carberry *et al.*, 2012; Hernandez-Sanabria *et al.*, 2012) associations with feed efficiency. *Succiniclasticum* represented 4.9 and 1.5 % of the total reads in heifers and steers and this genus has a role in the production of propionate (Van Gylswyk, 1995). Based on the principle coordinate analyses we conclude that the rumen bacterial population is more variable when steers are fed a high-concentrate diet than when replacement heifers are fed a high-forage diet, which implies that there is greater opportunity to manipulate the rumen microbiome in the steers fed a concentrate diet for improvements in feed efficiency. Additionally, we are currently working to construct a model which uses feed efficiency phenotypes from ADG and DMI to create a discovery set using a small number of animals. The remaining samples will be used to develop linear regression models to predict DMI, ADG, and G:F based on the abundance of OTUs using the discovery data set.

Current and Ongoing Activities

- Energy balance studies to determine the ME:DE ratio and the composition of recovered energy across varying forage and concentrate diets
- Evaluation of the rumen microbiome associated with finishing cattle with and without liver abscesses
- Identify metabolites associated with the presence of *Fusobacterium necrophorum* and liver abscesses in beef cattle
- Isolate and characterize candidate strains of bacteria that negatively associate with liver abscesses and *F. necrophorum* abundance in beef cattle, and determine ruminal parameters and metabolites that impact *F. necrophorum*.
- Novel backgrounding systems for growing calves and subsequent feedlot growth performance and carcass characteristics
- Development of dry matter intake prediction equations for replacement heifers on high-forage diets
- Development of dry matter intake prediction equations for mature cows on high-forage diets

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Table 1. Descriptive statistics for steer (S) and heifer (H) dry matter intake (DMI), average daily gain (ADG) and postweaning gain (PWG) in crossbred beef cattle

Trait	Number	Mean (kg)	Maximum	Minimum	Standard
SDMI	3,212	9.45	17.26	1.63	1.167
ADG	3,212	1.64	2.45	-0.35	0.241
SPWG	3,211	1.53	2.34	0.70	0.176
HDMI	2,394	7.75	12.94	1.72	1.032
HADG	2,394	0.96	1.77	0.07	0.176
HPWG	2,392	0.97	1.65	0.15	0.145

Table 2. Across breed comparisons in grams (SE) of dry matter intake (DMI), average daily gain (ADG), and postweaning gain (PWG) for steers of eighteen AI sire breeds relative to Angus

Breed	DMI (g)	ADG (g)	PWG (g)
Angus	0	0	0
Hereford	**-788 (286)**	-35 (55)	-59 (42)
Red Angus	-310 (275)	-66 (52)	-54 (41)
Shorthorn	**-997 (320)**	-100 (61)	**-123 (47)**
South Devon	-1856 (666)	**-274 (134)**	**-387 (100)**
Beefmaster	**-771 (346)**	72 (68)	**-152 (52)**
Brahman	**-1321 (350)**	-124 (68)	**-359 (52)**
Brangus	-173 (335)	-31 (65)	**-146 (50)**
Santa Gertrudis	-569 (334)	22 (63)	**-97 (49)**
Braunvieh	**-1488 (351)**	**-180 (68)**	**-219 (52)**
Charolais	-521 (289)	-18 (55)	-50 (43)
Chiangus	**-1245 (334)**	-81 (64)	**-174 (49)**
Gelbvieh	**-1051 (278)**	-72 (53)	**-153 (41)**
Limousin	**-1238 (281)**	-5 (53)	**-159 (41)**
Maine Anjou	**-1646 (334)**	**-150 (64)**	**-218 (49)**
Salers	**-1211 (333)**	**-136 (63)**	**-205 (49)**
Simmental	-43 (288)	-19 (55)	18 (42)
Tarentaise	-1178 (678)	-150 (136)	-178 (102)

Significant breed differences (*P* <0.05) in bold.

Table 3. Across breed comparisons in grams (SE) of dry matter intake (DMI), average daily gain (ADG), and postweaning gain (PWG) for heifers of eighteen AI sire breeds relative to Angus

Breed	DMI (g)	ADG (g)	PWG (g)
Angus	0	0	0
Hereford	**-962 (266)**	-21 (44)	-56 (38)
Red Angus	**-684 (255)**	**-86 (42)**	**-75 (36)**
Shorthorn	**-1021 (298)**	**-98 (49)**	**-121 (43)**
South Devon	**-1576 (641)**	13 (109)	-8 (91)
Beefmaster	**-1556 (334)**	-91 (56)	**-157 (48)**
Brahman	**-1351 (319)**	**-185 (53)**	**-257 (46)**
Brangus	-585 (317)	**-120 (53)**	**-149 (45)**
Santa Gertrudis	**-1039 (306)**	**-113 (50)**	**-137 (44)**
Braunvieh	**-1841 (305)**	**-299 (50)**	**-303 (44)**
Charolais	**-876 (270)**	-75 (45)	**-92 (38)**
Chiangus	**-1049 (296)**	**-118 (49)**	**-134 (42)**
Gelbvieh	**-723 (253)**	**-114 (42)**	**-120 (36)**
Limousin	**-1471 (255)**	**-160 (42)**	**-177 (36)**
Maine Anjou	**-1101 (302)**	**-102 (50)**	**-109 (43)**
Salers	**-1176 (306)**	**-139 (51)**	**-164 (44)**
Simmental	-530 (275)	-68 (45)	**-78 (39)**
Tarentaise	**-1926 (566)**	**-312 (96)**	**-291 (81)**

Significant breed differences (*P* <0.05) in bold.

Table 4. Across breed comparisons of efficiency evaluated using either postweaning gain (PWG) or average daily gain (ADG) during feed intake data collection (SE) of eighteen sire breeds relative to Angus with a more positive number indicating a more efficient breed

	Steers		Heifers	
Breed	ADG, DMI	PWG, DMI	ADG, DMI	PWG, DMI
Angus	0.000	0.000	0.000	0.000
Hereford	0.099 (0.051)	**0.067 (0.038)**	**0.094 (0.037)**	**0.069 (0.030)**
Red Angus	-0.014 (0.050)	-0.004 (0.037)	-0.004 (0.035)	0.014 (0.029)
Shorthorn	0.070 (0.057)	0.036 (0.042)	0.025 (0.041)	0.012 (0.034)
South Devon	-0.041 (0.118)	-0.090 (0.087)	**0.203 (0.094)**	**0.197 (0.078)**
Beefmaster	**0.203 (0.062)**	-0.029 (0.046)	**0.096 (0.047)**	0.046 (0.039)
Brahman	0.100 (0.063)	**-0.147 (0.046)**	-0.023 (0.045)	**-0.081 (0.037)**
Brangus	-0.002 (0.060)	**-0.118 (0.044)**	-0.049 (0.045)	-0.073 (0.037)
Santa Gertrudis	**0.119 (0.060)**	-0.006 (0.044)	0.012 (0.042)	-0.002 (0.035)
Braunvieh	0.073 (0.063)	0.019 (0.046)	-0.078 (0.042)	-0.063 (0.035)
Charolais	0.070 (0.052)	0.033 (0.038)	0.030 (0.037)	0.021 (0.031)
Chiangus	**0.130 (0.060)**	0.025 (0.044)	0.008 (0.041)	0.002 (0.034)
Gelbvieh	**0.107 (0.050)**	0.016 (0.037)	-0.027 (0.035)	-0.026 (0.029)
Limousin	**0.206 (0.051)**	0.039 (0.037)	0.017 (0.035)	0.014 (0.029)
Maine-Anjou	**0.130 (0.060)**	0.045 (0.044)	0.031 (0.042)	0.034 (0.035)
Salers	0.070 (0.060)	-0.011 (0.044)	0.002 (0.042	-0.011 (0.035)
Simmental	0.027 (0.052)	0.025 (0.038)	-0.004 (0.038)	-0.009 (0.031)
Tarentaise	0.050 (0.120)	0.011 (0.089)	-0.081 (0.081)	-0.041 (0.067)

Significant breed differences (*P* <0.05) in bold.

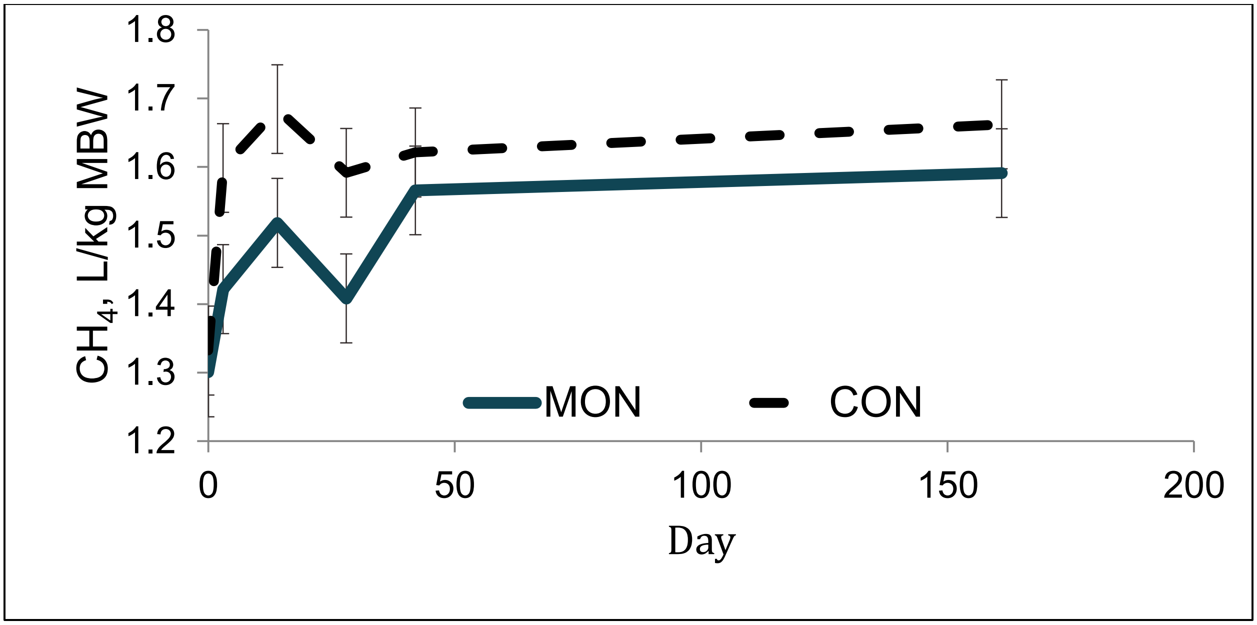

Figure 1. Methane production per kilogram of metabolic body weight for heifers limit-fed a control or monensin containing diet (0 or 250 mg/heifer) at 100% of metabolizable energy for maintenance.

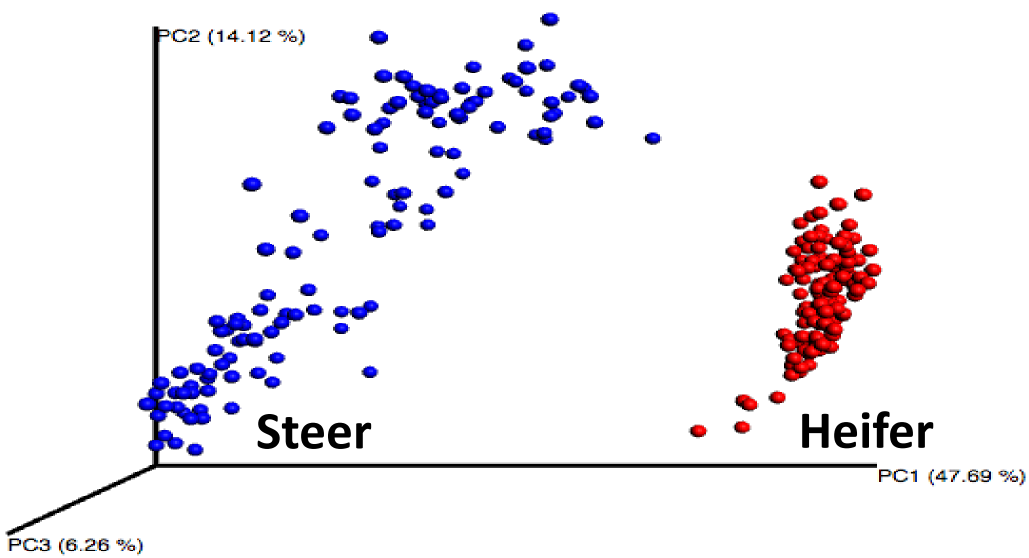

Figure 2. Principal coordinate analysis plot of rumen microbiome from steers fed a high-concentrate diet and heifers fed a high-forage diet.

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Estimating Energy Values of feedstuffs – Approaches and Problems

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Introduction

It was a pivotal accomplishment when Lofgreen and Garrett (1968) put forth the CNES. The approach simplified the complexities of biology and thermodynamics of feed utilization. It gave us a workable way to differentiate useful energy values across the wide range of feedstocks we use in cattle production. They simplified matters to where we needed only a cattle scale, a feed scale and a drying oven to determine NE_m of a feed. We no longer needed to measure energy. The approach of determining Retained Energy (RE) was similarly simplistic, although getting there involved a monumental amount of work. Refinements that came later, many of which are tied to D Fox made the system applicable to a wide variety of cattle types and production situations. The tool has stood the test of time and is the underpinning of all cattle feeding formulations today.

The direct determination of the NE value of a novel feed source requires measuring apparent ME, CH_4, and heat production. Because of the equipment expense and time required, few laboratories are equipped to do this. The next option to consider would be to do a comparative slaughter experiment, much like Loftgreen and Garret (1968) employed. That too is too expensive and intensive to accomplish today. The 3rd option, typical of today, is to derive NE values from cattle performance. The concept is valid but is not as simple as feed and weigh. The objective of this paper is to outline critical steps of the procedure to derive effective NE values for feeds.

Feed and Diet

Few feeds can be tested as sole dietary ingredients. In most instances we will need to substitute the feed of interest for a relatively known value feed such as corn. The true DM proportions of ingredients is critical to the final calculation. This requires continuous sampling of ingredients. Assayed DM of the TMR alone will not be sufficient. This is especially true when there are high moisture components included in the diet. An analogous concern arises in feeding systems or circumstances that lead to sorting and feed refusals. Sorting may contribute to variation in diet consumed among individuals. In systems with carry over feed, there is a possibility that proportionality among ingredients in the orts differs from the original formulation.

These sources of variation are not as trivial as they may seem. When feed substitutions are done at low inclusion (<30% of the diet) even small errors in actual inclusion level become exaggerated with extrapolation to 100% of the test feed value. As an example suppose we have a planned substitution of a test feed at 20% of the diet. Based on that inclusion level we estimate the test feed to contain 70 Mcal/cwt NE_g. If the true inclusion level was at 18% of the diet the NE_g inflates to 78 Mcal/cwt. Alternatively, if we could include the test feed at 70% of the diet and the error in inclusion remained as 2% points, this error only changed the calculated NE_g from 70 to 72 Mcal/cwt. Diet precision and inclusion level are critical.

Mixer performance becomes involved when multiple experimental units are fed from a single batch of mixed feed. A bias of 2% points of a test feed inclusion level from the beginning to the end of a batch is virtually undetectable. The sensitivity of ingredient inclusion also becomes a consideration when studies involve smaller numbers of cattle fed per batch. The scale sensitivity (ie 1 lb, 2, lb or 5 lb) and the tolerance limits for ingredient weights (over/under) are critical when one considers feeding 4 head or 40 head or 200 head per batch. This source of variation makes feeding once daily advantageous when feeding individuals or pens of 4 head, as once daily feeding limits variation for the day to half of what it would be if batching and feeding twice daily.

The potential exists for the test feed to improve or detract from the quality of the mix and consequently alter the apparent NE value of the diet. As an example WDGS will improve mix quality and mix stability of many finishing diets. There is also the potential to encounter positive or negative associative effects that may be unique to the Control diet, which appear as differences in NE_g. The NE of soybean hulls looks quite different depending on whether the hulls replace DRC in a finishing diet, or they replace DRC in a high roughage backgrounding diet. Finally there is always the chance that the test feed has impacted nutrient(s) supply in a way that we do not recognize. Correcting or creating a nutrient deficiency can have a large impact on the estimate of NE_g content of the diet. Collectively these issues suggest that a dose titration study may be the best approach for determining the relative NE_g value for a novel feed.

Cattle

To estimate the NE_g we are estimating the RE based upon LWG. Failure to account for the variables that influence the energy content of LWG leaves us with no more information than we had at Feed/Gain. We have the same results simply expressed using different units. The best tools we have available for estimating RE are the equations published by Guiroy et al (2002). We can use those equations to estimate the mature size of the cattle and it is essential that we do so. This objective determination of mature size (FSBW [NRC 1996]) is critical to subsequent calculation to estimate RE.

Weighing conditions are critical. To be consistent with procedures used to develop the equations we are applying, individual BW needs to be measured in the morning before cattle are fed and then shrunk 4%. Individual BW is important because the predicted %EBF is being estimated on an individual basis. In our group we also use the individual final live BW to calculate Dress% for each individual as a way to confirm that identity was properly maintained in the packing plant. To allow for fill or tags, we calculate final live BW by dividing the experimental unit HCW by a constant Dress%. It would be wise for us all to agree on what that Dress% value should be to standardize methods across our discipline.

The live performance NE determination should be restricted to the period of time the cattle were on full feed of the final test diet. The influence of the novel feed on diet adaptation is a distinctly different factor than the NE value we are seeking. Rather than using off truck, or processing BW, the appropriate initial BW would be a BW captured at 30 to 40 day on feed and shrunk 4%. The amount of elapsed time when capturing BW should not be overlooked. The cattle may not weigh the same at 0700 as they do at 1100 h and BW is critical to the estimate. In our system, the elapsed time limit that I am comfortable with is 2 h.

It does not work to mix cattle with remarkable difference in frame size in each experimental unit. I don't know how much difference in frame size is acceptable, but I do know from past experience that you can go too far. The NE math does not allow averaging these frame size difference in the experimental unit. On a good day the resulting estimates of NE_g are obviously unrealistic. On a bad day, the NE values were wrong, but not obvious.

Assay Sensitivity

I calculated the NE_g in a series of 6 experiments we conducted for other purposes and where things seemed to go right. The number of 8 head pen replicates ranged from 6 to 16 pens. From the statistical analysis we found that the least significant difference in NE_g means ranged from 2.86 to 1.65 Mcal/cwt. The sensitivity response was linear to the number of replicate pens (lsd, Mcal NE_g=3.36-0.106(number of reps); r^2=0.80). Using this relationship, 8 pen replications, and a test feed substitution at 50% of the diet, the difference in NE_g content of the test feed would have to be 5 Mcal/cwt to be recognized as different (P=0.05). This size of study could distinguish the NE differences between DRC and SFC. It would require 18 pen replicates to detect the published NE_g value difference between WSC (65 Mcal) and DRC (68 Mcal). (No wonder people keep arguing about this.)

Beyond all of the sources of variability already discussed, there is the issue of how well a pen stays on feed over the course of the study. It is inevitable that some pens will go off feed. Off feed events and intake cycling are likely not occurring to the same degree in all feeding facilities. Cattle feeding skill becomes a factor in the outcomes (although feeding skill is not a considered issue for JAS). Furthermore, health challenges may not be uniformly distributed among pens and pen location within a facility can impact maintenance costs for the cattle.

The NE Calculations

Zinn et al, (2003) are frequently credited as providing the math necessary to calculate diet NE values from cattle performance. Those equations are preferable because they will allow us to correct for elevated maintenance costs due to environmental conditions. Essentially we can estimate how much to increase maintenance costs by assuming the NE content of the Control diet is correct. Using the Control diet NE values we can go through iterations of the maintenance coefficient until predicted and actual cattle performance converge. If you are not seeking that level of information you can use the spreadsheet that Dr Galyean has published on his TTU web site. Keep in mind that the BW for the Target Endpoint in Dr Galyean's spreadsheet is the FSBW in NRC (1996) vernacular. This is the BW we suggested estimating from the equations published by Guiroy et al. (2002). Using the actual final BW of the cattle will not lead to a good estimation of NE_g unless the cattle were at the 28% EBF when harvested.

Summary

The influence of a feedstuff on F/G is an obviously important criteria to assess when feeding cattle. However, the differences in F/G caused by an ingredient substitution does not necessarily reflect a difference in NE_g. This limits application to the next dietary use of the test ingredient. Many variables unique to the facility or the Control diet can alter F/G. Remember that 2 feeds of similar NE content can result in differences in F/G if one feed simply allows for a higher DMI to be expressed.
Determining the NE content of a feed based on live animal performance requires a rather meticulous approach to cattle feeding. Even then, the sensitivity of the assay is not as good as we would like for it to be. Key components include the relationship between the precision with which we can measure intake of the test feed and the amount of feed provided to the experimental unit, the inclusion level of the test feed in the diet, how we estimate the RE in the cattle, and our ability to keep an experimental unit on feed.

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Analyzing Undegradable and Bound Nitrogen Fractions in Feeds

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"Bound N" is total tract indigestible N **(TTIN)** or more explicitly the N components in a feedstuff that appear in the feces without first being absorbed by the animal or incorporated into microbial mass. Ideally, "bound N" would also include N absorbed by the animal in forms, such as Maillard reaction products, that are unavailable for use by the animal and subsequently are excreted in the urine, but there is a scarcity of data measuring this "bound N" excreted in urine.

Before we consider methods to analyze protein availability in feeds, it is first important to know what information will be of value. A suitable model for evaluating protein in cattle diets should accurately estimate metabolizable protein supply, and this estimation will require knowledge of the ruminal degradability of the dietary protein as well as the postruminal digestion of the ruminally undegraded protein **(RUP)**. For most beef cattle diets, dietary protein supplementation is most important to meet the N needs of the ruminal microbes to ensure that ruminal fermentation maximizes energy availability. For most diets fed to beef cattle, the metabolizable protein requirements of the animal will be met if the N needs of the ruminal microbes are first satisfied. Ruminal microbes can obtain ruminally available N **(RAN)** either directly from ruminally degraded protein **(RDP)** in the diet or from recycled urea-N.

Recycling of urea-N to the gastrointestinal tract **(GIT)**, and presumably that to the rumen, is generally similar when RDP or digestible RUP are included in the diet, at least under conditions where RAN is limiting (Wickersham et al., 2008, 2009). However, RDP will additionally provide the initial amount of ruminally degraded dietary N directly to the microbes and, thus, it is better able to meet the microbes' needs than equivalent amounts of RUP. In other words, RDP provides the microbes with N from the degraded protein as well as N from recycled urea, whereas RUP only provides microbes with N from recycled urea. Therefore, in typical situations for most types of beef cattle production where RAN is the most critical nutrient provided by the dietary protein, RDP will be of greater value than RUP.

Although it is possible to find examples of supplemental RUP improving performance in different classes of beef cattle as a result of increasing metabolizable protein supply, the metabolizable protein requirements of most beef cattle are met or surpassed when the microbes' requirement for RAN is satisfied. Thus, for most situations in the beef cattle industry, we can roughly equate the value of a protein source with its ability to provide RAN, either directly as RDP or via recycled urea-N. In this context, ruminal degradability and postruminal digestibility of RUP are the factors that will affect the ability of protein sources to provide RAN.

In the work of Wickersham et al. (2008, 2009), digestible RUP led to slightly more of the supplemental N being recycled to the rumen (98%) than did RDP (66%). Because the protein sources were provided on an equal total N basis, the RDP provided significantly more RAN to the cattle than did the RUP. The efficiency of urea recycling decreases as RAN supply increases, which might suggest, therefore, that recycling might be quite similar between RDP and RUP, when providing equal amounts of RAN. Thus, for some calculations presented herein, I simplified the relationship between protein supply and urea recycling by using an intermediate value of 80% to predict the recycling of urea from either RDP or RUP. As such, the RAN supply from a protein source could be calculated as RDP plus 0.80 times digested N (regardless of where the N is digested).

Using the 80% estimate for urea recycling from either RDP or digestible RUP, the calculations in Table 1 are designed to consider the effects of ruminal degradability of protein as well as of the bound N content on the value of a protein source in providing RAN. Protein degradabilities were set to range from 20 to 80% of the feed's N, and bound N ranged from 0 to 40% of the total N. Few feedstuffs would have values outside of these ranges. From the calculations in Table 1, there are clearly disadvantages to increasing the RUP content of a feedstuff, even if there is no detrimental effect on TTIN. At the same time, there are additional detrimental effects on RAN if there are increases in TTIN, regardless of the ruminal degradability. Additionally, the effect on RAN of a 30% shift in ruminal N degradability (such as decreasing from 80% to 50%) is greater than the effect of a 30% change in TTIN. A 30% change in ruminal degradability is a real-world possibility if a feedstuff with highly degradable protein were treated to reduce ruminal degradation (e.g., heating of soybean meal). In contrast, 30% of total N being TTIN would represent a rather poor quality feed, likely with extensive heat damage. Feedstuffs with large concentrations of TTIN are generally more likely to have large concentrations of RUP, so it would be unlikely to find a feedstuff with high RDP along with a large fraction of TTIN. In contrast, it is possible to find feeds, such as quality ring-dried blood meal, that would have a large fraction of RUP along with very small concentrations of TTIN (i.e., the RUP is well digested in the small intestine).

The most common way that RUP concentration is increased in many feedstuffs is through heating during manufacturing, and the response is dependent on both the temperature as well as the time of heating. Heating may be added intentionally to increase RUP, or it may simply be a part of normal manufacturing (such as drying). Heating that increases RUP content can also reduce total tract digestibility of protein (i.e., increase bound N), although the heat required to reduce total tract digestibility is usually more than that required to increase RUP concentrations.

With the viewpoint that the main goal of protein supplementation to most beef cattle diets should be to provide RAN, it is obvious that we primarily want to select protein sources that are extensively degraded in the rumen (high RDP) and that also have extensive small intestinal digestion of any RUP that is present. The question then becomes: How can we effectively measure these two characteristics in feedstuffs in a manner that is accurate, fast, and inexpensive?

Assessing ruminal degradation of feed proteins

The gold standard for measuring ruminal protein degradation is *in vivo* evaluation with intestinally cannulated cattle. This is much too slow and expensive to evaluate feedstuffs routinely. However, it is useful for definitively assessing a well-regulated process of feed production.

Many protein systems consider the *in situ* Dacron bag method as an acceptable way to assess ruminal degradation of feed proteins. Most routine analyses with this approach use a single time point for the incubation to improve throughput and reduce cost. By increasing the number of time points, it is possible to more thoroughly partition a feedstuff's protein into fractions (e.g., completely degraded, potentially degradable, and undegradable) and determine the rate of degradation for the potentially degraded fraction; this allows RDP can be calculated across a range of passage rates. If a single time point is used, the time of incubation is important. For example, companies marketing to the dairy industry, where high RUP is valued, are likely to utilize a shorter incubation time to elevate their product's RUP concentration. In the beef industry where greater RDP should be valued, longer incubation times might be preferred for marketing purposes; few feedstuffs seem to be specifically marketed on the basis of a high ruminal degradability. This may be because few feeds have greater RDP than the commonly used soybean meal, alfalfa, and urea.

There are alternative methods that have been used to assess ruminal protein degradation, e.g., *Streptomyces griseus* protease assays (Krishnamoorthy et al., 1983), which seems to work reasonably well for forages (Coblentz et al., 1999). Assays based on non-ruminal proteolytic systems are unpredictable (Luchini et al., 1996) and likely to be even more so when applied to novel feedstuffs. For specific feedstuffs that might experience significant batch-to-batch variation (e.g., distillers grains with solubles), it might be possible to develop specific proteolytic assays that would accurately predict ruminal protein degradation. However, for use across wide ranges of feed types, particularly for novel feedstuffs, I would be leery of basing estimates on laboratory proteolytic assays.

Assessing indigestible or "bound" N

Bound N can be defined as the N from a feedstuff that is not degraded in either the rumen or in the intestines, and thus bound N would be found in feces in a form unaltered from that in the feedstuff. The gold standard for assessing indigestible N would be an *in vivo* total tract digestion study where increases in fecal N are measured as increasing amounts of the supplemental protein source are fed. For this assessment, it is critical to have a control treatment that does not include the protein source being evaluated so both endogenous fecal losses as well as indigestible N from the basal diet can be assessed. Even a total tract digestion study may not truly measure the unavailability of dietary N to the animal. Some dietary N may disappear from the GIT in forms that are not metabolized by the animal but rather are excreted unchanged in the urine. This is believed to be the case for some Maillard reaction products, but there has not been much research to quantify this urinary loss of unavailable N.

Most of the post-ruminal digestion of protein will take place in the small intestine. Titgemeyer et al. (1989) observed that about 10% of the N from fish meal and corn gluten meal disappeared from the large intestine, whereas large intestinal disappearance of N from soybean meal or blood meal was not important. Given the many issues involved, a 10% difference in digestion may not be enough to worry about.

More than 40 years ago, Goering et al. (1972) identified acid detergent insoluble N **(ADIN)** as a useful measure of bound N in heat-damaged forages. A regression coefficient of -1.02 between N digestibility and ADIN concentration suggested that ADIN was quantitatively indigestible in the total tract. Yu and Thomas (1976) provided further evidence to support the observation that ADIN is an adequate measure of bound N in heated forages. Forages without heat damage are likely to contain 7 to 9% of their N as ADIN (Yu and Thomas, 1976), so this could be considered as a threshold for heat-damage. For heat-damaged forages, the use of ADIN to predict TTIN is an easy and accurate approach.

Based on the success of ADIN as a measure of TTIN in heated forages, a number of researchers have assessed ADIN as a measure of bound N in various feedstuffs, and this concept still remains in some models. For non-forage protein sources, there is not a direct relationship between ADIN content and bound N, suggesting that ADIN cannot be used as an accurate assessment of bound N. For example, Nakamura et al. (1994) measured total tract N digestibilities of various sources of distillers grains in lambs, and they found no relationship between ADIN content of the distillers grains and the N digestibility. This agreed with previous work from Nebraska where the ADIN fraction of the feed was not found to be indigestible (Britton et al., 1987). Using the Nebraska data, Van Soest (1994) calculated that 58% of the ADIN disappeared from the GIT.

Demjanec et al. (1995) heated soybean meal **(SBM)** at 165°C for times up to 210 minutes and observed increases in ADIN concentration with increased heating time, although increases in ADIN were not observed until SBM was heated for at least 150 minutes (Table 2). After heating for 75 minutes, there were important increases in RUP concentration but no change in ADIN, demonstrating that ADIN is not a good predictor of changes in RUP. This demonstrates that some processing methods (i.e., heating of SBM) can reduce ruminal protein degradation without increasing ADIN. At the same time, heating for 150 minutes increased ADIN and RUP concentration, but also increased small intestinal digestibility of the RUP, without affecting total tract N digestion. Similarly, although heating for at least 150 minutes increased ADIN concentration, the changes in ADIN weren't related to any large decreases in N digestion. For example, heating the SBM for 210 minutes increased ADIN to 28% of N, but total tract N digestibility decreased by only 4 percentage units. Interestingly, Hussein et al. (1995) demonstrated for these heated SBM that, in agreement with the Nebraska data, ADIN itself was moderately digested by sheep. As discussed above, this would invalidate the use of ADIN as a measure of bound N. The nature of the ADIN seemed to differ across heating times; total tract and postruminal digestibility of ADIN increased with heating time, whereas ruminal digestion of ADIN increased with moderate heating times, but then decreased for SBM heated longer than 150 minutes.

One key piece of information that is lacking is the fate of the ADIN that is digested from heated SBM (as well as other protein sources that contain significant amounts of ADIN). The general assumption is that digested N would be available for urea production and subsequently for recycling to the GIT. However, some heat damaged amino acids (i.e., Maillard reaction products) may be absorbed from the GIT but not subsequently available for use by the animal. In that situation, the nitrogenous compounds may be excreted in the urine unchanged. Nitrogen lost in this manner would be considered as digested N, but it would have the same nutritional value as bound N.

Although ADIN might be useful for qualitatively identifying heat damaged SBM, visual assessment of the color of SBM or distillers grains could provide that same qualitative information much quicker and more cheaply.

Hsu and Satter (1995) evaluated a modification to the protein dispersibility index where the absorbance at 420 nm was measured in the supernatant. They observed that absorbance at 420 nm was inversely related to lysine availability. Lysine availability should be related to intestinal digestion, so it might be possible to predict indigestible N using this simple assay. However, the relationships between absorbance at 420 nm and digestibility have only been evaluated for SBM, so it is not a universally applicable method. It would seem possible that similar methodology could be adapted to other feedstuffs such as dried distillers grains with solubles **(DDGS)**.

Practical recommendations

To this point, I have hopefully convinced the reader that ADIN is not reflective of unavailable N for feeds other than heated silages. When protein supplementation is provided for the purpose of increasing RAN supply, as is the case for most of the beef industry, we would ideally be able to measure the ruminal degradability of the protein as well as the portion of the protein that is indigestible in the total tract (or unavailable for use by the animal, even if absorbed).

In my opinion, the best current option for assessing RUP concentration and postruminal digestion would be the three-step procedure described by Calsamiglia and Stern (1995). This procedure estimates ruminal digestion using a 16-hour in situ ruminal fermentation followed by sequential treatment with acid-pepsin and pancreatin to determine small intestinal digestion of the RUP. The three-step procedure does not directly estimate TTIN. However, as noted above, large intestinal disappearance of N from a supplemental protein source is unlikely to be large, so the estimate of indigestible RUP from the three-step procedure should be a reasonable estimate of unavailable N.

The three-step procedure is used fairly widely to evaluate protein sources, and it has been considered as an acceptable approach by the NRC (2001) as a means of determining small intestinal protein digestibility of protein supplements. Certainly there are some aspects of the three-step procedure that are not ideal. Most importantly, ruminally cannulated cattle are required, which increases the complexity of the assay. One could argue that the data are directly applicable only to feeding conditions that match the diet fed to the cannulated cattle. Moreover, the cost and length of the assay are concerns. Some commercial labs will provide data from the three-step procedure; most commercial analyses would be conducted for feeds destined for use in the dairy industry where high RUP concentrations are valued.

The three-step procedure of Calsamiglia and Stern (1995) provides the key information needed to determine the ability of a protein source to provide RAN. Because the procedure is based on in situ ruminal protein degradation and uses mammalian enzymes to assess postruminal digestion, its biological foundation is relatively strong. Although there are some technical challenges and it is neither the simplest or cheapest analysis, it receives my recommendation for providing a good balance of useful information against cost. Using data collected from the three-step procedure, one could compare the value of protein sources for the beef industry as RDP + 0.8 x total tract digestible protein.

Additional comments relevant to bound N in several protein sources

Dried distillers grains with solubles

DDGS is widely used throughout the beef industry. Currently it is used more as an energy source than as a protein source in finishing diets, so the abundance of protein in the final diet obviates most concerns about unavailability of protein from the DDGS. DDGS has moderate levels of RUP (56% of total N) with reasonably good intestinal digestion (81%; Stern et al., 1997). As demonstrated by the work of Nakamura et al. (1994), even DDGS products with quite high concentrations of ADIN may have reasonably good total tract N digestibilities.

When used as a protein source for supplementing forage-fed cattle, the ability of DDGS to provide RAN is important. In this regard, DDGS would be considered a reasonable, but not exceptional, source of RAN.

Several studies have verified the expected conclusion that DDGS that have experienced more heating have a greater ADIN concentration and a darker color. Cromwell et al. (1993) showed a general relationship between dark color and ADIN concentration of dried distillers grains, although most of the samples in that study were from beverage plants and not from fuel alcohol manufacturers. Cromwell et al. (1993) demonstrated that darker DDGS had lower lysine contents and led to worse performance of pigs fed protein-limiting diets. Lower lysine concentrations reflect irreversible binding of lysine in Maillard reaction products, which would be expected to increase both RUP and unavailable N. In contrast, Nakamura et al. (1994) observed different colors among their distillers grains as well as large differences in ADIN concentrations, yet total tract digestibility of N did not differ appreciably among sources, suggesting that color and ADIN may not be good predictors of the ability of distillers grains to provide RAN to cattle.

Soybean meal

In general, there should not be any concern about unavailable N in any solvent SBM products that have not been purposely heated to increase their RUP concentration. If solvent SBM has been heated, then the product likely is targeted to dairy and not beef cattle. Mechanically processed SBM should similarly be relatively low in unavailable N unless the heat inputs to the products have been purposefully manipulated to increase the RUP concentration. For example, Stern et al. (1997) showed that expeller SBM had an average small intestinal digestibility of 93% of RUP, whereas that for solvent SBM averaged 90%.

Blood meal

Blood meal is a high quality protein source (good amino acid profile) that typically has an RUP concentration of 80% of total N. Among blood meal products, there are broad ranges in unavailable N, with batch-dried products being more likely to have more unavailable N (Stern et al., 1997). The high RUP content as well as high concentrations of TTIN would decrease its value for most beef cattle diets. Because blood meal has greater value in diets for dairy cows or monogastric animals, it is not a feedstuff that has much relevance in the beef industry. Like blood meal, fish meal can be a high quality protein source that has greater value in dairy or swine diets than in beef cattle diets.

Feather meal

Feather meal has limited value in dairy diets or in monogastric diets due to is poor amino acid profile. Feather meal protein is typically quite resistant to ruminal degradation and often has poor small intestinal digestibility, and thus it is not a preferred protein source for beef diets unless it is appropriately processed. A number of studies have shown that processing can dramatically affect the quality (i.e., the ruminal degradability and intestinal digestibility) of feather meal protein. For example, Moritz and Latshaw (2001) showed that increasing the steam pressure during hydrolysis of feathers led to lower ADIN and greater RDP, but also reduced intestinal digestibility of the amino acids, which presumably would be associated with increases in TTIN. Samples of feather meal averaged 76% RUP with only 67% average small intestinal digestibility of the RUP (Stern et al., 1997). Neither of these characteristics suggest that feather meal would be a particularly good source of RAN for beef cattle.

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Table 1. Amount of ruminally available N (RAN) provided by protein sources with different proportions of ruminally degradable protein (RDP) and total tract indigestible N (TTIN)

	RDP, % of total N		
TTIN, % of total N	20	50	80
	--------------- RAN[a], % of feed N ---------------		
0	100	130	160
10	92	122	152
20	84	114	144
30	76	106	NA[b]
40	68	98	NA[b]

[a]RAN was estimated as: RDP + 0.80 x (digestible protein), where digestible protein equals RDP plus intestinally digested RUP. The 0.80 coefficient is based on the assumption that 80% of RDP as well as 80% of digestible RUP will be recycled to the rumen as urea.
[b]NA: more than 20% undigestible N is not compatible with 80% of total protein as RDP.

Table 2. Digestion in sheep of protein from soybean meals (SBM) heated at 165°C (Data from Demjanec et al., 1995 and Hussein et al., 1995)

	Heating time, minutes				
Item[a]	0	75	150	180	210
RUP, % of intake N	35	51	61	77	93
SI digestibility, % of RUP	76	86	97	71	60
Total tract N digestion, %	81	80	79	77	76
ADIN, % of SBM-N	1.6	1.6	10.7	16.8	28.0
ADIN digestibility, % of intake					
Total tract	38	48	67	75	78
Ruminal	30	45	54	52	33

[a]RUP = ruminally undegradable protein. SI = Small intestinal. ADIN = acid detergent insoluble N.

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Predicting gain from intake

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For decades, professionals have attempted to predict or evaluate the performance of cattle based on energy intake. There are three main uses of prediction equations:

1. **Pre-data:** To project the performance of cattle that have been purchased or may be purchased;
2. **Post-data:** To evaluate the performance of cattle fed in the past to determine whether potential was reached; or
3. **Modeling:** To estimate the performance impact of changes in strategy, such as increased days on feed, dietary changes, etc.

The Net Energy system, based largely on the work of Lofgreen and Garrett (1968) provides the basis for most growth models. The original gain prediction equations from this system (NRC, 1984) and the logic behind them will be described in this paper. Following that, updated equations will be described, along with the impact of changes made and assessment of fit with population data will be shown.

The Net Energy system is based on the expectation that cattle require a specific amount of energy for maintenance, based on their body weight, and that cattle will assign energy consumed exclusively to maintenance, until that need has been met. Once maintenance needs have been met, all additional energy consumed creates gain.

Feedstuffs are assigned values for both net energy for maintenance (NEm) and for gain (NEg) so the energy content of the diet consumed can be calculated, based on the inclusion rate of ingredients. A maintenance energy requirement for cattle is calculated, based on their weight.

Energy required for maintenance is calculated using the equation:

NEm (Mcal/d) = $0.077*SBW^{0.75}$, where SBW = shrunk body weight, in kg

SBW can be a weight taken after 12+ hours of feed withdrawal, which used to be a common practice prior to weighing research cattle or it can be actual weight*.956, which approximates the way that live cattle are typically sold (4% shrink off a full weight). When applying the equation to closeouts, it is usually appropriate to use pay weight as the indicator of final weight.

This simple equation produces a straight-line relationship between body weight and NEm required. The exponent (slope) is less than 1, meaning that as weight increases, NEm required increases at a slower rate so a 400 kg steer does not require twice as much energy for maintenance as a 200 kg steer. The equation is not influenced by age, sex, breed, etc. and a case will be made later that it is an oversimplification of actual maintenance required.

Given that, the quantity of feed required to provide required NEm can be calculated by dividing the energy required by the energy content of the feed. Once feed has been set aside for maintenance, remaining feed is used for growth. NRC (1984) provided the basic framework for these calculations in the following equations:

$$\text{Steer ADG} = 13.91 * \text{NEg}^{.9116} * \text{SBW}^{-0.6837}$$
$$\text{Heifer ADG} = 10.96 * \text{NEg}^{.8936} * \text{SBW}^{-0.6702}$$

where weights are in kg and NEg is in Mcal/d, calculated by multiplying the feed available for growth by the NEg content of the feed.

Predicted gain is based on the energy retained in the empty body of the growing animal. The exponents attached to the NEg intake are lower than one, meaning that as intake increases, the next unit of energy consumed will create less growth (weight) than the previous. That reflects the knowledge that as growth rate increases, fat comprises an increasing proportion of that gain (Figure 1). Calories are deposited with equal efficiency but because of increasing energy density of gain, additional calories have less impact on weight gain.

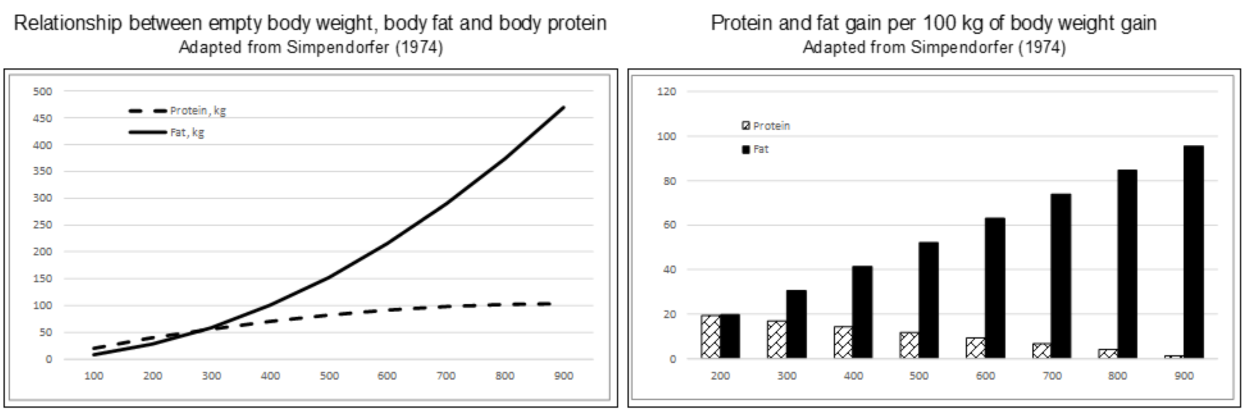


Figure 1. The relationship between body weight, weight gain, and fat and protein gain.

The exponents attached to weight are negative, reflecting that as weight increases, energy is converted to weight gain less efficiently. This also reflects composition of gain since maintenance has already been separately accounted for.

Additionally, slopes and intercepts differ between steers and heifers in the 1984 equations (Table 1), accounting for differing composition of gain between the sex groups. At any given weight, representative heifers are fatter than steers of similar weight. At any given rate of gain, fat deposition comprises a greater proportion of heifer weight gain than of steer weight gain.

Table 1. Effect of feed intake and weight gain on predicted daily gain of steers and heifers.

Effect of increasing intake on predicted ADG
700 lb animal consuming a diet containing .70 Mcal NEg/lb
NRC (1984) equations

ADFI, lb	Feed for gain	NEg, Mcal/d	Steer ADG	Heifer ADG
10	4.28	3.00	1.62	1.35
12	6.28	4.40	2.30	1.91
14	8.28	5.80	2.96	2.44
16	10.28	7.20	3.61	2.96
18	12.28	8.60	4.24	3.47
20	14.28	10.00	4.86	3.97

Effect of increasing weight on predicted ADG
Steer or heifer consuming 18 lb of a diet containing .70 Mcal NEg/lb
NRC (1984) equations

Wt, lb	Feed for gain	NEg, Mcal/d	Steer ADG	Heifer ADG
200	15.77	11.04	12.54	10.05
400	14.24	9.97	7.11	5.77
600	12.91	9.03	4.93	4.03
800	11.68	8.18	3.70	3.04
1000	10.53	7.37	2.89	2.38
1200	9.43	6.60	2.31	1.91

The original equations were developed from populations of cattle fed in the 1950's and 1960's. Although based on sound science, they require adaptation to be applicable to the modern cattle population. The cattle used by Lofgreen and Garrett (1964) were British breed cattle without substantial genetic variation. The original equations fit such cattle well but as the cattle population changed with the introduction of Continental breeds and accelerated selection for growth, a mechanism was required to adapt the equations to fit a cattle population that was larger, more muscular and more variable than before.

A scaling mechanism was required that allowed adaptation of the equations to cattle populations of differing mature size. Such a mechanism was introduced with the 1996 NRC revision. This version included new terminology and additional calculations, all designed around the concept of describing cattle by use of the weight at which they were expected to achieve a designated percentage of empty body fat (EBF), equivalent to the steers in the Garrett (1980) database.

New terminology included equivalent shrunk body weight (EQSBW), standard reference weight (SRW) and final SBW (FSBW), defined by NRC as:

EQSBW = the SBW equivalent to the NRC (1984) medium frame steer
SRW = standard reference body weight for the expected final body fat
FSBW = final SBW at the expected final body fat of the animal

The new equation for prediction of gain becomes:

$$ADG = 13.91 * NEg^{.9116} * EQSBW^{-0.6837}$$

where EQSBW = SBW*(SRW/FSBW). Structurally, the equation is the same as the 1984 steer equation with EQSBW in place of SBW. Maintenance calculations were unchanged as were the exponents and intercept.

So what is different and what does it really mean? We now have to deal with EQSBW, which is a calculated value, used in the equation in place of an actual weight. Essentially, the actual weight is multiplied by an adjustment factor (SRW/FSBW) which should reflect the difference between the animal being evaluated and a standard reference animal.

The challenge is in identifying the appropriate FSBW for an animal or group of animals. Precise identification of FSBW would require knowledge of the current composition of the animal in question, and the weight at which that animal would contain a specific EBF percentage. That is more or less impossible but there are estimates that can be made. NRC uses marbling score to describe body composition and equates a marbling category to a percentage of empty body fat. Standard reference weights for a medium frame steer are defined by NRC as:

Marbling category	Body fat, %	SRW, kg
Traces	25.2	435
Slight	26.8	462
Small	27.8	478

The Small marbling category corresponds to low Choice quality grade (assuming A maturity). If NRC means an average of Small 0, that would indicate approximately 50% of the cattle in a group grading Choice with a normally distributed population. So then, if the cattle being evaluated will reach 27.8% EBF (50% Choice) at exactly 478 kg, that is defined as their FSBW and the EQSBW is equal to SBW because SRW/FSBW = 1. In that case, the equation will deliver the same prediction as the original (1984) steer equation.

There are two problems with practical application of this approach. First, we generally have no earthly idea how much a given animal would weight at 27.8% EBF and no way to estimate that weight with much precision.

Second, in many markets these days, 478 kg (1053 lb) is a feeder steer, not any type of a finished product. If the cattle being evaluated are of a different size, the inclusion of EQSBW produces an adjustment. That effect is detailed in table 2 below, where all factors are equal except the FSBW (projected weight at 27.8% EBF). Increasing FSBW means larger mature size and therefore leaner composition at any given weight (300 kg in the example below). With leaner composition, an equal amount of feed produces

Table 2. Final Shrunk Body Weight (FSBW) and predicted gain

Impact of mature size (FSBW) on predicted gain

	small	medium	large	larger
Current weight (SBW), kg	300	300	300	300
Standard reference weight (SRW), kg	478	478	478	478
Final shrunk body weight (FSBW), kg	425	478	600	650
Equivalent shrunk body weight (EQSBW), kg	337	300	239	221
Predicted ADG, kg	1.21	1.31	1.54	1.62

Note: ADG assumes consumption of .70 Mcal NEg diet at 2% of SBW greater ADG because the gain has lower energy density. There are all kinds of equations that can be used to predict daily protein or fat gain but they make my brain hurt so I just stick with weight gain but will discuss relationship with carcass results briefly later.

NRC estimates FSBW of an average steer in the current industry to be 600 kg so that is a reasonable starting point for any predictions or evaluations.

Note that the intercept and exponents in the updated equation are the same as the original steer equation and that the heifer equation has disappeared. There is no need for separate equations for steers and heifers now that the impact of mature size is managed through alteration of FSBW. As a rule, heifers can be assumed to have FSBW 80% that of steers of equal genetic merit. In the example above, the “medium’ column uses FSBW of 478 kg, which is just under 80% of the “large” column. That serves as an example of prediction for a steer and heifer of equal genetic merit where the steer would gain 1.54 kg/d and the heifer 1.31 kg/d, with current weight and feed consumption equal.

Impact of growth promotants Implants and beta-adrenergic agonists increase protein deposition, which is best depicted in the prediction equation by use of higher FSBW. The original equation assumed use of an estrogenic implant but did not account for typical current practices like reimplantation, use of trenbolone acetate, and beta agonists. NRC recommends the following FSBW adjustments to account for use or non-use of these management practices:

No implant – decrease FSBW by 25-45 kg
Use of TBA+E – increase FSBW by 25-45 kg
Use of a beta agonist – increase FSBW by 6-36 kg

Although beta agonists can have a substantial effect on final weight and carcass weight, they are applied at the end of the feeding period and thus do not affect performance for most of the days on feed. As a result, the low end of the FSBW adjustment range should be used.

Impact of previous nutrition It is generally agreed upon that extended periods of slow growth increase mature size and that placing young cattle directly on feed (calf-feds) reduces mature size. NRC facilitates believers in these concepts with the following adjustments:

Extended periods of slow gain – increase FSBW by 25-45 kg
Continuous high energy beginning at weaning – decrease FSBW by 25-45 kg

NRC recognizes the effects of growing programs, defined as extended periods of slow gain as having substantial impact on the mature size of the animal. This differs from compensatory gain, the rapid and efficient gain that follows a period of undernutrition. Adjustment for compensatory gain is best handled by adjusting maintenance requirement and will be discussed later.

NRC does not specifically comment as to whether effects of growth promotants and previous nutrition are additive but the author assumes that they are due to differing mechanisms of action. The user should apply some caution because the average steer now receives a TBA+E implant and most are fed as yearlings so those adjustments should not be added to the 600 kg FSBW.

Validation with population data

To determine how well the equations work with current cattle performance, data were obtained from three large commercial feedyards. Yard K is in southwest Kansas, feeds flaked corn as the primary energy source and feeds high quality cattle, marketing mostly on a quality-based grid. Yard N is in Central Nebraska, feeds high moisture corn as the primary energy source and feeds high quality cattle, marketing mostly on a quality-based grid. Yard T is in the Texas panhandle, feeds flaked corn to a population that varies in genetic capability and markets on a grid with both quality and yield grade incentives. From each yard, closeout records from all lots closed in 2016 were obtained. In addition, each yard provided diet composition and dates and amount fed for each diet. Yard T also provided yield grade data on each lot. No natural, NHTC or other reduced technology programs were implemented by these yards during this time period. All cattle in the data set received TBA+E implants and Optaflexx.

Data were cleaned in the following way:

1. All lots with fewer than 40 head placed were excluded.
2. Lots defined as anything other than steers or heifers were excluded from the analysis. There were no lots identified as Holstein in any yard. A subset of lots identified as of Mexican origin in yard T was analyzed separately from native cattle records.
3. Raw data (pay weights, total dry feed and total head days) were used to calculate performance results for each lot.
4. “Deads out” ADG and ADFI were calculated by removing initial weight for each dead according to the pen average initial weight and removing the estimated amount of feed that each dead animal consumed.
5. Mean body weight was the average of initial and final body weight for each lot and was used as the SBW for calculations.
6. Mean NEg concentration of the total feed consumed by each lot was calculated from quantities and NEg concentrations of the various step-up diets and finishing diets. NRC (2016) energy values for feedstuffs were used, which, in some cases differ from previous publications. A few minor ingredients were included with energy estimates provided by the nutritionists responsible for the diets.

Following cleaning, the data set used in analysis included 1687 lots of native cattle, totaling 292,589 head, plus an additional 297 lots and 61,396 head of Mexican origin.

For descriptive purposes, gain was predicted for each lot using the NRC (1984) equations (separate steer and heifer equations). Observed (actual) ADG exceeded predicted ADG by 11%, validating the need for a scaling mechanism to adjust for increased genetic capability of the current cattle population.

To create a best fit relationship using the entire data set and the newest equation, SRW was defined as 1053 lb (478 kg) for each lot (Table 3). Through an iterative process, a single FSBW value that resulted in the smallest total prediction error for all steer lots was identified. For this exercise, yards were weighted equally. The exercise was repeated with heifer data.

Using SRW of 1053 lb, the FSBW values that provided the least prediction error were 1204 lb for steers and 1005 lb for heifers. These results indicate that a modern steer with a mean weight of 1204 would have the gain predicted for a 1984 steer weighing 1053 lb and a modern heifer weighing 1005 would perform like a 1984 **steer** weighing 1053 lb.

Table 3. Best-fit relationships from commercial feeding population dataset

Results of "Best Fit" iteration using population data
SRW = 1053 lb for all lots, FSBW = 1204 lb (steers) or 1005 lb (heifers)

Sex	Yard	Wt in	Wt out	Wt mean	NEg conc	ADFI	Pr ADG	Obs ADG	FtG	Err	Abs err	Obs v Pred	EQSBW
HFR	K	717	1245	981	0.68	20.10	3.27	3.40	5.92	-0.14	0.22	104%	1028
	N	845	1365	1105	0.65	23.60	3.29	3.33	7.22	-0.04	0.25	101%	1157
	T	751	1242	996	0.70	19.62	3.20	3.02	6.52	0.19	0.25	94%	1044
Total		770	1283	1027	0.68	21.10	3.25	3.25	6.54	0.00	0.24	100%	1076
STR	K	810	1368	1089	0.68	21.38	3.61	3.78	5.67	-0.17	0.27	105%	952
	N	792	1463	1127	0.65	23.54	3.63	3.67	6.43	-0.04	0.23	101%	986
	T	822	1431	1126	0.70	21.39	3.59	3.40	6.31	0.20	0.27	95%	985
Total		811	1428	1119	0.68	22.01	3.61	3.55	6.22	0.05	0.26	99%	979
Combined		793	1365	1079	0.68	21.62	3.45	3.42	6.36	0.03	0.25	99%	1021

To simplify the process, once a best fit FSBW has been calculated, the proportion of those two, expressed as a percentage can be used for subsequent calculations instead of going through the exercise of using SRW and FSBW to calculate EQSBW. Table 4 below shows what the adjustment would be for the data set used in this exercise, with cattle of Mexican origin separated.

Table 4. Adjustments to Final Shrunk Body Weight (FSBW) as a proportion of SRW based on commercial feeding dataset.

Adjustment required based on best fit

	SRW	FSBW	Proportion
Steers	1053	1204	87.5%
Heifers	1053	1005	104.8%
MX steers	1053	980	107.4%
MX heifers	1053	837	125.8%

As an example,

$$\text{Steer ADG} = 13.91*\text{NEg}^{.9116} * (\text{BW}*.875)^{-0.6837}$$
$$\text{Heifer ADG} = 13.91*\text{NEg}^{.9116} * (\text{BW}*1.048)^{-0.6837}$$
$$\text{Mexican steer ADG} = 13.91*\text{NEg}^{.9116} * (\text{BW}*1.074)^{-0.6837}$$
$$\text{Mexican heifer ADG} = 13.91*\text{NEg}^{.9116} * (\text{BW}*1.258)^{-0.6837}$$

Thus, to predict ADG for a steer that weighs 1000 lb, or for a post-data evaluation of a steer with mean weight of 1000 lb, the equation should be used with 875 lb as the current or mean weight.

These adjustments based on FSBW seem plausible and fit the data in total. If the cattle and results from this population are representative of the entire industry, use of 1053 lb for SRW and FSBW of 1005 (heifers) or 1204 (steers) would be appropriate.

Relationship between observed (vertical) and predicted ADG
All yards, all sex groups

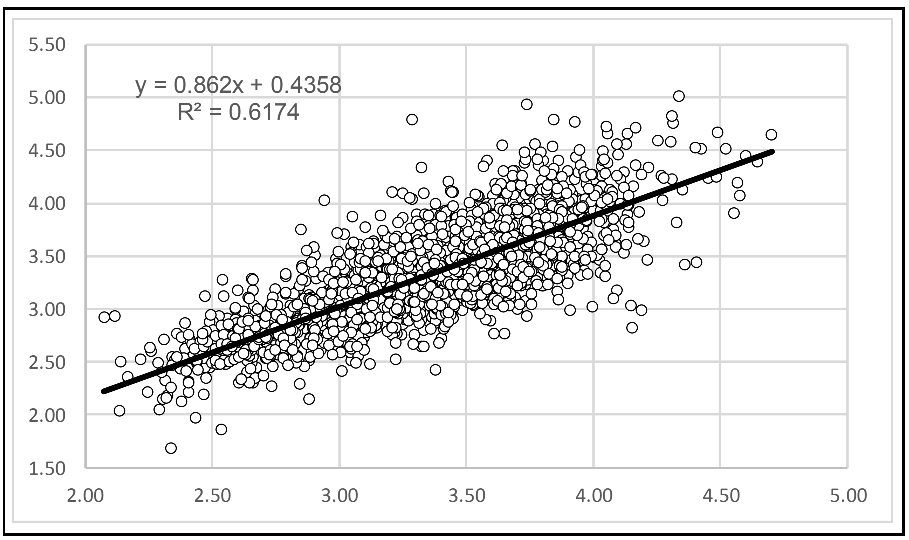
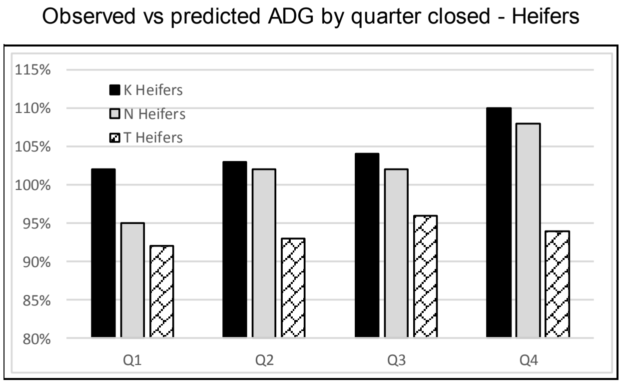


Figure 2. Predicted (X-axis) compared to observed (Y-axis) daily gains for the commercial feeding population dataset.

While use of the indicated FSBW values resulted in the smallest possible error for the entire group, fit for individual lots was mediocre as shown by the scattergraph above (Figure 2). The equation only accounted for 61.74% of the variation in lots and mean absolute error was .25 lb/d, or 7.3% of an overall mean ADG of 3.42.



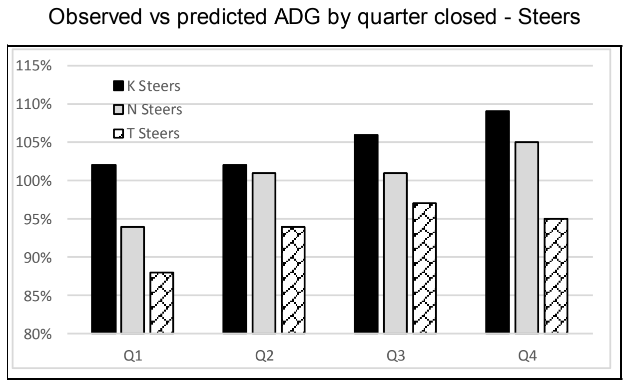


Figure 3. Observed and predicted daily gains by sex, feedyard, and quarter of the year that lots were closed out in the commercial feeding population dataset.

To improve precision, two adjustments were made to the predicted ADG values. Based on data reflected in the charts above (Figure 3), mean adjustments were made based on the quarter that cattle were closed and the mean yard effect. As shown in the scatter below (Figure 4), R-squared was improved by including adjustments for yard and season. The equation accounted for 73.71% of variation and mean error was reduced to .21 lb/d, or 6.1% of mean ADG.

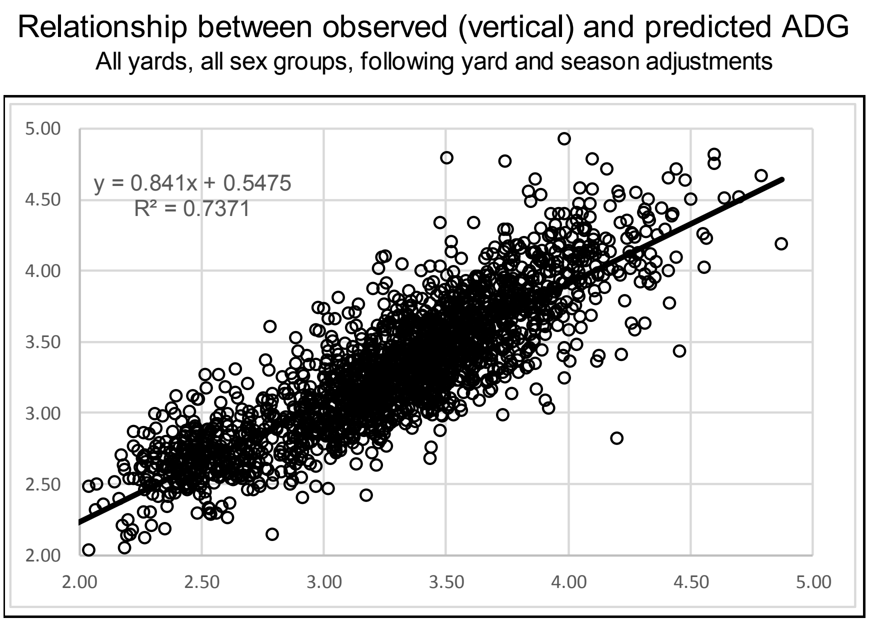


Figure 4. Predicted (X-axis) compared to observed (Y-axis) daily gains for the commercial feeding population dataset after adjusting for close-out date and mean feedyard effect.

As expected, adjustments for yard and season improved precision but they did not alleviate a concern from the first exercise. In both cases, the slope of the line depicting the relationship between predicted and observed ADG was less than 1, indicating that predicted ADG did not increase at the same rate as observed ADG. While fit was close for lower ADG lots, error increased as ADG increased.

Within sex groups, high ADG is related to both weight (placement weight, final weight or mean weight) and feed consumption. One way to adjust for weight in the prediction model is to alter the calculated maintenance requirement, since energy required for maintenance is strictly a function of weight.

Reducing the exponent in the maintenance equation to 0.72 from 0.75 increased predicted ADG by making more feed available for gain and the increase was proportionately higher for heavier cattle. With the different maintenance requirement, FSBW had to be refigured and the best fit was obtained with FSBW of 1055 for steers and 885 for heifers. Following these adjustments, R-squared was increased further and mean error was reduced to 0.19 lb/d or 5.5% (Figure 5). Equally important, the slope of the line is now 0.9935 so although this version does not account for all of the variation in ADG, error is now equal across weight and ADG groups.

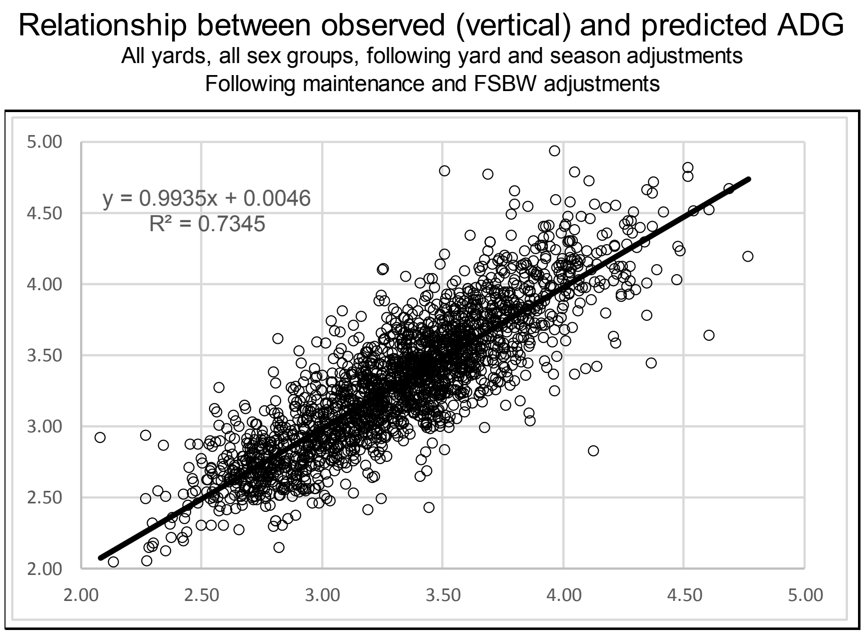


Figure 5. Predicted (X-axis) compared to observed (Y-axis) daily gains for the commercial feeding population dataset after adjusting for close-out date, mean feedyard effect, maintenance and FSBW.

Although the maintenance equation has not changed for decades, it makes some sense to adjust it, reflecting potential error at both ends of a feeding period. Cattle that are placed on feed in thin condition, following a period of undernutrition will typically show some compensatory gain, meaning that they gain more than predicted for a period of time, mostly due to a transient reduction in maintenance requirement during realimentation. At the start of the feeding period, adjusting maintenance downward by

15-25% for a period of 14 to 21 days is a relatively precise way to account for compensatory gain.

Adjustment makes sense at the end of the feeding period as well. Cattle are often fed to higher EBF endpoints than in the reference populations that were used to develop the original equation. Addition of 100 lb of body weight at a high EBF percentage would not be expected to increase metabolic activity by the same proportion that weight increased since adipose has low metabolic activity. Further, it is the author's opinion that cattle become more sedentary at high EBF, following extended feeding periods. This lower level of physical activity would reduce energy required for maintenance.

As a result, changing the maintenance exponent to 0.72 and re-setting FSBW improved both accuracy and precision. For an interesting aside on the origin of the 0.75 exponent for maintenance calculation, see the Appendix at the end of the paper.

Here are some options that were tried but did not improve precision further:

1. Adjusting intercept or exponents in the gain equation instead of maintenance calculations.
2. Using an SRW different from 478 kg (1053 lb) and resulting appropriate FSBW.
3. Weighting initial weight higher (or lower) than final weight when calculating mean weight or applying shrink to initial weight.

One additional possibility for the differences in precision between yards is variation in by-product energy levels or error in assigning energy values to those by-products.

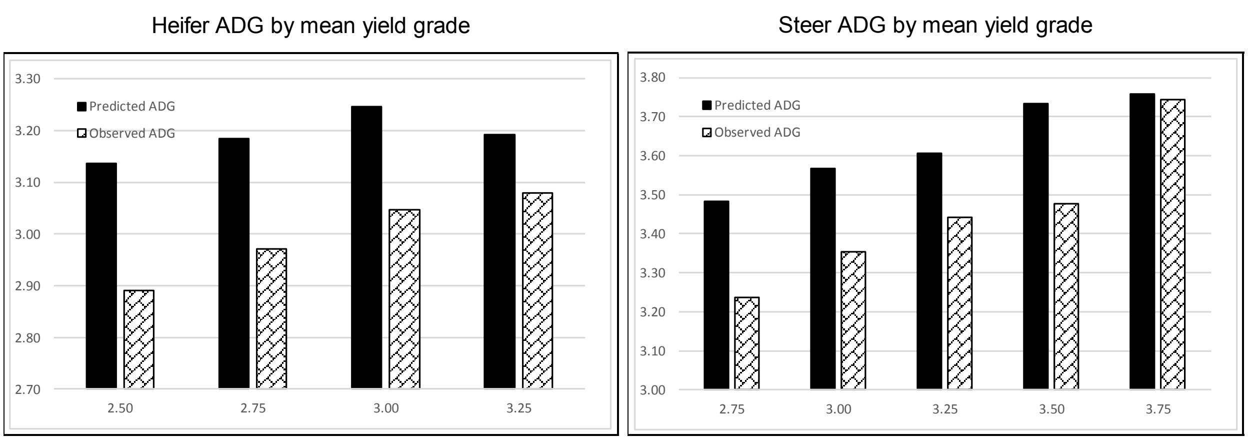


Figure 6. Predicted compared to observed (Y-axis) daily gains for the commercial feeding population dataset by gender and mean USDA Yield Grade for each lot.

Yard T provided yield grade data along with live performance. Across weight groups, error in prediction was smaller as mean yield grade increased (fatter carcasses; Figure 6). This was largely due to substantial overprediction of ADG in the lower yield grade groups but further explanation is not apparent. An area of need for further investigation is the validation of retained energy calculations for modern cattle, some of which remain remarkably efficient, even at high levels of EBF.

Putting all this to work

NRC validations (not shown) indicate that the equation can account for 95% of variation when predicting net energy. NRC (2016) suggests that “problems” are likely due to:

1. choosing the wrong FSBW,
2. short-term, transitory effects of previous nutrition, gut fill or anabolic implants,
3. variation in NEm requirement,
4. variation in ME value assigned to the feed because of variations in feed composition and extent of ruminal or intestinal digestion,
5. variation in NEm and NEg derived from ME because of variation in end products of digestion and their metabolism, and
6. variations in gut fill.

Recommendations:

1. Use historic data to create a specific FSBW for the population under consideration. Note the differences between best fit FSBW for the example yards when analyzed separately (Table 5), rather than combined to reflect the entire industry.
2. Mean weight can be used for post-data evaluations.
3. Be sure to use actual NEg values, considering step-up diets, not just finisher NEg.
4. Be sure to compare to “deads out” ADG.
5. Determine the best fit FSBW for the cattle population that is being evaluated. Use an adjustment factor to reflect SRW/FSBW once the best fit FSBW has been calculated.
6. Include seasonal adjustments.
7. Adjust NEm calculation instead of using 0.75 as the exponent.

Table 5. Best-fit Final Shrunk Body Weight (FSBW) for each feedyard in the commercial feeding dataset.

Best fit FSBW (lb) by yard

Using 1053 lb as SRW

	Steer	Heifer
Yard K	1285	1073
Yard N	1210	1033
Yard T	1095	905

Summary

ADG of cattle can be predicted (or evaluated) using the NRC equations. Accuracy can be excellent as long as an appropriate FSBW can be identified, which takes some work. Precision is OK and can be improved with adjustment of maintenance requirement and re-adjustment of FSBW. The equations are excellent for the prediction of average results for a large number of cattle but error for individual lots or animals can easily approach 10%.

Required reading

Brody, S. 1945. Bioenergetics and Growth. Reinhold publishing Corp., New York.
Blaxter, K.L. (ed.). 1965. Energy Metabolism, Proceedings of the 3rd Symposium, Troon, Scotland, May, 1964, Academic Press, Cambridge, MA.

Appendix: Origin of the 0.75 exponent for maintenance – a food fight in the literature in the middle of the last century

Comments below were excerpted from Brody's book and the proceedings listed above and are presented in chronological order. Emphasis is mine except for the word "tentatively" which Brody italicized in his book.

- Brody and Proctor, 1932: "on average, the basal metabolic rate of mammals and birds was proportional to the 0.734th power of body weight."
- Brody, 1934: "… from mice to elephants… was proportional to the 0.734 power of body weight."
- NRC, 1935: "…body weight to the 0.73 power be *tentatively* adopted as the base of reference…"
- Brody, 1945: "Kleiber's observation that the ratio of maximum food consumption to basal metabolism…cannot be generally true."
- Brody, 1945: "generalizations of the type of Rubner's and Kleiber's necessarily involve large margins of error. Nonetheless, they are useful, serving as pegs on which to anchor ideas, however insecurely."
- Benedict, 1938: "Very strong support for the 3/4th power of body weight…<u>*undoubtably the most extensive amount of data."*</u>
- Kleiber, 1961: "… a confirmation of the ¾ power rule of metabolic body weight, <u>*which could not be better.*</u>"
- Colovos, 1965: "I was present at the NRC conference… when the 0.73 exponent was proposed by the late Dr. Brody and adopted instead of the value of 0.75 suggested by Professor Kleiber. … Professor Ritzman told me later that <u>*the decision was hasty*</u> and the majority of the members would be in favor of the Kleiber exponent."
- Blaxter, 1965: "This proposal would reverse the recommendation of the 1935 Conference on Energy Metabolism at which <u>*it was agreed, possibly for not very good reasons*</u>, to use an exponent of 0.73."
- The proposal was then made formally by Professor Kleiber that weight raised to the ¾ power should be used… and was carried by a vote, 29 being in favour and nobody against.

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Graduate Student Poster Presentations

Dry rolled corn reconstitution using sorghum silage *A.A. Alrumaih, J. O. Sarturi, M. A. Ballou, B. J. M. Lemos, J. D. Sugg, P. R. B. Campanili, L. Ovinge, and L. A. Pellarin, Texas Tech University, Lubbock*
Three levels of dry rolled corn (DRC) were reconstituted on sorghum silage to determine fermentations characteristics, losses profile, and the nutritional value of blends post fermentation phase. Laboratory experimental silos, the experimental units, (n = 49; 3/treatment; 18.93 L units with sand in bottom for effluent collection and gas valve on top for gas release) were treated for the three DRC levels (0%, 25%, and 50%, DM basis) on three sorghum hybrid harvesting sites. Experimental silos were assigned in a randomized complete block design and ensiled for 108, 114 and 115 d; silos were opened together and measured for gas and effluent losses. Samples taken post storage period were analyzed for DM, ash, in vitro true dry matter digestibility (24h and 30h), pH, and total starch. An aerobic stability measurement phase (5, 10, and 15d post silo opening) in which, DM losses and pH was evaluated. Data were analyzed using the GLIMMIX procedures of SAS; orthogonal contrasts were used to test for linear and quadratic effects of DRC inclusion of measured variables. Total DM loss of silos for 50% DRC inclusion had the least ($P < 0.01$) loss (5.96%) compared both DRC at 0 and 25% inclusion. Gas loss linearly decreased ($P < 0.01$) by 7% as DRC was included. Volume of effluent, L/ tonne of DM ensiled linearly decreased ($P < 0.01$) as DRC 50% was included by 27 L compared to DRC 0%. The 50% DRC inclusion showed linear increase ($P < 0.01$) in vitro DM digestibility, in both 24 and 30 h; while corn inclusion linearly increased ($P < 0.01$) digestibility of OM of materials. Silages containing corn were on average 24h more stable ($P < 0.01$) than control treatment, in which a quadratic effect showing silages containing 25% corn with the greatest ($P < 0.01$) stability (130 h). Losses post opening tended ($P = 0.10$) to be decrease in corn treated silages. Current results show the potential for such strategy, since dry-rolled corn reconstitution in sorghum silages not only improved nutritional value of silages, but also minimized losses related to fermentation process, as well as improved stability of material during the silage post-opening aerobic phase.

Evaluation of hay and silage in receiving diets of newly weaned calves *E. J. Blom and R. H. Pritchard, South Dakota State University, Brookings*
Silages are often viewed as less desirable feedstuffs in receiving diets offered to newly weaned calves. An experiment was performed to determine the effects of hay versus silage in receiving diets on cattle performance and diet integrity. Steer calves (n=180) were weaned and transported to the Ruminant Nutrition Center. The next morning, calves were processed and processing BW was used to allot steers to 1 of 3 dietary treatments (6 pen replicates/diet; 10 steers/pen). Diets differed only in oat forage as the roughage source and included either oat hay (**HAY)**, oat hay with added water (**HAYW)**, or oat silage (**SIL**). Water was added to the HAYW diet by first blending water onto the hay at 26.6 lb water/100 lb hay (DM basis). Bunk samples were collected on d 32 at feed delivery and post-meal and subjected to particle separation with a 0.5 in^2 sieve. Particles captured in the sieve and passed through the sieve were considered larger particles and smaller particles, respectively. Due to an initial underestimate of oat silage

DM, the SIL steers were offered less (8.96, 9.06, 8.00 ± 0.055 lb; *P* < 0.01) feed during the 14 d after arrival when intake limits were set by management. Regardless, there were no diet effects on ADG (2.94 ± 0.132 lb) or G/F (0.338 ± 0.0143) from d 1 to 16. From d 17 to 42, DMI was greater (13.56, 14.09, 14.83 ± 0.176 lb; *P* < 0.01) and ADG tended to increase (2.07, 2.07, 2.45 ± 0.122 lb; *P* = 0.08) in SIL fed cattle. Cumulative DMI tended (11.81, 12.18, 12.23 ± 0.122 lb; *P* = 0.06) to be greater in calves fed SIL, but no differences were observed for ADG or G/F. The SIL diet contained a greater (*P* < 0.01) proportion of larger particles at delivery compared to HAY. The change in proportion of larger particles from delivery to post-meal was greater (123.3, 86.3, 31.6 ± 19.23%; *P* = 0.02) for HAY compared to SIL. The larger particle proportion of the HAY (*P* = 0.08) and SIL (*P* = 0.07) diet at delivery tended to increase linearly with batch fraction. In conclusion, there were no apparent adverse effects of silage inclusion in receiving diets on weaned cattle performance. Oat silage reduced changes in mix integrity from delivery to post-meal. Variations in diet mixing across a batch were not recognizable by visual appraisal but can impact cattle performance as ADG was reduced as larger particles associated with batch fraction increased (*P* = 0.03).

Innate immune response, diet digestibility, and ruminal fermentation patterns of calves supplemented with crude glycerin via drinking water during endotoxin challenge. *R.E. Carey[1], K.L. Samuelson[1], E.R. Oosthuysen[1], F.A. Lopez[1], S.L. Pillmore[1], L.T. Klump[1], J.M. Brooks[1], N.C. Burdick Sanchez[2], J.A. Carroll[2], and C.A. Löest[1], [1]Department of Animal and Range Sciences, New Mexico State University, Las Cruces, [2]Livestock Issues Research Unit, USDA-ARS, Lubbock, TX*
Reduced DMI of receiving calves could decrease available energy needed to mount an innate immune response. Crude glycerin has been used in feedlot cattle diets as an energy source. Therefore, supplementing crude glycerin via drinking water could provide dietary energy regardless of DMI. This study evaluated the innate immune response, diet digestibility, and ruminal fermentation of calves when crude glycerin was supplemented via drinking water during an endotoxin challenge. Twenty-four crossbred steers (467 ± 8.4 lb) blocked by BW, then randomly assigned to 4 treatment combinations in a 2 × 2 factorial arrangement. Treatments were glycerin supplementation via drinking water at 0 or 25 g/L (-GLY vs +GLY) throughout the 12-d study and 2 mL sterile saline subcutaneous injection containing 0 or 3 µg of endotoxin (-LPS vs +LPS) per kg of BW on d 8 of the study. Whole blood and serum were collected before endotoxin (LPS) administration as well as 2, 4, 8, and 12 h after. Whole blood was analyzed for glucose concentrations, and serum was analyzed for tumor necrosis factor-α (TNF-α). Rectal temperatures were collected at the same time as serum and again at 24 h after LPS. Ruminal fluid samples were collected at -2h and immediately before LPS, then at 2, 4, 8, 12, 24, 36, 48, and 72 h after. Ruminal fluid pH was measured and samples were analyzed for VFA and NH_3 concentrations. Total tract diet digestibility was determined by calculating fecal excretion using an external marker (Cr_2O_3). Total urine output was collected, weighed, and a representative sample analyzed for N to determine CP. Diet, orts, and fecal samples were analyzed for NDF and CP concentrations. Rectal temperatures increased from 0 to 2 h for +LPS steers, and were greater than -LPS steers at h 2 and 4, with greater rectal temperatures for +LPS steers receiving +GLY than –GLY at 2 and 4 h (GLY × LPS × h interaction;

$P = 0.02$). Serum concentrations of TNF-α for +LPS steers receiving +GLY increased from 0 to 2 h, were greater than all other treatment combinations at 2 h, then decreased from 2 to 4 h and were not different among all treatments at 4, 8, and 12 h after LPS injection (GLY × LPS × h interaction; $P = 0.01$). Blood glucose was not different between +LPS and –LPS steers at 0 to 2 h, then decreased from 2 to 4 h for +LPS steers and was lower for +LPS than –LPS steers at 4 and 8 h, but was not different between treatments 12 h (LPS × h interaction; $P < 0.01$). Supplementation of glycerin did not alter the already high urinary CP excretion observed for +LPS steers, but when steers did not receive LPS they tended to excrete more CP when supplemented with +GLY than –GLY (GLY × LPS interaction; $P = 0.05$). Pounds of CP retained was lower ($P = 0.05$) for +GLY than –GLY steers, and CP retention (as % of intake) was lower ($P < 0.01$) for +LPS than -LPS steers. Ruminal acetate:propionate and NH_3 were lower ($P < 0.01$) for + GLY than -GLY. Although glycerin supplementation at 25 g/L via drinking water lowered CP retention, it improved innate immune response and ruminal fermentation.

Effect of OmniGen-AF ® on Calf Performance and Immunity *T. S. Crook[1], P. A. Beck, J.E Koltes, C. B. Stewart, C. Shelton, M. B. Sims, D. J. McLean[2], and J. D. Chapman[2], [1]University of Arkansas, Fayetteville, AR, [2]Phibro Animal Health Corporation, Teaneck, NJ*

The objective of this research was to determine the effects of feeding OmniGen-AF, (**OG**, Phibro Animal Health Corp., Teaneck, NJ) to mature cows (n = 112) and primiparous heifers (n = 48) from 60-d pre-calving to breeding and to their calves in creep feeds for 90-d pre-weaning through the 42-d pre-conditioning period on calf performance and immune function. Mature cows and heifers at the University of Arkansas Southwest Research & Extension Center were fed OG (4g/100 lbs BW) from 60 d prior projected calving to breeding (December 15, 2015-May 2, 2016) or were fed Control supplements without OG. Calves offered OG at a daily rate of 4g/100 lbs BW in the creep feed and topdressed on the diets fed during preconditioning following weaning or were offered similar diets without OG (CON). A subset of heifer calves in each pasture (n = 3/pasture) were inserted with an intravaginal device containing a temperature data recorder for a 9-d period during September, and core body temperatures (CBT) were recorded every 20 minutes. Diets fed during preconditioning contained (as-fed basis) 40% grass-legume hay, 25% corn, 15% soybean hulls, 15% corn gluten feed, and 5% mineral supplement. Performance data were analyzed by ANOVA using the Mixed procedure of SAS. Immune cell counts, CBT, and serum BVDV titers were analyzed as a repeated measures analysis. Calves supplemented with OG gained more BW ($P = 0.03$) than CON calves during creep feeding (80.7 kg vs 72.5 kg, respectively), however BW at weaning or at the end of preconditioning did not differ ($P \geq 0.27$). A treatment by hour interaction ($P < 0.01$) for CBT was observed, with OG supplemented heifers tending to have 0.27 °F lower CBT ($P \leq 0.10$) at 1400 and 1700 and significantly lower CBT (0.29 °F, $P = 0.05$) at 1800 than CON heifers. There were no differences in BVDV titers due to treatment ($P \geq 0.51$) but basophil percentage was greater in OG than CON at the day of weaning. Providing OG in the creep diet of calves was shown to have a positive influence on BW gain pre-weaning and reduce CBT heat stress, however additional studies are needed to investigate this effect further.

Influence of ractopamine hydrochloride and days on feed on feedlot performance and redmeat yield in thin cull beef cows targeted for a lean market *J. C. DeClerck, L. W. Lucherk, N. R. Reeves, M. F. Miller, B. C. Bernhard, and R. J. Rathmann, Texas Tech University, Lubbock*

Thin, beef, cull cows (n = 144; initial BW = 1026 ± 125 lbs., initial body condition score = 2.13 ± 0.68) were serially slaughtered to evaluate the relationship between ractopamine hydrochloride (**RH**) administration and days on feed (**DOF**) on feedlot performance and carcass cutout value in a lean cow market. Cows were organized into a 3 x 2 factorial arrangement of treatments (48 pens, 8 pens/treatment, 3 cows/pen), and blocked by body weight nested within pregnancy status. Treatment pens were top dressed 400 mg/(animal*d) of RH (Actogain 45; Zoetis, Florham Park, NJ) for the final 28 d prior to slaughter to cows spending 28, 42, or 56 DOF. Performance data (feedlot and carcass) and carcass traits were analyzed with pen and carcass as the experimental unit, respectively. No RH × DOF interactions were detected ($P \geq 0.17$), indicating that despite a majority of compensatory gain occurring during the first 28 d of the trial, the magnitude of RH response was not effected by DOF. However, compared to controls feeding RH causes improvements in feedlot performance, but, to a greater extent on carcass weight gain and efficiency. Specifically, RH improved ADG by 15% and carcass ADG by 17% ($P \leq 0.05$). Cattle fed RH documented a 11.5% improved feed to gain ratio and more impressively a 20% improved carcass feed to gain ratio ($P \leq 0.01$). Inclusion of RH in finishing diets tended to increase HCW by 3.9% ($P = 0.08$). However, supplementation of RH did not alter carcass composition or red meat yield ($P \geq 0.30$), but provoked a 10.6% improvement in lean maturity ($P = 0.02$). Evaluation of the main effect of DOF helped elucidate the compensatory state of beef cull cows on a high concentrate diet. Serial slaughter offal weights presented confounding results. With additional DOF a linear increase in liver weight was observed ($P = 0.04$), suggesting organ tissue replenishment occurred throughout the trial, and cattle experienced compensatory gain during the entire feeding phase. In contrast, kidney, heart, and lung weights, were not altered despite additional DOF. ($P \geq 0.16$). Furthermore, additional DOF provoked a linear increase in DMI ($P = 0.01$) yet a precipitous decline in ADG ($P = 0.04$), reinforcing the premise that a majority of compensatory gain occurred during the first 28 d of the trial. Regardless, documented gains throughout the 56 d trial were very impressive from an economic perspective. Despite implementation of growth promoting technologies and considerable heat stress marbling scores and REA continually improved, suggesting that opportunities exist for short fed beef cull cows in value added markets. Often overlooked as a source of income, thin beef cull cows represent a potentially economic rewarding opportunity. If lean (BCS ≤ 3), healthy candidates can be finished and harvested, feeders can reap the benefits of an additive relationship between compensatory gain and growth promoting technologies.

Effect of Original XPC in receiving diets on newly weaned beef steer performance and response to a *Mannheimia haemolytica* vaccination challenge *E. L. Deters, R. S. Stokes, O. N. Genther-Schroeder, S. L. Hansen, Iowa State University, Ames*

The objective was to determine the effects of Original XPC™ (Diamond V, Cedar Rapids, IA), a *Saccharomyces cerevisiae* fermentation product, in the diets of beef steers on total tract nutrient digestibility as well as feeding behavior and acute phase protein (**APP**) response following a vaccination challenge. Twelve days after arrival, 36 newly weaned crossbred beef steers (711 ± 26 lb) were blocked by BW and randomly assigned to one of three doses of XPC: 0 (**CON**), 14 (**XPC14**), or 28 (**XPC28**) g·steer·d^{-1}. Steers were fed via bunks capable of measuring individual intake and received ear tags (Cow Manager, Select Sires, Plain City, OH) that recorded real time ear surface temperature, rumination, and eating behavior. Body weights were collected on d -1, 0, 14, 28, 42, and 56. To determine diet digestibility, titanium dioxide was fed from d 12 to 27. All steers received a *Mannheimia haemolytica* vaccination (One Shot, Zoetis, Kalamazoo, MI) on d 34. Blood was collected prior to vaccination and on d 3, 6, 9, 11, and 14 post-vaccination for analysis of APP. Data were analyzed as a randomized complete block design using Proc Mixed of SAS (experimental unit = steer; 12 per treatment). Post-vaccination eating behavior, APP, and DMI data were analyzed as repeated measures. Digestibility of DM and OM on d 27/28 tended to be greater for XPC14 vs. XPC28 ($P \leq 0.07$). Steers fed either dose of XPC exhibited greater CP digestibility compared to CON ($P < 0.0001$). Steers fed XPC14 exhibited greater ADG from d 28 to 56 vs. XPC28 ($P = 0.05$) and exhibited greater DMI than CON or XPC28 for the 15 d post-vaccination ($P = 0.001$). Haptoglobin and serum amyloid A concentrations peaked 3 d post-vaccination (day effect; $P < 0.0001$) but did not differ due to treatment ($P \geq 0.14$). Ceruloplasmin concentrations were lesser on d 14 post-vaccination for XPC14 vs. CON or XPC28 while treatment did not affect ceruloplasmin concentrations on other sampling days (treatment × day; $P = 0.02$). For the 15 d post-vaccination, CON had more non active min/d than XPC14 or XPC28 ($P = 0.02$). Steers fed XPC14 or XPC28 had lesser average, minimum, and maximum ear surface temperature vs. CON ($P \leq 0.01$) during this period. Overall, these data suggest that steers fed XPC at 14 g/d responded better to a vaccination challenge than steers fed 0 or 28 g/d.

Ruminal characteristics and feedlot performance of steers during accelerated step-up to high-concentrate diets using *Megasphaera elsdenii* (Lactipro advance)

T.J. Ellerman[1], L.M. Horton[1], S.L. Katulski[1], C.L. Van Bibber-Krueger[1], H.C. Muller[1], C.C. Aperce[2], and J.S. Drouillard[1], [1]Kansas State University, Manhattan, [2]MS Biotec, Wamego, Kansas

This material is partially based upon work supported by the National Institute of Food and Agriculture, under Agreement No. 2014-33610-22112 of the Small Business Innovation Research Grant Program.

Ruminal characteristics and feedlot performance were measured for steers adapted to a high-grain diet using a traditional 22-d step-up program (CONTROL), and for steers adapted over 10 d with the aid of *Megasphaera elsdenii* (ME) using fresh culture administered as an oral gavage (FRESH), an oral gavage of rehydrated lyophilized culture (REHYD), or rehydrated product combined with lyophilized culture powder administered daily as a ration top-dress (REHYD+DAILY). Yearling steers (n = 435; initial BW = 900 ± 12 lb) were blocked by weight and randomly allocated to 64 concrete surfaced pens with 7 steers/pen and 16 pens/treatment. Step-up diets included 50:50 mixture of corn silage and alfalfa hay, providing progressively less forage with each step (40, 30, and 20% forage), and the finishing ration contained 10% corn silage and 90% concentrate. Ruminal fluid was obtained by rumenocentesis from 96 steers (3/pen from 32 pens) approximately 26 h after steers received their first step-up diet.

Strained digesta was then inoculated into culture tubes containing lactate medium to determine microbial growth, extent of lactate metabolism, and fermentative end-products after 24 h. Thirty two animals were equipped with in-dwelling, radio frequency boli for continuous monitoring of ruminal pH. Steers were fed once daily *ad libitum* for 156 d, then weighed and harvested. No differences were detected for feedlot performance ($P > 0.20$) or carcass traits ($P > 0.20$). Capacity for lactate utilization increased with all forms of ME, as evidenced by increases in microbial growth within cultures (i.e., increased absorbance), disappearance of lactate, and accumulation of butyrate production ($P < 0.01$). Ruminal pH remained above 5.6 for all treatments during the step-up phase. Ruminal pH was higher for freeze-dried treatments compared to CONTROL or FRESH later in the feeding period ($P < 0.01$). In conclusion, steers dosed with ME can be stepped up to finishing diets in 10 d with no adverse effects on performance.

Item	CONTROL	FRESH	REHYD	REHYD +DAILY	SEM	*P*-value
Feed:gain	5.73	5.77	5.87	5.87	0.095	0.66
Hot carcass weight, lb	956.6	962.5	967.6	959.7	9.46	0.63
Choice + Prime, %	49.1	51.0	52.7	46.6	5.00	0.82
Absorbance at 600 nm	1.30^{a}	1.50^{b}	1.53^{b}	1.53^{b}	0.04	< 0.01
Lactate, mM	22.6^{a}	7.2^{b}	10.5^{b}	7.8^{b}	3.17	0.01
Butyrate, mM	3.46^{a}	8.80^{b}	7.06^{c}	$7.46^{b,c}$	0.52	< 0.01

[a,b,c] Means within a row without a common superscript letter are different, $P < 0.05$

Effect of suckling phase implants on weaning weight, and post-weaning performance of steer calves *W. W. Gentry and R. H. Pritchard*, *South Dakota State University, Brookings*

An experiment was conducted to determine the effect of a conventional implant (Synovex C; **SYN-C**), and an extended release implant (Synovex One Grass; **ONE-G**) on weaning weight (**WW**), and post-weaning performance of steer calves. On May 8th, calves were assigned to treatment in the order in which they were restrained for branding and castration as: no implant (**NONE**; n=31), SYN-C (n=30), SYN-C (n=30), and ONE-G (n=29). Calves were predominantly 30 to 60 d of age. On October 31st (176 d later), steers were weaned and shipped 365 mi to the SDSU Ruminant Nutrition Center Feedlot. Steers were processed the following morning. The arrival processing BW was considered WW. Weaning weight was greater for SYN-C compared to NONE (629 vs 642 ± 2.5 lb; $P = 0.04$), and greater for ONE-G compared to SYN-C (642 vs 656 ± 2.5 lb; $P = 0.02$). Only one-half of the SYN-C steers were retained in the post-weaning experiment, with 3 pen replicates per implant group (7-11 hd/pen). An allotment discrepancy for the composition of pens in a replication of ONE-G compromised the DMI data for that treatment. Consequently, only BW and ADG could be evaluated for the ONE-G treatment in the post-weaning phase. Steers were fed long-stemmed grass hay on d 1-3, and a common receiving diet (12.3% CP; 51 Mcal/cwt NEg) was fed beginning on d 2. Steer appetite was met using a clean bunk management system. Interim BW were measured on 21 and 44 d post-arrival. No differences (P > 0.20) in interim or cumulative post-weaning performance due to implant strategy were observed. Cumulative post-weaning ADG was 2.33, 2.37, and 2.37 lb (SEM = 0.150 lb), for NONE, SYN-C, and ONE-G, respectively. Cumulative DMI was 12.83, and 12.91 lb (SEM = 0.132 lb), and F:G was 5.73, and 5.40 lb (SEM = 0.307 lb) for NONE, and SYN-C, respectively. In conclusion, suckling phase implants increased WW. With an established pay out of 200 d in older steers, it is unclear why the ONE-G steers did not gain more than the NONE steers during the first 21 d of the post weaning phase (197 d post-implant). In this study, exposure to growth promotion implants prior to weaning increased WW of steer calves, but did not affect early post-weaning growth or efficiency.

The effects of growth-promoting technologies on rumen temperature and panting scores of black hided-feedlot steers *C. L. Haviland, C. L. Maxwell, B. C. Bernhard, B. K. Wilson, C. L. Goad, D. L. Step, C. R. Krehbiel, and C. J. Richards, Oklahoma State University, Stillwater*

Increased ambient temperature, humidity and solar radiation have been shown to influence respiration rates and panting scores of feedlot cattle. These extreme summer conditions have been proven to increase core body temperature, and decrease feed intake, performance, and efficiency of feedlot cattle. The objectives of this experiment were to determine the effects of production system on rumen temperature (**RT**) and panting scores (**PS**) of black-hided feedlot steers, 30 d before harvest. Two-hundred and fifty-two steers (initial BW = 405 ± 10 kg) were used in a randomized complete block design experiment with three production systems. Steers were randomly allocated based on BW to 1 of 3 production systems; natural (**NAT**; did not receive growth promoting technologies), conventional (**CONV**; received an implant at arrival and monensin and tylosin daily), or conventional with zilpaterol hydrochloride (**ZH; CONVZ**; fed ZH during the last 20 d of the feeding period with 3-d withdrawal). Panting scores were assigned based on a 0 to 4 scale and were assigned daily between 1600 and 1700 h for all steers. Comprehensive climate index (**CCI**) was recorded daily at the same time as PS and was categorized into 1 of 4 heat stress threshold categories; no stress, mild, moderate, and severe. A subset of steers were selected from each pen based on median BW for continuous RT monitoring (n = 108 steers; BW = 377 ± 9 kg). Rumen temperature boluses were orally administered at the beginning of the feeding period and area under the curve calculations were utilized to determine the amount of time spent above normal body temperature of 38.6ºC. Throughout the 30 d period, CONV and CONVZ steers had increased average and maximum RT (P < 0.001) and spent more time > 40.0º C when compared to NAT steers (P < 0.001). There was an increased percentage of steers with a PS less than 1 when CCI stress threshold was categorized as no stress (P < 0.001). When CCI stress threshold was moderate to severe, there was an increased percentage of steers with a PS greater than 2 (P < 0.001). Natural steers had a decreased percentage of steers with a PS of 0 and CONV steers had an increased percentage (P = 0.01), but production system did not affect the percentage of steers with a PS greater than 0 ($P \geq 0.56$). For performance, CONVZ steers had increased ADG, G:F, and BW gain when compared to the CONV and NAT steers through the ZH feeding period ($P \leq 0.01$). Overall, there was an improvement in performance with the conventional production systems when compared to the natural production system. Production system had an effect on RT, but did not have an effect on increasing steers with PS above 0 and increased CCI did have an effect on the steers with PS greater than 1. In conclusion, the addition of growth-promoting technologies such as β-agonists did not have an effect on heat stress in black-hided feedlot steers in the present experiment.

Effects of excess dietary sulfur on performance, carcass characteristics, and mitochondrial complex IV activity in beef steers *J. Hawley[1], E. B. Kegley[1], J. W. S. Yancey[1], J. K. Apple[1], and W. G. Bottje[2], [1]Department of Animal Science, University of Arkansas Division of Agriculture, Fayetteville, [2]Department of Poultry Science, University of Arkansas Division of Agriculture, Fayetteville*

Beef producers must be aware of potentially high S concentrations when utilizing distillers' grains. While S is an essential component of the ruminant's diet, ingesting large amounts can lead to acute S toxicosis. Sulfide is readily absorbed through the rumen wall into the bloodstream. Once absorbed, sulfide is thought to competitively inhibit mitochondrial complex IV, resulting in a shutdown of the mitochondrial electron transport chain and cellular ATP generation. To test the effects of excess dietary S on performance, carcass characteristics, and mitochondrial complex IV activity in beef steers, 20 steers (initial BW = 283 ± 7.2 kg; 13 ± 0.6 mo of age) of predominantly Angus breeding were stratified by initial BW and assigned randomly to 1 of 6 pens (3 to 4 steers/pen). Pens were assigned randomly to 1) no additional S (~ 0.15% S) or 2) 0.40% S (from Na2SO4). Steers grazed fall mixed-grass pastures and were offered corn and soybean meal supplements for a 114-d growing phase. When the average BW reached 373 ± 0.2 kg, steers were stratified within dietary treatment by BW and assigned randomly to 16 dry-lot pens (1 to 2 steers/pen; 8 pens/dietary treatment). Steers remained on the same dietary treatments, and received corn and soybean meal concentrate diets for a 123-d finishing phase. Steers were slaughtered (average BW = 565 ± 38.4 kg), and liver and LM samples were collected immediately postmortem and snap-frozen. Mitochondrial protein yield and complex IV activity obtained from liver and LM mitochondrial preparations were measured spectrophotometrically. Statistical significance was declared at $P \leq 0.10$. During the finishing phase, steers supplemented 0.40% S had less DMI ($P < 0.001$) and ADG ($P < 0.10$) than steers fed 0.15% S. Dietary S did not ($P \geq 0.15$) have an appreciable effect on carcass characteristics. Liver mitochondrial protein yield was 2.41 times greater ($P < 0.0001$) when compared to the LM mitochondrial protein yield. There was no effect ($P \geq 0.66$) of dietary S on the extractable yield of mitochondrial protein per gram of liver or LM. Liver and LM mitochondrial complex IV activities were not ($P \geq 0.38$) influenced by dietary S. These results suggest that beef steer performance can be altered during the finishing phase without a concomitant impact on carcass characteristics or measureable mitochondrial complex IV activity inhibition when feeding 0.40% S in the total diet DM.

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Effects of feeding monensin to bred heifers in drylot on nutrient and energy balance *C. N. Hemphill[1], T. A. Wickersham[1], J. E. Sawyer[1], H. C. Freetly[2], and K. E. Hales[2], [1]Texas A&M University, College Station, [2]Meat Animal Research Center, Clay Center, NE*

Intensification of beef cow systems may be a viable production method when forage availability is limited. Confined cows receiving limit-fed diets containing monensin may benefit from decreased methane production, increased feed efficiency, and greater nutrient utilization. The objective of this study was to evaluate the effect of monensin on duration and magnitude of methane reduction and digestible and metabolizable energy intake. Sixteen pregnant MARC III (1/4 Angus, 1/4 Hereford, 1/4 Red Poll, 1/4 Pinzgauer) composite heifers (482 ± 7 kg initial BW) were used in a 161-d completely randomized design. Heifers were randomly assigned to one of two treatments, 250 mg monensin per d (MON) or no monensin (CON). Diets consisted of corn stalks (80%), corn silage (10%), and wet distillers' grains with solubles (7%). Monensin was delivered in a pelleted supplement that was top-dressed at 3% of the diet. Pellets not containing monensin were fed to CON at 3% of the diet. Heifers were limit-fed 100% of estimated ME_m requirements, with amounts recalculated for the first, second, and third trimesters. Total fecal and urine collections were conducted over 96 h to determine digestion and energy metabolism. Collection periods occurred on d 14, 42, and 161 of feeding monensin, corresponding to the first, second, and third trimesters of gestation. Gas exchange was measured on d 0, 3, 14, 28, 42, and 161 using portable headbox calorimeters designed on the concepts of open-circuit calorimetry. Individual heifer oxygen consumption, carbon dioxide production, and methane production were determined over a 24 h period. There were no significant differences ($P > 0.10$) in DM intake as a result of feeding monensin (6.51 kg/d vs 6.52 ± 0.12 kg/d; CON and MON, respectively). Diet digestion did not differ ($P > 0.10$) between treatments, averaging 43%. On d 42 there was a tendency ($P = 0.09$) for MON heifers to consume 1.12 ± 0.64 Mcal/d more DE and 1.19 ± 0.63 Mcal/d more ME ($P = 0.07$) compared to CON heifers. Monensin resulted in a significant reduction ($P < 0.05$) in methane production from 1.58 L/kg MBW for CON to 1.47 ± 0.03 L/kg MBW for MON. Retained energy between treatments was not significant ($P > 0.10$). The magnitude of methane reduction was consistent across time, suggesting monensin is a viable production option for reducing methanogenesis long-term.

Exploratory observational quantification of liver abscess prevalence, economic impact and bacterial flora, specific to region and cattle type *R. T. Herrick[1], C. L. Rogers[1], T. J. McEvers[1], R. G. Amachawadi[2], T. G. Nagaraja[2], C. L. Maxwell[3], and T. E. Lawrence[1], [1]Beef Carcass Research Center, West Texas A&M University, Canyon, [2]Kansas State University, Manhattan, [3]Elanco Animal Health, Greenfield, IN.*

An observational experiment was conducted to quantify liver abscess prevalence, economic impact, and bacterial flora specific to region and cattle type. Observational liver audits occurred at seven fed beef (n = 130,845 livers evaluated) and four cull beef (n = 30,646 livers evaluated) processing facilities. Processing facilities were selected to target the greatest frequency of Holsteins harvested per region and were audited for one week of production. Processing facilities were audited from October 2015 through March 2016. Within each processing facility, liver abscesses were visually assessed and scored according to a modified scoring system based on the Elanco Liver Check Service (no abscesses, A- = 1 or 2 small abscesses, A = 2 to 4 small active abscesses, A+ = 1 or more large active abscesses, A+ Adhesion = liver adhered to GI tract, A+ Open = open liver abscess). Other liver abnormalities that were recorded include: cirrhosis, flukes, telangiectasis, carotenosis, sawdust, torn, and contaminated. At each processing facility, 30 (10 A-, 10 A, 10 A+) intact liver abscess samples were collected. Samples were cultured at Kansas State University to determine prevalence of *Fusobacterium necrophorum*, *Trueperella pyogenes*, and *Salmonella enterica*. Visceral loss was calculated based on the value of a liver and other visceral organs reported in the USDA Agricultural Marketing Service by-product drop value (steer) report (NW_LS441; USDA, Oct. 2015 – Mar. 2016) and weekly USDA by-product drop value (cow) report (NW_LS444; USDA, Oct. 2015 – Mar. 2016), and includes lost revenue from condemnation of liver (liver abscess, contamination, or other abnormality) or liver and gut mass, when open abscess was present. Outcome frequency and economic data were analyzed using the GENMOD procedure of SAS v9.4 (SAS Inst. Inc., Cary, NC), with the fixed effects of region, cattle type or liver score. Least square means were generated and separated using the PDIFF option with a Tukey-Kramer adjustment for multiple comparisons. Significance was declared at $P \leq 0.05$. Average liver abscess incidence was 20.3% for cattle harvested at fed beef processing facilities, and 17.6% for cull beef processing facilities. Within fed beef processing facilities, High Plains had the greatest ($P < 0.01$) edible liver incidence rate (76.9%) and Pacific Northwest had the lowest edible liver incidence rate (46.8%). The greatest ($P < 0.01$) total abscess incidence rate for a fed beef processor occurred in the Pacific Northwest (33.8%) while the Northeast had fewest incidences of liver abscesses (10.0%). Holsteins had greater ($P < 0.01$) abscess incidence rates (25.0%) than fed steers (18.2%) or heifers (19.1%). Cull beef had abscess incidence rates (18.8%) less ($P < 0.01$) than fed beef (20.0%). *Fusobacterium necrophorum* subsp. *necrophorum* was present in 79.9% of abscesses, from fed beef processing facilities and 76.9% in abscesses from cull beef plants. *Fusobacterium necrophorum* subsp. *funduliforme* was isolated from 24.3% of abscess samples taken from fed beef processors, and 17.6% of abscess samples collected at cull beef facilities. *Salmonella enterica* was present in 27.5% of abscess samples collected from fed beef processors and 16.5% of samples from cull cow processors. No, *S. enterica* was isolated in samples collected from fed beef processors in: North Plains – A, North Plains – B, and Pacific Northwest; or cull beef processors in: High Plains, Northeast, and West Coast. When segregated by abscess severity, A+ abscesses had the greatest ($P < 0.01$) incidence rate for: *F. necrophorum* subsp. *necrophorum* (100.0%), *F. necrophorum* subsp. *funduliforme* (27.7%), and *S. enterica* (27.7%), when compared to A (62.2%, 24.4%, and 23.3% respectively) and A- (71.8%, 10.3%, and 20.5% respectively) abscesses. There was no difference in total visceral loss ($/animal) by region ($2.02/animal; $P = 0.40$) or cattle type ($2.00/animal; $P = 0.85$). Based on conservative estimates, liver abscesses and other abnormalities cost the beef industry $64 million annually in viscera losses. In conclusion, liver abscesses in feedlot cattle significantly impact the beef industry, these data indicate there are regional, and cattle type differences that affect abscess and bacterial speciation and prevalence.

Effects of feeding brown midrib corn silage in growing and finishing diets

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Three experiments evaluated the use of brown midrib (bm3) corn silage hybrids in growing diets and finishing diets. The three hybrids were a standard silage hybrid control (CON; hybrid-TMF2R720), a bm3 hybrid (BM3; hybrid-F15579S2), and an experimental bm3 hybrid (BM3-EXP; hybrid-F15578XT) with soft endosperm. In Exp. 1, 360 steers (In. BW = 736 ± 55 lb) were blocked by BW and assigned randomly to pens (n = 36; 10 steers/pen). Treatments were in a 2×3 factorial arrangement that consisted of inclusion of corn silage in the finishing diet (15% or 45% of diet DM) and silage hybrid (CON, BM3, or BM3-EXP). All diets contained 20% MDGS. There was a silage inclusion by hybrid interaction for ADG and F:G. Cattle fed 45% silage had greater DMI ($P < 0.01$) compared to steers fed 15% silage. Cattle fed BM3-EXP had greater ADG than CON or BM3 at 15% of the diet. When silage was fed at 45% of the diet DM, cattle fed BM3 and BM3-EXP gained similarly, but both were greater than CON ($P < 0.05$). For steers fed 15% silage, F:G was lowest for cattle fed BM3-EXP, greatest for cattle fed BM3, and intermediate for cattle fed CON ($P < 0.05$). For steers fed 45% silage, F:G was lowest for cattle fed BM3 ($P<0.03$), while cattle fed CON and BM3-EXP had similar F:G ($P = 0.24$). At 15% corn silage inclusion, HCW was greater (P < 0.01) for BM3-EXP compared to CON and BM3, but similar between BM3 and CON. At 45% corn silage inclusion, steers fed BM3-EXP and BM3 had similar HCW, but were both heavier (P < 0.01) compared to CON. In Exp. 2, 216 crossbred steers (initial BW= 714 ± 5 lb) were stratified by BW and assigned randomly to pens (n=18; 12 steers/ pen). All diets included 15% MDGS, 5% supplement, and 80% corn silage fed as 1 of the three hybrids (CON, BM3 or BM3-EXP). Ending BW was greater (P < 0.01) for steers fed the BM3 and BM3-EXP compared to the CON, but not different between the two BMR varieties. Steers fed both BM3 and BM3-EXP had greater (P < 0.01) DMI and ADG compared to the steers on the CON treatment, but DMI and ADG were not different between steers in the BM3 or BM3-EXP treatments. While BM3 and BM3-EXP had greater DMI and ADG, there were no differences (P = 0.26) in F:G between the silage treatments. In Exp. 3, ruminally fistulated steers (n = 6; BW = 604 ± 60 lb) were used to evaluate the effects of using the same silage hybrids used in Exp. 2 on nutrient digestibility and ruminal fermentation. Corn silage treatment tended ($P = 0.11$) to impact DMI and OM intake, with steers fed BM3 and BM3-EXP having greater intake than CON steers. Steers fed both BM3 and BM3-EXP had greater ($P < 0.01$) NDF digestibility than the CON. Similarly, there were no differences ($P = 0.29$) in ADF digestibility between BM3 and BM3-EXP, but both were greater ($P < 0.01$) in ADF digestibility than CON. Average ruminal pH for steers fed bm3 hybrids was lower (P < 0.01) compared to CON. Total VFA concentration was greater ($P < 0.01$) for BM3 hybrids compared to CON corn silage. BM3 silage hybrids improved ADG and F:G depending on inclusion in finishing diets, while the use of bm3 silage increases fiber digestibility increasing DMI and ADG in growing diets.

A meta-analysis on the effects of pre-finishing strategy on feedlot and carcass performance *H. Johnson, and A. DiCostanzo, University of Minnesota, St. Paul.*
Utilizing a meta-analysis approach we modeled how pre-finishing (PF) strategies: high energy feeding (HE), ad libitum forage or restricted energy feeding (RE), grazing dormant (G) or wheat pastures (WW) affected feedlot and carcass performance. Data were derived from 32 manuscripts (20 drylot and 12 grazing studies) containing 158 treatment means. Multiple regressions were conducted using mixed models to describe effects of PF ADG, days on feed (DOF) and strategy on finishing phase DMI, ADG, final BW, HCW, marbling score, LMA, and fat depth. Greater PF ADG and longer DOF resulted in greater ($P < 0.05$) DMI during finishing ($R^2 = 0.62$). Cattle fed HE during PF had lower ($P < 0.05$) DMI during finishing than those consuming RE during PF or those grazing G or WW pastures ($P < 0.05$). Greater ADG or longer DOF during PF resulted in lower ADG during finishing ($R^2 = 0.294$). A change in PF ADG of 0.1 kg or 15 DOF had an equivalent impact on ADG during finishing. The relationship between DMI and ADG during finishing was best represented ($P = 0.03$) by equations for each PF strategy. Gain during PF interacted with strategy to impact final BW and HCW (R^2 = 0.453 and 0.463). In spite of greater PF ADG, cattle fed HE during PF had lighter ($P < 0.03$) final BW than those fed RE or grazing. Similarly, cattle fed RE during PF had lighter final BW than those grazing G ($P = 0.0014$) or WW ($P = 0.0104$). Correspondingly, cattle fed HE or RE during PF had lighter ($P < 0.001$) HCW than those that grazed. Differences observed for HCW were mirrored by differences in LMA; carcasses of cattle fed HE during PF had smaller ($P < 0.04$) LMA than those that grazed while RE trended ($P = 0.0579$) smaller ($R^2 = 0.385$). Fat depth responded inversely to PF energy supply; cattle that grazed had carcasses with greater ($P < 0.05$) fat depth than those of cattle that were fed RE or HE ($R^2 = 0.314$). Strategy during PF had no impact on marbling score, but end weight after PF did. Cattle fed to weights greater than 385 kg during PF, regardless of strategy, had carcasses with lower ($P = 0.043$) marbling scores ($R^2 = 0.343$). Therefore, restricting energy intake during pre-finishing phase resulted in greater carcass weight but prolonging pre-finishing resulted in lower marbling.

Gross return to corn acres through cattle feeding as influenced by choice of harvest endpoint *T. Johnson, A. Hohertz, A. DiCostanzo, University of Minnesota, St. Paul*
Forty-nine Charolais x Red Angus steers (initial average BW = 1182 lb) were fed individually in a Calan-Broadbent feeding system to evaluate performance and interactions resulting from performance and crop yield when corn is harvested as either silage (SIL), earlage (EAR), high-moisture corn (HMC), or dry corn (DRC). Steers were randomly allocated to 1 of 4 dietary treatments where SIL, EAR, HMC, or DRC constituted 75% of diet DM. The remaining of SIL, EAR, HMC and DRC diet contained 11% haylage (0% for SIL), 10% modified wet corn distillers grains (MDGS), 4% liquid supplement with Rumensin (SUPP) and 11% DRC (SIL only). Gross return (gross $/hd) was determined as dollars remaining after subtracting non-corn crop expenses (cattle purchase, veterinary medicine, yardage, bedding and purchased feed ingredients) from gross cattle sale. Worth of each corn crop endpoint was determined from corn grain worth ($/56 lb) and its relationship to corn grain content in SIL, EAR, and HMC crops.

This value was compared to SIL, EAR, HMC worth determined by ANOVA (crop equivalent \$/bu) . Worth of each corn crop endpoint was also determined by dividing gross return (gross \$/hd) by acres used to raise crop. The former method is used to determine corn crop endpoint worth for a feeder that purchases crops (owns no land) and the latter is used to determine corn crop endpoint worth for a feeder who owns corn land. Net return to corn acres dedicated to cattle feeding during the last 18 years was 6.2 times greater than that realized through marketing corn through a local elevator. Cattle fed HMC had the lowest ($P \le 0.05$) DMI. Cattle fed DRC gained at faster ($P < 0.05$) ADG than cattle fed the other corn crops. Cattle fed HMC had greater ADG ($P < 0.05$) than those fed SIL. No difference between cattle fed DRC or HMC was observed for G:F, but feeding either led to greater ($P < 0.05$) feed conversion than SIL or EAR. Final BW and HCW were greatest for DRC ($P < 0.05$), intermediate ($P < 0.05$) for HMC and lowest ($P < 0.05$) for EAR and SIL. There was a tendency ($P = 0.08$) for treatment effect on fat thickness wherein cattle fed DRC or HMC tended to have greater fat thickness than those fed SIL. No treatment differences were found for REA or marbling. There was no effect seen for equivalent value of corn crop (\$/bu). Harvesting corn as either SIL, EAR, HMC or DRC had no impact ($P > 0.05$) on crop worth (gross \$ return/acre). Despite performance differences, all harvest end points dedicated to cattle feeding result in greater gross return to corn acres. This permits greater flexibility in corn harvest end point decisions for cattle feeders.

Evaluation of 0 or 300 mg of Optaflexx® on Growth Performance and Carcass Characteristics of Steers Fed to Different Degrees of Finish *R. M. Jones[1], C. J. Bittner[1], F. H. Hilscher[1], M. F. Wilken[2], and G. E. Erickson[1], [1]University of Nebraska, Lincoln, [2]Elanco Animal Health, Greenfield, IN.*
The objective of this study was to test the effect of 0 or 300 mg of Optaflexx® on growth and carcass performance of yearling steers fed to differing degrees of finish. Crossbred yearling steers (n=342; initial BW = 917, SD = 74 lb) were utilized in a generalized randomized block design (3 BW blocks) with a 2 × 3 + 1 factorial treatment design. Factors included Optaflexx dosage (0 or 300 mg / steer daily) and different days on feed (118, 139, or 160) plus cattle fed 2 weeks longer (174 d) without Optaflexx to evaluate just feeding longer. Steers were fed Optaflexx for the last 35 d prior to harvest. No significant dose × days on feed interactions ($P > 0.40$) were observed for growth performance. Live final BW was 28 lb heavier ($P = 0.01$) for steers fed 300 mg of Optaflexx as compared to steers fed 0 mg. Steers fed 300 mg of Optaflexx had greater ($P = 0.04$) carcass-adjusted ADG compared to steers fed 0 mg. Feeding 300 mg of Optaflexx resulted in an improvement ($P = 0.05$) in carcass-adjusted G:F. There were no differences ($P = 0.24$) in DMI between Optaflexx doses. HCW and carcass-adjusted final BW were 15.3 and 23 lb greater ($P < 0.06$), respectively, for steers fed 300 mg of Optaflexx compared to 0 mg. As days on feed increased, final BW increased linearly ($P < 0.01$); whereas, intake decreased linearly ($P < 0.01$). Carcass-adjusted ADG was constant ($P > 0.15$) which lead to a small linear improvement ($P = 0.02$) in G:F, due to the reduction in DMI. Cattle performance was negatively influenced by wet, cold, muddy conditions in January and February which lowered ADG and HCW compared to targeted finish weights/HCW for the study. From d 90-97 of the trial, cattle on both Optaflexx treatments had a negative ADG response. During d 111 to 118, cattle

performance suffered a reduction in live interim BW for steers fed 118 d for both Optaflexx and control treatments. During these time points, weather was adverse with low comprehensive climate index numbers resulting a reduction in performance for cattle fed 118 or 139 d, as cattle fed longer than 139 d had time to recover in performance. Feeding Optaflexx at 300 mg improved ADG, G:F, and HCW regardless of days on feed (i.e., degree of finish).

Effect of water restriction on performance, hematology and antibody responses in parenteral or intranasal modified-live viral vaccinated beef calves *E. L. Kaufman[1], J. M. Davidson[2], P. A. Beck[3], S. L. Roberts[1], H. D. Hughes[1], and J. T. Richeson[1], [1]Department of Agricultural Sciences, West Texas A&M University, Canyon [2]Boehringer Ingelheim Vetmedica, Inc., St. Joseph, MO, [3]Southwest Research and Extension Center, Division of Agriculture, University of Arkansas, Hope*
The objective was to determine if water restriction affected performance, hematology or antibody responses in beef calves with parenteral or intranasal vaccination. On d -7, crossbred beef steer (n=28) and heifer (n=32) calves were assigned randomly within sex to 1 of 6 treatments arranged in a 3 × 2 factorial. Water restriction treatments (Factor A) were applied at the origin ranch: A_1) Control, no water restriction except during transport to the feedlot (**CON**), A_2) Acute, 48 h water restriction prior to transport to the feedlot (**ACU**), or A_3) Chronic, alternating 24 h periods of water restriction, over a 7-d period prior to transport to the feedlot (**CHR**). Upon feedlot arrival (d 0), 2 respiratory vaccine treatments were applied (Factor B): B_1) parenteral administration of a pentavalent modified-live virus (MLV) respiratory vaccine (2 mL s.c. in the neck; **SUB**), or B_2) intranasal administration of a trivalent MLV respiratory vaccine (1 mL/naris; **INT**). Blood was collected on d -7, -5, -3, -1, 0, 1, 3, 5, 7 and weekly thereafter through d 56 to determine complete blood count. Rectal temperature (RT) and BW was recorded on the same days blood sampling occurred. Nasal swabs were collected on d 0, 3, 7, 14, 21, 28, 35, 42, 49 and 56 to determine presence of bovine respiratory syncytial virus (BRSV)-specific secretory antibodies (sIgA). Sera was collected weekly from d 0 to 56 for serum antibody titer analyses. Data were analyzed using PROC MIXED, with repeated measures where appropriate. Hematocrit increased on d -5 and -3 for CHR ($P \le 0.04$) and d -1 for ACU ($P \le 0.03$). Transportation (d-1 to 0) increased neutrophils in a manner indicative of stress (day effect, $P<0.01$). The INT groups had greater total leukocytes ($P<0.01$) and monocytes were increased on d 3 and 5 ($P<0.01$). The RT was increased for INT on d 7 and 14 ($P \le 0.04$). The BW of ACU and CHR decreased 9.5 and 9.7 kg, respectively, from d -7 to -1; however, CON gained 5.5 kg BW ($P<0.01$). Conversely, CON lost 8% BW during relocation (d -1 to 0) while the ACU and CHR treatments had 2% increase in BW ($P<0.01$). The ACU and CHR treatments had reduced ADG from d 0 to 14 ($P \le 0.04$). The SUB treatments had increased BRSV-specific sIgA on d 3 and 7 ($P \le 0.03$); however, these were greater for INT from d 35 to 56 ($P \le 0.05$). The BRSV ($P \le 0.01$) and IBRV ($P \le 0.04$) antibody titers were greater for INT vs. SUB from d 14 to 56 and d 21 to 35, respectively. Water restriction prior to transport altered some hematological variables and briefly reduced performance (d 0 to 14) but did not clearly alter antibody responses to either vaccine type. Intranasal vaccination increased monocytes, RT, sIgA and BRSV- and IBRV-specific antibodies compared to SUB.

Evaluation of statistical process control algorithms for preclinical detection of BRD in beef cattle *W.C. Kayser[1], G.E. Carstens[1], I.L. Parsons[1], K.E. Washburn[2], S.D. Lawhon[2] and W.E Pinchak[3], [1]Department of Animal Science, [2]Department of Large Animal Clinical Sciences, [2]Department of Veterinary Pathobiology, Texas A&M University, College Station and [3]Texas Agrilife Research and Extension Center, Vernon.*
Current methods of morbidity detection rely on subjective clinical illness observations, which have been shown to have relatively low sensitivity (0.27) and high specificity (0.92) indicating that many animals contract respiratory disease (**BRD**) but are not treated. Incidence of morbidity is related to reduction in performance, carcass value and beef quality. Thus, there is a need for more accurate objective methods for pre-clinical BRD detection. The objectives of this study were to evaluate the effectiveness of predictive statistical process control (**SPC**) algorithms coupled with remote sensor technology for pre-clinical detection of BRD and determine if multivariate models constructed with principal components analysis were more effective than univariate models. Two trials were evaluated; Trial 1 consisted of 231 growing bulls (BW = 391 ± 55 kg) that experienced a spontaneous outbreak of BRD (n = 30), Trial 2 consisted of 36 steers (BW = 352 ± 23 kg) that were experimentally inoculated with either *Mannheimia haemolytica* (**MH**) or phosphate buffer solution (**PBS**). Animals were housed in pens equipped with electronic feed bunks (GrowSafe) to continuously measure DMI and feeding behavior patterns. Ruminal thermo-boluses (Trial 2, Medria) were used to measure rumen temperature (**RT)** at 5-min intervals, with data averaged over 6 h periods to minimize variation associated with diurnal patterns. In Trial 1, animals were deemed clinically ill (**CI**) if they displayed symptoms and had elevated rectal temperature (> 39.5 C°). Steers inoculated with MH (Trial 2) exhibited elevated serum concentrations of haptoglobin, white blood cells, neutrophils and RT ($P < 0.02$), indicating that the MH challenge effectively stimulated immunologic and febrile responses. However, only 1 animal displayed overt clinical signs of disease. Cumulative summation procedures were used in Trial 1 and Shewhart procedures were used in Trial 2 (SAS 9.4, Proc CUSUM and Proc Shewhart). Sensitivity (CI and MH), specificity (healthy and PBS) and accuracy of SPC models were calculated for all univariate and multivariate models to compare their relative values. In Trial 1, sensitivities (0.77 – 0.80) and accuracies (0.83 – 0.84) of bunk visit frequency, duration and head down duration were equivalent to the sensitivity (0.77) and accuracy (0.80) of DMI. All of the SPC models detected ($P < 0.05$) BRD (2.6 to 4.5 d) prior to clinical observation with the exception of time to bunk. The multivariate SPC model was numerically more sensitive (0.90) and accurate (0.85) than the corresponding univariate models. In Trial 2, time to bunk numerically was the most accurate (0.94) univariate model followed by DMI (0.85) and first quarter RT (0.84). The intake based and RT multivariate SPC models were more sensitive (0.94 and 0.78) and accurate (0.95 and 0.85), respectively, than the corresponding univariate models. The SPC algorithms effectively detected BRD prior to overt clinical signs in Trial 1 and sub-clinical BRD in Trial 2. The multivariate PCA models were numerically more sensitive and accurate than their corresponding univariate models and should be more robust in application. These results suggest that remote monitoring of feeding behaviors and RT coupled with predictive SPC algorithms would be a valuable tool for pre-clinical detection of BRD in order to mitigate the economic effects of undetected morbidity.

Chromium and ractopamine hydrochloride affected muscle fiber-related gene expression in bovine satellite cells *J. Kim[1], K. B. Wellmann[1], Z. K. Smith[1], and B. J. Johnson[1], [1]Department of Animal and Food Sciences, Texas Tech University, Lubbock.*
Chromium is known to improve insulin sensitivity. Insulin is required for amino acid and glucose uptake into insulin sensitive peripheral tissues. As beef cattle mature they become less sensitive to circulating insulin. Beta-adrenergic agonists increase bovine skeletal muscle mass by hindering protein degradation while promoting myofibrillar protein synthesis, and are fed late in the finishing phase. A completely randomized study design with a 2 × 2 factorial arrangement of treatments was used to evaluate the impacts chromium (Cr) and ractopamine hydrochloride (RH) have on indicators of muscle hypertrophy in bovine satellite cells (BSC). The BSC were isolated from the semimembranosus of two 14-month-old cross breed steers. The isolated muscle satellite cells were incubated in Dulbecco's Modified Eagle's Medium (DMEM) solution with 10% Fetal Bovine Serum, 1× Antibiotic-Antimycotic at 37ºC under a humidified atmosphere of 95% O_2 and 5% CO_2. Upon reaching 80 to 90% confluence, the growth medium was replaced with differentiation medium composed of DMEM, 2% horse serum and the respective treatment to induce myogenic differentiation. The BSC were incubated for 120 h in the treatment media, the treatment media included: 1) differentiation media (-Cr/-RH), 2) 10μM of Cr in differentiation media (Cr/-RH), 3) 10μM of RH in differentiation media (-Cr/RH), and 4) 10μM of Cr with 10μM of RH in differentiation media (CR/RH). Relative abundance of insulin-like growth factor-1 (IGF-I), AMP-activated protein kinase (AMPKα), myosin heavy chain (MHC) I, MHCIIA, MHCIIX, and glucose transporter type 4 (GLUT4) relative to the quantity of ribosomal protein subunit 9 (RPS9) mRNA in total RNA were measured by real-time quantitative PCR. All data were analyzed with the MIXED procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) suitable for a 2 × 2 factorial. No Cr × RH interactions were detected for IGF-1 ($P = 0.38$), AMPKα ($P = 0.30$), and GLUT4 ($P = 0.54$). However, the main effects of Cr and RH did alter ($P < 0.01$) the IGF-1 mRNA expression. Expression of AMPKα was increased ($P < 0.01$) with Cr treatment. Chromium tended to alter ($P = 0.09$) GLUT4 mRNA expression. Expression of GLUT4 also increased ($P < 0.01$) by RH. A tendency ($P = 0.08$) for a Cr × RH interaction was noted for MHC I. Expression of MHC I was increased ($P < 0.01$) with Cr/RH over all other treatments. Furthermore, Cr × RH interactions were detected for MHC IIA ($P = 0.01$) and MHCIIX ($P = 0.02$). The mRNA expression of MHCIIA ($P < 0.01$) and MHCIIX ($P < 0.01$) were greatest for Cr/RH overall other treatments. Immunochemistry was performed to determine translocation of GLUT4. The results of the study indicated that Cr in conjunction with RH have potential to improve different types of muscle fiber growth by upregulating MHC mRNA expression.

The impact of the anti-inflammatory drug (Meloxicam) on performance, and health of arriving feedlot calves *C. G. Lockard[1], N. K. Van Engen [2], C. L. Haviland[1], M. E. Youngers[1], L. J. McPhillips[1], M. A. Woolsoncroft1, W. R. Ryan[1], E. S. Desocio[1], T. A. Jackson1, J. F. Coetzee [2], T. J. Engelken, C. R. Krehbiel[1], and B. K. Wilson[1].* *[1]Department of Animal Science and College of Veterinary Medicine, Oklahoma State University, Stillwater, **[2]**Department of Veterinary Microbiology and Preventative Medicine, College of Veterinary Medicine, Iowa State University, Ames.*
The stress of weaning, comingling at auction markets, and transportation to feedlots can all increase the risk of bovine respiratory disease (**BRD**) in receiving cattle. Non-steroidal anti-inflammatory drugs (**NSAID**) may potentially reduce stressors at the time of transportation. The objective of this experiment was to determine the impact of meloxicam administration on overall feedlot BRD risk, feed efficiency, and performance during a 42 d receiving period. One-hundred and sixty four crossbred steers (n = 164, initial BW = 242 ± 9 kg) were allocated to one of 3 experimental treatments: meloxicam administered at the auction market prior to shipment (**PMEL**), meloxicam administered 1 d after arrival to the feedlot (**AMEL**), or no meloxicam administered, administered a whey protein placebo (**CON**). Treatments were arranged in a complete randomized block design (18 pens; 6 pens/treatment). Steers were initially processed at the auction market on d -1 and on d 0 were transported 533 km to the Willard Sparks Beef Research Center (**WSBRC**). Steers were processed again on d 1 at the WSBRC. Steers were dosed meloxicam or placebo orally at (1 mg/kg of BW). On d -1 and d 1 steers not given a meloxicam treatment received the placebo. Pen weights were recorded on d 1, 28, and 42. There were no differences (P > 0.10) in overall ADG, DMI, or G:F. Calf health was monitored by using a modified DART system at the WSBRC. There was a tendency for CON steers to have reduced clinical illness scores (CIS) of 1 and 2 (P = 0.06). However, there was a numeric increase in CON steers having CIS of 3 and 4 (P = 0.12). Steers treated with meloxicam prior to transit tended to experience increased BRD treatment rates (P = 0.09). There was no difference in rectal temperatures at the time of BRD treatment (P ≥ 0.52). Steers receiving PMEL had numerically greater BRD treatment rates compared to steers from both other experimental treatments at the end of the 42 d receiving period (P = 0.67). These results suggest that meloxicam did not have a positive impact when dosed prior to shipping or at feedlot arrival on BRD treatment rates in feedlot cattle. More research is needed with larger groups of high-risk receiving cattle to conclusively determine the effects of meloxicam administration.

Effects of intermittent feeding of tylosin phosphate on feedlot performance, carcass characteristics, antimicrobial resistance and incidence of liver abscesses in steers *H. C. Muller[1], C. L. Van Bibber-Krueger[1], O. J. Ogunrinu[3], R. G. Amachawadi[2], H. M. Scott[3], and J. S. Drouillard[1], [1]Department of Animal Sciences and Industry, Kansas State University, Manhattan, [2]Department of Clinical Sciences, College of Veterinary Medicine, Kansas State University, Manhattan, [3]Department of Veterinary Pathobiology, Texas A&M University, College Station*
This study was conducted to evaluate intermittent feeding of tylosin phosphate as strategy to decrease usage of a medically important antibiotic drug, the impact on cattle performance and incidence of liver abscesses, and its effect on the amount of

antimicrobial resistant *enterococci*. Steers (n = 312; 906 ± 14.8 lb initial BW) were blocked by bodyweight and randomly assigned, within block, to one of 3 treatments in a randomized complete block experiment. Treatments included no tylosin (NC), tylosin fed continuously (CT), and tylosin fed on an intermittent basis (IT; 1 wk on, 2 wk off). Steers were housed in 24 dirt-surfaced pens with 13 steers/pen and fed once daily *ad libitum*. Finishing diets contained 57.7% steam-flaked corn, 30% wet corn gluten feed, 8% corn silage and 2.3% supplement (DM basis), and supplied 30 g/T monensin and either 0 or 10 g/T tylosin. Steers were harvested after 119 d. Feces were collected from 8 randomly selected animals per sampling day (0, 20 and 118) and *Enterococcus* spp. bacterial counts were obtained on plain and antibiotic selective media (m-*Enterococcus* agar). No differences were observed among treatments for ADG, DMI, or feed efficiency ($P > 0.20$). Marbling score was less for CT compared to IT and NC (Sm^{29}, Sm^{58}, and Sm^{55}, respectively; $P = 0.022$), but no other differences were observed for carcass traits ($P > 0.10$). Incidence of LA was greater for NC compared to IT and CT treatments (21.4% vs. 7.8% and 9.6 %, $P = 0.01$), but IT and CT were not different ($P > 0.50$). *Enterococcus* spp. bacterial counts did not differ by treatment group over time ($P > 0.05$); however, there was a strong period effect for macrolide resistance among all groups ($P < 0.01$). We concluded that intermittent feeding of tylosin decreases overall use of antibiotics in feedlot cattle without compromising cattle performance and incidence of liver abscesses, and antibiotic resistance is more likely acquired through exposure to resistance elements that have accumulated within the feeding environment over an extended period of time.

Item	No Tylosin	Continuous Tylosin	Intermittent Tylosin	SEM	*P*-value
ADG, lb	4.04	4.12	3.97	0.079	0.207
DMI, lb/d	23.99	24.69	23.92	0.518	0.278
Feed:gain	5.32	5.38	5.38	0.003	0.752
Dressed yield, %	60.5	60.3	60.7	0.21	0.512
USDA Choice + Prime, %	76.0	73.4	78.7	5.88	0.671
Total LA, %	21.4	7.8	9.6	4.65	0.012

Effect of trace mineral supplementation at NRC or industry concentrations with or without hormone implants on growth and carcass characteristics of steers

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To determine the effects of trace mineral (**TM**) supplementation and hormone implant strategy on growth and carcass characteristics of cattle, 72 Angus-cross steers (854 ± 15.4 lbs) were blocked by BW (6 steers per pen) to a 2 x 3 factorial. Steers were either implanted (d 0 with Component TE-IS, reimplanted d 56 with Component TE-200; **IMP**) or not (**NoIMP**). Within implant treatments cattle received no supplemental TM (**CON**), TM supplemented at 2016 NRC recommendations of 10 Cu, 30 Zn, 20 Mn, 0.10 Se, 0.15 Co, and 0.50 I (ppm; **NRC**), or TM supplemented at feedlot consultant recommendations of 20 Cu, 100 Zn, 50 Mn, 0.30 Se, 0.20 Co, and 0.50 I (ppm; **IND**). Liver biopsies were collected on d -9, and 70 and samples were collected at harvest.

Steers received a finishing diet for 124 d in GrowSafe bunks and were harvested on d 125. Data were analyzed in SAS as a 2 × 3 factorial with the fixed effect of implant and TM treatment and block, and steer was the experimental unit (n = 12 per combination). There were no IMP × TM effects for liver Cu, Zn, Mn, Se, or Co ($P \geq 0.11$) on d 70 or 124. NoIMP steers had greater liver Cu and Mn on d 70 ($P \leq 0.05$) and lesser liver Zn ($P = 0.01$) on d 124, compared with IMP steers. On d 70 steers in the IND treatment had greater liver Cu, than NRC and CON ($P < 0.0001$). On d 70 steers in the IND treatment had greater liver Mn and Se, than CON, with NRC intermediate ($P \leq 0.01$). On d 70 NRC steers had greater liver Co than CON, with IND intermediate ($P = 0.02$). On d 124 IND steers had greater liver Cu than CON, with NRC intermediate ($P < 0.0001$). NRC steers had greater liver Zn than CON with IND being intermediate on d 124. IND steers had greater liver Mn than CON on d 124 with NRC being intermediate ($P = 0.001$). IND steers had greater liver Se than CON and NRC on d 124 ($P < 0.0001$). On d 124, NRC steers had greater liver Co than CON, with IND being intermediate ($P = 0.0004$). There were no IMP × TM effects for final BW, overall ADG, DMI, F:G, dressing percent, backfat, marbling score, or KPH ($P \geq 0.17$). Overall ADG tended ($P = 0.07$) to be and HCW was ($P = 0.03$) affected by TM, where IND was greater than CON (HCW: 820, 832, and 854 lbs for CON, NRC, and IND, respectively). Overall DMI was increased by TM ($P < 0.0001$) with NRC and IND being greater than CON. Steers receiving implants had greater ($P < 0.0001$) final BW (1230 and 1357 lbs for NoIMP and IMP, respectively), overall ADG (2.97 and 4.03 lbs for NoIMP and IMP, respectively), DMI, F:G, and HCW (790 and 880 lbs for NoIMP and IMP, respectively) than NoIMP. There was an IMP × TM effect ($P = 0.02$) for ribeye area (**REA**) with IMP/CON having greater REA than IMP/IND, with IMP/NRC being intermediate; NoIMP had smaller REA, regardless of TM supplementation. There was an IMP × TM ($P = 0.02$) for YG where NoIMP/IND was greater than IMP/CON with all other treatments intermediate. These data indicate NRC TM recommendations might not be adequate for finishing beef steers, irrespective of hormone implant administration.

Temperament on arrival alters growth efficiency, feeding behavior, and carcass characteristics of feedlot cattle *C. A. Olson, G. E. Carstens, A. D. Herring, D. S. Hale, I. L. Parsons, J. R. Johnson, W. C. Kayser and R. K. Miller, Texas A&M Univesity, College Station*

Temperament can be defined as the behavioral response of an animal to handling by humans, with calm cattle reacting minimally, and excitable cattle exhibiting nervous responses when handled. The objectives of this study were to evaluate the effects of temperament classification upon feedlot arrival on cattle growth performance, feed intake, feed efficiency, and feeding behavior traits; and to evaluate the impact of temperament classification on carcass quality (tenderness, marbling) and yield grade, and grid-formula carcass value. Angus, Braford, Brangus, and Simbrah heifers (N = 415, BW = 279 ± 35 kg) from Deseret Ranch were evaluated during 3 trials. Exit velocity was recorded at feedlot arrival and at the beginning (d 0) of the trials. All trials were conducted in pens equipped with electronic feed bunks (GrowSafe®) to continuously measure feed intake and feeding behavior traits. The heifers were fed a corn-based feedlot ration (3.09 Mcal ME/kg DM). After the performance trial, heifers were group fed and slaughtered at a target backfat thickness of 1.2 cm. Yield and quality data were collected at harvest, and Warner-Braztler shear force (**WBS**) measured on steaks at 1-, 7- and 14-d post-mortem aging. RFI was calculated as the residual from the regression of DMI on mid-test $BW^{0.75}$, ADG and ultrasound backfat thickness. Calm heifers had 5% heavier initial BW, gained 14% more per day, and consumed 10% more DM per day than excitable heifers ($P < 0.001$). For Brangus and Simbrah, calm heifers had more favorable F:G than excitable heifers, whereas, temperament did not affect F:G in Angus and Braford (EV x breed; $P = 0.03$). RFI was not affected by temperament classification, but excitable Braford heifers had lower RFI (EV x breed; $P < 0.05$). Calm heifers spent 12% more time at the feed bunk ($P < 0.01$) than excitable heifers. Temperament did not affect meal frequency, but calm heifers had 14% longer ($P < 0.01$) meal events and visited the feed bunk more times per meal ($P < 0.01$) than excitable cattle. The carcasses of calm heifers were 12.8 kg heavier ($P < 0.001$) than carcasses of excitable heifers. Calm heifers had 3% more backfat ($P < 0.01$) and tended to produce carcasses with higher USDA YG ($P = 0.08$) than excitable heifers. Marbling also tended ($P = 0.10$) to be higher in calm heifers. Warner-Bratzler shear forces were lower ($P < 0.01$; more tender) in steaks from calm heifers on 1-, 7- and 14-d post-mortem. These results suggest that management systems that sort calves based on temperament phenotypes, into targeted production-outcome groups, would reduce within-group variance in production efficiency and carcass quality, thereby improving animal-performance predictability and product-quality consistency. Such a system would facilitate selective use of technologies (e.g., implants, feed additives) for targeted production-outcome groups to improve overall production efficiency, reduce market risks, and optimize the value of the beef production chain and consistency of the beef product to the consumer.

Protein Value in Corn Silage and Response to RUP by Calves *C.R. Oney, F. H. Hilscher, R. B. Bondurant, A. K. Watson, G. E. Erickson, J. C. MacDonald, and T. J. Klopfenstein, University of Nebraska, Lincoln*
The amount of RUP in corn silage and the extent to which it is digested in the small intestine are uncertain. Moisture content and length of ensiling period both affect the digestibility of grain in corn silage. Four studies were conducted to determine the effect of increasing supplemental RUP on growing performance of calves fed corn silage based-diet, and to determine RUP and RUP digestibility values for corn silage using *in vitro* and *in situ* methods. Exp. 1 utilized 60 individually fed steers (initial BW = 597 lb; SD = 70) to evaluate the effects of supplementing increasing levels of RUP on growing performance of calves fed a silage-based diet. Supplement levels consisted of 0, 3.25, 6.5, 9.75 and 13% RUP (as a % of diet DM). The RUP supplement consisted of 60% SoyPass and 40% Empyreal (DM basis). The diet consisted of 85% corn silage with the remaining 15% of the diet being accounted for in the supplement (DM basis). Exp. 2 utilized *in situ* methods with two ruminally cannulated steers and one duodenally cannulated steer to compare RUP content and RUP digestibility of two corn silages (35% and 42% DM) along with Empyreal (wet corn milling byproduct; 75% CP; 65% RUP) and SoyPass. Samples were ruminally incubated for 20 or 30 h and ½ of the samples were then duodenally incubated to determine RUP digestibility. In Exp. 3, four feeds (35% and 42% DM corn silage, soybean meal (SBM), and SoyPass) were utilized in an *in vitro* study with 100-mL bottles incubated for 16 or 24 h. Purine analysis was done to correct for microbial N when calculating RUP content. In Exp. 4, dry-rolled corn

(14% DM) was reconstituted to 25, 30, 35, and 50% moisture and ensiled in mini silos for 30 days. After ensiling, samples were ruminally incubated for 20 or 30 hours to determine RUP content. In Exp. 1, ADG and G:F linearly increased ($P > 0.01$) as supplemental RUP increased. In Exp. 2, RUP averaged 9.1% of CP for the 37% DM corn silage and 8.7% of CP for the 42% DM corn silage. Digestibility of DM averaged 67.5 and 67.2 for 37 and 42% DM corn silage, respectively, while RUP digestibility averaged 39% of RUP for the 37% DM corn silage and 35% of RUP for the 42% DM corn silage. In Exp. 3, RUP as a % of CP was greatest for SoyPass ($P = 0.02$) with no differences between the two corn silages, averaging 23.2% (SEM = 7.4), similar to SBM. In Exp. 4, as moisture content of the corn grain increased, % RUP decreased linearly ($P < 0.01$). The RUP content and RUP digestibility of corn silage is low, and lower than previous estimates. Increased moisture content makes the protein in the grain portion of corn silage more degradable in the rumen, further decreasing total RUP levels. Increasing the amount of RUP in silage growing diets increases ADG, ending BW, and G:F by meeting MP requirements.

Hydration status, health and performance of newly received feedlot heifers in response to delayed processing *E.R. Oosthuysen[1], M.E. Hubbert[2], J.R. Graves, C.A. Löest[1] and E.J. Scholljegerdes[1], Department of Animal and Range Sciences, New Mexico State University, Las Cruces, [2]Clayton Livestock Research Center, New Mexico State University, Clayton.*
Calves arriving at the feedlot are often subjected to prolonged periods of water deprivation during marketing and transportation. Dehydrated calves are believed to be more susceptible to disease due to the inability to clear inhaled pathogens and compromised antibody responses to invading pathogens. This study evaluated the effects of delayed processing on calf hydration status, subsequent health and performance. A total of 224 crossbred heifers (initial BW = 411 ± 6.9 lb), blocked by 2 truckloads (114 and 115 calves per truckload), were assigned to 16 pens and 2 treatments in a randomized complete block design. Treatments were initial processing upon arrival (**ARV**) or a 24 h delay in initial processing (**REST**), after 12 h of transportation (720 mi.) on a truck. Calves assigned to REST were allowed access to wheat hay, a receiving ration (RAMP), and fresh drinking water during the 24 h delay. At initial processing, heifers were individually weighed, ear tagged, dewormed, vaccinated and received no metaphylactic antibacterial treatment. On d 1, 2, 3, and 28 of the experiment, individual BW, and rectal temperatures were obtained. Jugular blood samples collected on d 0 (ARV calves only), 1, 2, 3 and 14, were used for hematocrit measurement as indicator of hydration status of calves. Health was monitored throughout the 56-d experimental period and pen weights were obtained on d 56. Performance and hematocrits were analyzed using MIXED procedures. Morbidity and mortality data were analyzed using GLIMMIX procedures. Delaying initial processing by 24 h did not affect ($P \geq 0.10$) heifer hematocrits, health, or performance. Blood hematocrit was lower (day; $P < 0.01$) on d 14 than d 1, 2, and 3 (33.8 vs. 38.1, 37.4, and 37.7 ± 0.62%). A tendency for a treatment × day interaction ($P = 0.12$) occurred for blood hematocrit percentage; on d 1, 2, and 14 blood hematocrit percentages were not different, but were greater ($P < 0.05$) for REST (38.2 ± 0.53%) than ARV (37.1 ± 0.53%) calves on d 3. Blood hematocrits on d 1 were correlated ($P < 0.01$) with hematocrits on d 2 ($R^2 = 0.54$), d 3 ($R^2 = 0.51$), and d 14 ($R^2 = 0.31$), but were not ($P \geq 0.61$) correlated

with calves receiving medical treatment. However, hematocrits on d 14 were correlated ($P \leq 0.09$) with calves receiving a first medical treatment (R^2 = -0.12), and a second medical treatment (R^2 = -0.12). Total medical treatments tended ($P = 0.14$) to be greater for REST (70.54 ± 4.61%) than ARV calves (60.71 vs. 4.61%). Calf ADG tended to be lower ($P = 0.13$) for REST than ARV calves from d 1 to 28 (0.44 vs. 0.57 ± 0.7 lb/d) and d 1 to 56 (0.89 vs. 0.97 ± 0.03 lb/d). Feed to gain tended to be greater ($P = 0.10$) for REST than ARV from d 1 to 28 (8.20 vs. 6.43 ± 0.71) and d 1 to 56 (5.33 vs. 5.00 ± 0.15). In conclusion, delaying initial processing by 24 h after 12 h of transportation is not enough time to allow calves to sufficiently rehydrate to observe health and performance benefits. Postponing initial processing delays exposure to many stress factors and may cause dehydration to the same magnitude as 12 h of transportation stress.

Type of BRD vaccine alters feed intake and feeding behavior responses to BVD viral challenge in beef steers *P.S. Smith[1], W. Kayser[1], G.E. Carstens[1], C.A. Runyan[2], J.F. Ridpath[3], J.E. Sawyer[1], and A.D. Herring[1], [1]Texas A&M University, College Station, [2]Angelo State University, San Angelo, and [3]USDA-ARS NADC and Ridpath Consulting, Ames, IA*
Despite the fact that multivalent vaccines for the prevention of BRD are widely used in of feedlot cattle (96%; NAHMS 2013), BRD remains the most costly and prevalent disease in the beef industry. Deviations in feeding behavior patterns are among the earliest indicators of the onset of disease in cattle. Statistical process control (SPC) is a method of monitoring a production system via control charts to distinguish normal from abnormal process variation. Objectives of this study were to examine the effects of multi-viral BRD vaccine treatment (**VT**) on DMI and feeding behavior responses following a BVD viral challenge; Response variables were analyzed using both mixed (SAS) and SPC (Proc CUSUM, SAS) models. Nellore-Angus F2 and F3 steers (N =364; BW 330 ± 48 kg) were assigned to 1 of 3 vaccine treatments within sire groups: non-vaccinated (**NON**), modified live (**MLV**), and killed (**KV**). DMI, and feeding behavior traits (bunk visit (**BV**) duration, frequency, and eating rate) were monitored for 56 d during four 14-d periods using a GrowSafe® system. All steers were intranasally challenged with BVDV (type 1b) at the end of the first 14-d period. As expected, DMI, ADG, and BV duration and frequency all decreased ($P < 0.01$) during period 2 following BVD challenge and then subsequently increased during period 3. ADG and BV frequency were not affected by VT or VT x period interaction. However, the BVD-induced reduction in DMI was less for MLV than KV and NON steers (VT x period; $P < 0.05$). MLV steers had increased ($P < 0.01$) BV duration and slower ($P < 0.01$) BV eating rate compared to KV and NON steers. In MLV steers, the SPC models had lower ($P < 0.01$) sensitivities for DMI and BV frequency (54, 66%) compared to KV (77, 83%) and NON (74, 86%) steers, respectively. Additionally the signal day detected by the SPC models for DMI and BV duration were delayed ($P < 0.05$) in MLV steers (6.7, 6.0 d) compared to KV (4.7, 4.5 d) and NON (5.0, 4.6 d) steers, respectively. The decrease in sensitivities and delayed signal day of MLV steers indicate their feeding behavior was less affected by BVD challenge compared to KV and NON steers. Monitoring feeding behavior responses via SPC models appears to be an effective metric to detect subclinical BRD. These results suggest that prior vaccination with MLV was more effective at mitigating the negative effects on DMI and feeding behavior in response to BVD challenge than

prior vaccination with KV. Furthermore, these results support previous findings showing that MLV mitigated immunological and febrile responses to BVD challenge to a greater extent than KV.

Evaluation of effective payout characteristics for various implants in yearling beef steers *Z. K. Smith[1], A. J. Thompson[1], W. T. Nichols[2], J. P. Hutcheson[2], and B. J. Johnson[1], [1]Texas Tech University, Lubbock, [2] Merck Animal Health, Madison, NJ.*
A randomized complete block design feedlot experiment was conducted to determine effective payout characteristics for Revalor-XR (200 mg TBA + 20 mg E_2 [coated], Merck Animal Health, Madison, NJ) in yearling steers. Crossbred beef steers (n=240; initial BW=305 ± 17.7 kg) were blocked by BW (n=12 blocks; 20 steers/block), then allotted to a pen within each block (n=4 steers/pen). Pen was then randomly assigned to 1 of 5 implant treatments: negative control (**NI**), Revalor-200 (200 mg TBA + 20 mg E_2 [uncoated], Merck Animal Health) on d 1 (**E200**), Revalor-200 on d 70 (**D200**), Revalor-XR on d 1 (**XR**), and Revalor-XS (80 mg TBA + 16 mg E_2 [uncoated], 120 mg TBA + 24 mg E_2 [coated], 200 mg TBA + 40 mg E_2 [total], Merck Animal Health) on d 1 (**XS**). Cattle were fed 1X daily to provide *ad libitum* access to feed using a clean bunk management approach. The finishing diet contained (DM basis): 97.0 Mcal/45.4 kg of NE_M, 66.0 Mcal/45.4 kg NE_G, monensin sodium (33 g/T), and tylosin phosphate (11 g/T). No β-adrenergic agonist was fed. Individual BW from all steers and whole blood (sentinel steers n=2/pen), harvested as sera, were obtained prior to feed delivery on d 1, 14, 35, 70, 105, 140, 175, and immediately prior to shipping on d 213. Cumulative performance and carcass traits were analyzed with the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC). Relative gain responses, gain energy density (GED):$(Energy\ Retained/day\ (Mcal/d))/(ADG(kg/d))$, and sera data were analyzed as repeated measures using the MIXED procedure of SAS. Regression analyses for performance variables as a function of average live weight (kg) were conducted using the GLM procedure of SAS. For all analyses, pen was the experimental unit; an α level of 0.05 determined significance. No differences ($P > 0.10$) were noted for initial BW. Final live BW of implanted steers was greater ($P \le 0.05$), and implants improved ($P \le 0.05$) ADG by 16.5% and FG by 9% over NI. Implants increased ($P \le 0.05$) HCW by 8% over NI. The XS steers had the greatest ($P < 0.05$) HCW and dressing percent over all other treatments. The XS group had greater ($P < 0.05$) BF than NI, XR, and D200; E200 was intermediate and did not differ ($P > 0.10$) from others. Increased BF for XS resulted in greater ($P < 0.05$) YG relative to other treatments. Across implants REA did not differ ($P > 0.10$); yet, XR had an increase of ~5% in REA over NI and E200. The NI steers had greater ($P < 0.05$) marbling scores than E200 and D200; XR and XS were intermediate, not differing ($P > 0.10$) from others. The XS steers had the greatest ($P < 0.05$) calculated EBF%. Implant × day interactions were noted ($P \le 0.05$) for relative gain responses, GED, and serum urea-N (SUN). Relative gain responses were greatest ($P \le 0.05$) on d 70 for E200 and XS. On d 140, gain responses were greater ($P \le 0.05$) for D200, XR, and XS than NI or E200. Values for GED were decreased ($P \le 0.05$) on d 70 for E200 and XS, on d 140 for XR and D200, and on d 213 for XR compared to XS. Across treatments SUN did not differ ($P > 0.10$) on d 1, 105, 140, 175 and 213. On d 14, D200 steers had greater ($P \le 0.05$) SUN than E200 and XS. On d 35, E200 had the lowest ($P < 0.05$) SUN. On d 70, E200 and XR had decreased ($P \le 0.05$) SUN

compared to NI. No implant × day interaction or treatment effect was noted (*P* > 0.10) for NEFA; while day did alter (*P* < 0.05) NEFA. Regression analyses indicated that growth performance variables for NI and Implanted steers were predictable functions of average live weight. The equivalent of an additional combination implant (i.e. XS) improved ADG and HCW without detriment to marbling scores compared to a single implant. Relative gain and GED responses indicate that effective payout for XR is altered relative to a single Revalor-200 on d 1 (i.e. E200), and similar to a single Revalor-200 on d 70 (i.e. D200).

Effects of energy concentration and intake of digestible fiber-based diets on immune response, health, and performance of newly received stocker cattle *T. J. Spore[1], S. P. Montgomery[2], G. A. Hanzlicek[1], K. T. Cavalli[1], W. R. Hollenbeck[1], R. N. Wahl[1], C. I. Vahl[1], E. C. Titgemeyer[1] and D. A. Blasi[1], Kansas State University, Manhattan, [2]Corn Belt Livestock Services, Papillion, NE*
370 crossbred heifers (initial BW = 491 ± 36.6 lb) were received at the Kansas State University Beef Stocker Unit from auction market facilities in Tennessee and Alabama to evaluate the effects of energy concentration and intake of highly digestible diets based primarily on wet corn gluten feed on immune function and performance of newly received stocker cattle. On arrival, all animals were administered metaphylaxis, vaccinated against common clostridial and viral diseases, and treated for internal parasites. All animals were re-vaccinated on d 14. Heifers were assigned to pens based on initial BW and pens randomly assigned to four treatments. There were 8 pens / treatment for a total of 32 pens each containing approximately 12 hd. Treatments consisted of four diets formulated to provide 45, 50, 55, and 60 Mcal NE_g/100 lb DM. The 45 NE_g treatment was offered to ensure *ad libitum* intake (45/100) and the other three offered at 95 (50/95), 90 (55/90), and 85% (60/85) of the 45/100 treatment intake. Leftover feed was removed and DMI calculated from the 45/100 treatment pens daily to adjust feed delivery of the other treatments. The trial was 55 days in duration taking place in May-July 2016 with the last 14 days of the trial used for gut-fill equalization where a common diet (45/100) was fed to all animals. A random selection of 32 heifers from each treatment were bled via a tail vein on d 0, 14, and 27 to analyze the effects of dietary treatment on serum haptoglobin concentrations and titer levels for Bovine Viral Diarrhea I (BVD I) Bovine Viral Diarrhea II (BVD II) and Infectious Bovine Rhinotracheitis (IBR). Haptoglobin was measured using a colorimetric assay and titer levels were obtained using serum neutralization. In general, heifers performed well on all treatments and morbidity and mortality were relatively low. Dietary treatment had no effect on haptoglobin concentrations (*P = 0.26*) or titer levels for IBR (*P = 0.62*), BVD I (*P = 0.89*), or BVD II (*P = 0.92*) viruses. Additionally, there was no effect of treatment on ADG (*P = 0.73*), morbidity (*P = 0.99*), or mortality (*P = 0.83)*.   Since animals performed similarly on decreased intakes of the higher energy treatments there was an effect of treatment on G:F (*P = 0.004*). These data indicate high-energy diets can be utilized in the receiving and growing period if the energy is derived mostly from fermentable fiber and not starch. Metabolic disorders such as subacute ruminal acidosis brought on by ingestion of rapidly fermentable carbohydrate were not evident in this study. Inflammation, as measured by haptoglobin, was not affected by increased energy and the antibody response to vaccines was also not affected implicating dietary

energy increased to 60 Mcal NE_g/100 lb DM in a limit-fed diet has little to no effect on overall health and immune response and can increase performance. In summary, limit-fed, high-energy diets based primarily on fermentable fiber can offer a more efficient approach to feeding newly received stocker cattle without negative effects on overall health.

The effects of bodyweight and implant status on blood parameters, carcass characteristics and animal performance of finishing steers *T. A. Vogel, Z. K. Smith, K. B. Wellmann, and B. J. Johnson, Texas Tech University, Lubbock*
Crossbred steers (n=20) were used to evaluate animal performance, sera metabolite responses, and carcass characteristics in a 2 × 2 factorial arrangement of treatments: [body weight at treatment initiation: Light (LT), or Heavy (HV); implant regimen: Non-implanted (NI), or Implanted (IMP)], with individual steer as the experimental unit. Initial body weight for LT and HV steers were 878 ± 60.8 lb. and 1205 ± 55.5 lb. Implanted steers received a Revalor-200 (200 mg TBA + 20 mg E_2, Merck Animal Health) at study initiation. Cattle within the same treatment were group housed in common pens (n = 5 steers/pen). Blood samples and bodyweight were collected at study initiation (d 0), d 14, 35, 70 and 104. Cattle were fed 1X daily to provide *ad libitum* access to feed using a clean bunk management approach. The steam flaked corn based finishing diet contained 13.3% CP, 97.0 Mcal/cwt NEm, 66.0 Mcal/cwt NEg, 33.0 g/ton of monensin sodium and 11.0 g/ton of tylosin phosphate. Cumulative performance and carcass traits were analyzed using the MIXED procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC). Sera metabolite data, including non-esterified fatty acid (NEFA) and serum urea-N (SUN) concentrations, were analyzed as repeated measures over time, with day included as the repeated statement. For all analyses an α level of 0.05 determined significance. Pen DMI was tabulated to provide context to animal performance and blood variable responses. Heavy cattle consumed 5.2 lb more DM per day during the study than LT cattle (22.54 vs 17.35 lb/d) and IMP steers consumed 2.1 lb more DM per day than NI steers (21.0 vs 18.9 lb/d). Cumulative ADG did not differ between the LT and HV (3.10 vs 3.34 ± 0.26 lb; $P = 0.18$) groups. Implanting increased ($P < 0.01$) ADG by 39 % (3.75 vs 2.69 ± 0.26 lb) during the study. However, no differences ($P > 0.05$) in ADG were observed in NI vs IMP cattle beyond d 70 (2.67 vs 2.33 ± 0.67 lb; $P = 0.41$), suggesting effective payout for Revalor-200 is ~70 d. Implanting LT cattle increased NEFA concentrations on d 14 suggesting implants result in rapid mobilization of fat early in the feeding period for lighter weight cattle. Likewise, SUN concentrations were lowest ($P < 0.01$) in LT cattle subjected to IMP for the duration of the study and increased over time for the other treatments. Carcass data including HCW, REA, backfat, marbling scores, calculated YG, and EBF were greater ($P \leq 0.01$) in HV vs LT. Implanted cattle had heavier HCW than NI ($P < 0.01$). There was no difference ($P > 0.05$) for REA, rib fat, calculated YG or EBF %; however, IMP cattle had decreased marbling scores ($P = 0.05$) compared to the NI group. In addition, no differences in rate of gain ($P = 0.18$) were observed between LT and HV cattle suggesting similar rates of gain in cattle up to 1600 lb of live weight. These results reaffirm the effects of implanting cattle on animal performance.

Effects of roughage inclusion and particle size on digestion and ruminal fermentation characteristics of beef steers *C. P. Weiss[1], W. W. Gentry[1], C. M. Meredith[1], B. E. Meyer[2], N. A. Cole[2], L. O. Tedeschi[3], F. T. McCollum III[1], and J. S. Jennings[1], [1]Texas A&M AgriLife Research and Extension Center, Amarillo, [2]USDA-ARS, Bushland,TX, [3]Texas A&M University, College Station.*
Roughage is fed in finishing diets to promote ruminal health and decrease digestive upset, but the inclusion rate is limited due to the cost per unit of energy and feed management issues. Rumination behavior of cattle may be a means to standardize roughage in beef cattle finishing diets, and increasing the particle size of roughage could modulate the ruminal environment and aide in maintaining ruminal pH. Therefore, an experiment was conducted to determine the effects of corn stalks (CS) inclusion rate and particle size in finishing diets on digestibility, rumination, and ruminal fermentation characteristics of beef steers. Four ruminally cannulated steers were used in a 4 × 4 Latin square experiment. Treatments were arranged as a 2 × 2 factorial with treatments consisting of 5% inclusion of a short-grind roughage (5SG), 10% inclusion of a short-grind roughage (10SG), 5% inclusion of a long-grind roughage (5LG), and 10% inclusion of a long-grind roughage (10LG). Differences in particle size were obtained by grinding corn stalks once (LG) or twice (SG) using a commercial tub grinder equipped with a 4 in screen and quantified using the Penn State Particle Separator (PSPS) to estimate physically effective NDF (peNDF). Each period included 14 d for adaptation and 4 d for diet, fecal and ruminal fluid collections. Animals were outfitted with rumination monitoring collars to continuously measure rumination activity. The 10LG treatment had a greater ($P < 0.01$) percentage of large particles (retained on the top three sieves of the PSPS) compared to the other treatments. This resulted in a greater ($P < 0.01$) percentage of estimated peNDF for the 10LG diet compared to the others. Feeding diets containing 5% roughage tended to increase ($P \leq 0.09$) DM, NDF, and starch total tract digestibility compared to diets containing 10% roughage. Cattle consuming LG treatments had greater ($P < 0.01$) rumination time, and greater ($P < 0.01$) ruminal pH than cattle consuming diets containing SG roughage. Cattle receiving the 5% inclusion rate of roughage tended to have greater ($P = 0.09$) time (hr/d) under a ruminal pH of 5.6 and a larger ($P = 0.03$) area under the threshold compared to 10% roughage treatments. Overall, feeding a lower inclusion of roughage with a larger particle size may stimulate rumination and aid in ruminal buffering similar to that of a higher inclusion of roughage with a smaller particle size, without negatively impacting on digestibility and fermentation.

Effect of Differing Backgrounding Systems on Performance and Carcass Characteristics of Yearling Steers *C. A. Welchons, R. G. Bondurant, F. H. Hilscher, A. K. Watson, G. E. Erickson, and J. C. MacDonald, University of Nebraska-Lincoln*
Profitability of a supplementation program is affected by timing and level, relative to the finishing period. From November 2015 to March 2017, 480 crossbred steers (541 lb, SD = 28; 240 each year) were utilized to determine the effects of different summer management strategies finishing performance and carcass characteristics. Steers were wintered on corn residue from November to mid-April and supplemented daily with MDGS at 1.0% of initial BW. After removal from stalks, steers were blocked by BW (n = 3), and stratified by BW within block using a 3-d average weight following 5 d of limit

feeding at 2% of BW to equalize gut fill. Calves were then assigned to 1 of 5 treatments with 4 replications per treatment each year. Treatments consisted of summer finished steers (SHORT), grazing smooth bromegrass and supplemented with DDGS at 0.6% of BW (SUPP), grazing smooth bromegrass with no supplement (UNSUPP), backgrounded in a pen to target ADG of 2.35 lb/d (HI), and backgrounded in pen to target ADG of 1.68 lb/d (LO). The level of targeted gain in the HI and LO treatments was equal to a 10-yr average of SUPP and UNSUPP gains on brome pastures. High and LO steers were fed a common backgrounding diet at 11.24 and 9.15% of initial metabolic BW, respectively. To account for forage substitution due to supplementation, SUPP steers were stocked at a rate of 4 AUM/ha while UNSUPP steers were stocked at 2.68 AUM/ha. The summer grazing/backgrounding season lasted 156 d in year 1 and 161 d in year 2. Following the conclusion of the grazing season in September, SUPP, UNSUPP, HI, and LO steers summer treatment experimental units were preserved and fed a common finishing diet *ad libitum* until reaching 0.55 in of 12th rib fat as assessed with ultrasound. There was a significant treatment x year interaction for performance variables and, therefore, data were reported by year. In year 1, summer ADG differed among all backgrounding treatments ($P \leq 0.01$) with HI cattle having the greatest ADG (2.28 lb/d) followed by LO (1.80 lb/d), SUPP (1.63 lb/d), and UNSUPP (1.03 lb/d). In year 2 however, ADG was similar for HI and SUPP cattle (2.08 and 1.99 lb/d, respectively; $P > 0.23$) followed by LO cattle (1.67 lb/d) and then UNSUPP cattle (1.05 lb/d; $P \leq 0.01$). Feedlot ADG was greatest for SHORT cattle in year 1 with all backgrounded cattle having similar ADG during the finishing period, while in year 2, feedlot ADG was greatest for UNSUPP cattle, suggesting compensatory gain, and was similar for all other treatments ($P \leq 0.01$). In year 1, UNSUPP cattle had the lowest HCW ($P \leq 0.01$) while in year 2 all summer backgrounded cattle had greater HCW than SHORT cattle, likely due to treatments being finished to a similar fat endpoint, compared to year 1. Overall, backgrounding programs increased HCW when all cattle were fed to a common fat endpoint. Contrary to previous research evaluating summer supplementation following winter supplementation, there was no compensatory gain in the feedlot except for the UNSUPP cattle in year 2. Therefore programs designed to target compensatory gain in the feedlot may have limited success.

Effects of zinc propionate supplementation on performance, skeletal muscle fiber and receptor characteristics in beef steers *K. B. Wellmann, J. O. Baggerman, W. C. Burson, K. Kennedy, Z. K. Smith, B. C. Bernhard, and B. J. Johnson, Texas Tech University, Lubbock*
Yearling crossbred beef steers (n=32; Initial average BW = 442 ± 17.0 kg) were utilized in a randomized complete block design feedlot experiment to evaluate the effects of added dietary Zn (KemTRACE® Zinc Propionate 27; Kemin Industries, Inc. Des Moines, IA) supplementation on live performance, skeletal muscle fiber, and beta adrenergic receptor characteristics during the finishing phase.. Steers were blocked by BW (n=4 blocks; 8 steers/block). Within each block, steers were assigned to pens (n=4 steers/pen); pen within each block was then randomly assigned to either of the following treatments: control (**CON**; 0.0 g/(hd · d) of additional Zn) or additional dietary Zn (**ZnP**; 1.0 g/(hd · d) additional Zn). Steers were fed a steam-flaked corn based diet 1X daily in order to achieve *ad libitum* access to feed, using a clean bunk management approach.

The basal diet contained Zn (60 ppm DM basis) from $ZnSO_4$; additional Zn was top-dressed at the time of feeding. Steers were fed for 111 d, of which ractopamine hydrochloride (**RH**; Optaflexx: Elanco Animal Health, Greenfield, IN) was included at 300 mg/ (hd · d) for the final 28 d of the feeding period. *Longissimus* muscle biopsy samples and BW measures were obtained on d 0, 42, 79, and 107. Final BW was collected immediately prior to shipping on d 111. Biopsy samples were used for immunohistochemical analysis (IHC). Live performance data were analyzed using the GLIMMIX procedure of SAS® 9.4 (SAS Institute, Inc., Cary, NC). All IHC data were analyzed as repeated measures over time, using the MIXED procedure of SAS 9.4. The experimental unit was pen for performance data and individual steer for IHC analyses. An α level of 0.05 was used to determine significance, with tendencies discussed at *P*-values between 0.05 and 0.15. Steers fed ZnP had greater ADG (P=0.02) and G:F (P=0.03) during the beta agonist feeding period compared to CON. There were no differences in other growth performance variables (P>0.05). There were no differences between treatments for β 1-adrenergic receptor density (β1-AR; P>0.05) in skeletal muscle tissue throughout the study as determined by IHC staining. There was a tendency for a treatment by day interaction for β 2-adrenergic receptor density (β2-AR; P=0.15) as well as β 3-adrenergic receptor density (β3-AR; P=0.09) throughout the RH phase. A treatment by day interaction was observed in β2-AR (P=0.02) and β3-AR (P=0.02) during the RH feeding period, where the abundance of the receptors increased with ZnP but did not change in CON. These data indicated that an upregulation of β2-AR and β3-AR occurs in feedlot steers during the RH feeding period in response to additional dietary Zn, supplied as Zn propionate. These results also indicated Zn propionate supplementation improves performance and gain efficiency of finishing steers during the beta agonist feeding period.

Effects of exercise and roughage source on the health and performance of receiving calves *M. A. Woolsoncroft, M. E. Youngers, L. J. McPhillips, C. G. Lockard, C. L. Haviland, E. S. DeSocio, W. R. Ryan, and B. K. Wilson, Oklahoma State University, Stillwater*

There has been increased interest in animal welfare and antimicrobial use from consumers regarding confinement beef production. Exercise may benefit animal health and could alleviate some animal welfare concerns. Roughage stimulates the rumen environment to improve digestive health and aids in the transition to a high concentrate diet. The objectives of this experiment were to determine the effects of exercise and roughage source on receiving calf health and performance during a 56 d receiving period. Newly received steers (n = 94; initial BW 250 ± 12 kg) were assigned to treatments in a randomized complete block design with a 2 × 2 factorial arrangement of treatments. Factors were: (HAY) 30% hay DM or (HULLS) 15% cottonseed hulls and 15% soybean hulls DM and (EX) 529 m of exercise or (NEX) no exercise resulting in 4 treatments with 5 pens/treatment. Every 14 d, BW were obtained and fecal samples were collected to determine fecal pH (FpH) and fecal score (FS; assessed on a 5-point scale with 1 = solid to 5 = water-like). There were no differences in BW or ADG throughout the experiment. However, HULLS had reduced DMI from d 29-42, 43-56 and 0-56 ($P \leq 0.04$). There was a interaction for G:F from d 43-56 with increased G:F for HULLS EX (P = 0.01). Throughout the experiment, G:F was increased for HULLS (P <

0.001) and EX (*P* = 0.02). There was a difference on d 0 in FpH (*P* = 0.01) with EX calves being greater. The HULLS diet had a greater FS on d 14 (*P* = 0.02) resulting in increased FS change (FSC) from d 0-14 (*P* = 0.01). There was a tendency for the HULLS diet to have a greater FS on d 28 (*P* = 0.08) and a FSC interaction was present from d 15-28 (*P* = 0.02). On d 56, there was an interaction for both FS and FpH with HAY NEX having decreased FS and FpH (*P* < 0.01 and *P* = 0.05, respectively). This resulted in a tendency for an interaction for FSC (*P* = 0.09) and an interaction for FpH change (FpHC; *P* = 0.04) overall. There was no significant difference among the experimental treatments for first antimicrobial treatment percentages, second antimicrobial treatment percentages, total antimicrobials administered, or rectal temperatures. When cottonseed hulls and soybean hulls were fed as the roughage source in the diet calves gained weight more efficiently during the first 56 d on feed. Calves that were exercise were also more efficient during the 56 d receiving period. Further investigation is needed to determine the effects of exercise on clinical health and fecal characteristics.

Effects of bacterial direct-fed microbials and feeding method of low-quality hay in drylot on subsequent wheat pasture performance by yearling beef heifers

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Wheat pasture gain performance of yearling beef cattle was measured to assess effects of a single-dose direct-fed microbial (DFM) in combination with preconditioning feeding strategy. Angus-sired heifers (n = 96; initial BW 230 ± 29 kg) were stratified by BW and assigned to one of 8 pens in a completely randomized design. Diet treatments were randomly assigned to pen and consisted of either ad libitum access to low-quality sorghum × sudangrass (*Sorghum bicolor* (L.) Moench.] hay with 3.50 kg/d of supplement, or a total diet utilizing 37.7% of the same hay, 38.4% dry rolled corn, and 3.8% distillers grains. Both dietary treatments were formulated to facilitate 0.90 kg ADG based on anticipated hay intake. Within pen, six heifers were randomly selected to receive either 0 or 15g of a commercially available DFM (Probios, Chr. Hansen, Inc.) in porcine gel caps on d 0. Heifers were confined to drylot for 70 d prior to grazing a single 32-ha field of winter wheat. Heifers were gathered and weighed on d 10 of grazing and each 7 d thereafter for 38 d. The DFM had no effect on ADG (*P* ≥ 0.38) during grazing, and no DFM × diet interaction was present (*P* ≥ 0.25). Heifer ADG from grazing d 0-10, 18-24, and 32-38 did not differ by diet (*P* ≥ 0.14). From d 11-17, heifers with ad libitum access to hay in drylot gained 0.46 $kg^{-1} \cdot d^{-1}$ more (*P* = 0.03) than heifers consuming a mixed diet. Similarly, an ADG increase attributed to ad libitum hay was 0.42 $kg^{-1} \cdot d^{-1}$ greater (*P* = 0.02) from d 25-31. Over the entire duration of the grazing period, drylot diet did not have a significant effect (*P* = 0.20) on heifer performance. Administration of direct-fed microbials at the beginning of a 70 day dry-lot feeding period had no effect on subsequent grazing gain performance. When feeding poor-quality hay in a drylot, providing ad libitum access in addition to a daily supplement relative to incorporation into a mixed diet could enhance subsequent wheat pasture weight gain.

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Richard "Dale" Furr	Irwin Dyer	Dean Hodge
Mel Karr	Marion Ensminger	Arthur (Art) P. Raun
Hollis Klett	William (Bill) N. Garrett	Leo F. Richardson
Jack E. Martin	Fred Owens	
	Rod Preston	

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Nominating Committee: Steve Armbruster, Tony Bryant, Andy Cole, Bill Dicke, Allen McDonald, Robbi Pritchard, and Spencer Swingle
Other contributors: Kenneth Eng, Keith Hansen, Kendall Karr, Bob Beville

2017 Inductees - Consultants

Richard "Dale" Furr

Richard "Dale" Furr was born in 1934 in Prosper, TX and was raised on a farm and ranch in Rhea Mills, TX. He graduated from McKinney High School in 1953 and studied Agricultural Education at Sam Houston State College where he received a B.S. degree in 1958. He earned M.S. and Ph.D. degrees in Animal Nutrition at Oklahoma State University in 1959 and 1961, respectively, under the direction of A.B. Nelson.

Dale started his career in October 1961 as an Area Livestock Specialist with the Agricultural Extension Service of the University of Hawaii. Much of his research centered around mineral supplementation and stilbesterol implantation for calves on pasture.

In 1964, Dale moved back to Texas where he took over the role of Professor and Superintendent of Farms at the Texas Tech University research facility at Pantex in Amarillo, TX. He managed a very diverse research program that included evaluation of feeding high quality paper to ruminants (remember this research facility was located alongside an atomic energy plant with a high need to destroy paper documents). He also conducted a great deal of grain processing research including micronized milo but also had a flaker on-site to provide some of the first work in the Texas panhandle evaluating flaking of the newly arrived corn crop to the area. In addition, he was heavily involved in the evaluation of the increasing number of new pharmaceutical products in the market during that time. In all, Dale authored over 100 scientific and popular publications dealing with beef cattle nutrition.

In August of 1969, Dale became one of the original owners and a nutritionist for Hi-Pro Feeds, a newly formed feedmill division of Friona Industries. During this time, Dale was one of the first to use and push forward the development of early computer formulation programs. At Hi-Pro feeds, he first started providing nutrition advice and consulting to customers of the feedmill.

Dale left Hi-Pro in 1977 to start an independent feedlot consulting business. He focused his efforts in the Texas panhandle and built a large business around a group of very devoted clients. Dale was the consummate people person and enjoyed working with people to improve their business. His friends will tell you that he loved people and people loved him mainly because he always had their best interest at heart. He was a perfectionist and was most satisfied when he had given his best to his customers.

Dale married his wife Jan in 1985 in Hereford, TX and lived there until moving to Amarillo in 2000. Dale battled heart issues and subsequent surgeries later in life and also suffered with Alzheimer's the last 4 to 5 years of his life. Richard "Dale" Furr passed away on August 30, 2011.

2017 Inductees - Consultants

Melvin Ray Karr

Mel Karr was born in 1933 in Chillicothe, Missouri. Karr served in the Armed Services in Germany from 1953 to 1955. Upon returning home, he married Lulabelle (Lou) Brown in 1957, and they remained married for the next 54 years. Mel and Lou had 2 children: Kendall and Kathy (Runnels).

Karr attended the University of Missouri where he received a Bachelor of Science in 1959 and a Master of Science in Animal Nutrition in 1960. Karr then earned a Ph.D. from the University of Illinois in 1964 in Animal Nutrition with minors in Biochemistry and Physiology. After receiving his doctorate, Karr spent almost 2 years at the University of Kentucky teaching and performing research before accepting a job in St. Louis with Ralston Purina.

While with Purina, Karr's duties included beef cattle nutrition consulting as well as conducting research at the company's research facility. In 1970, Karr moved his family to Lubbock, Texas just in time to survive the tornado that destroyed a large part of Lubbock on May 10th. In Lubbock, Karr set up his feedlot nutrition consulting business which was successful for the next 38 years. Mel took flying lessons in the early 1970's and eventually purchased a Cessna 210 to better serve his clients. During his 20 plus years of flying and landing on makeshift runways, he survived 2 plane crashes.

Karr continued to be interested in all types of research throughout his career. He was especially interested in grain processing, and he helped in the development of several feed products and in increasing the knowledge base in this area. Mel's legacy continues as his son, Kendall, is also a feedlot nutritionist.

Not long after moving to Lubbock, Karr started breeding Quarter Horses for show, cutting, and then racing. The highlight of his racing career was running second in the All-American Derby and being 1 of only 10 invited to the Champion of Champions Quarter Horse race in Los Alamitos, California in 1981.

Mel continued working even after being diagnosed with lymphoma and later leukemia. At the age of 77, Mel passed away on June 26th, 2010.

Hollis Klett

Hollis Klett is a native of Menard, Texas and an identical twin. Hollis majored in Animal science at Texas A&M University. While at TAMU he was a member of the wool and livestock judging teams. After receiving his B.S. in 1958, he worked as a ranch manager in Mississippi for three years before returning to TAMU to pursue his Masters degree. He then moved to Oregon State University where he received his Ph.D. in 1963.

For the next nine years Hollis taught animal science at Louisiana State University and then became a professor at Texas Tech University where he led the Texas Tech Research – Pantex Station east of Amarillo.

In 1972 he presented a groundbreaking paper on the feeding of urea in liquid supplements at the annual conference of the American Feed industry Association (AFIA). This led to research and demonstrations in Kenya and Uganda and to international travel as a nutritional consultant and researcher.

In 1974 Dr. Klett accepted a feedlot nutritional consulting position with Nutrition Service Association where he consulted for as many as 20 feedlots in Texas, Arizona, California, Kansas, and Mexico. After managing the Southwest Division for 12 years, he purchased the company in 1986. Today, he is the President and major shareholder of XF Enterprises, the holding company for Nutrition Service Associates (NSA). NSA now does business in the U.S., Canada, and Australia and represents over 2.5 million feedlot cattle. XF Enterprises also comprises the feed and supplement manufacturer XtraFactors and three other companies that service the feedlot and range cattle industries throughout the central and eastern parts of Australia. They recently completed construction of a non-medicated feed plant to manufacture companion animal premixes near Pratt, KS.

Hollis also owns the Klett Ranch near Tucumcari, NM and the 22,000 head OT-Feedyard and Research Center near Hereford, TX. The research center collaborates with industry and commercial groups as well as with Texas A&M and West Texas A&M Universities to provide opportunities for student internships.

Dr. Klett was inducted into the AFIA Hall of Fame in 2006, was named an Honorary Lifetime Member of the Saddle and Sirloin Club in 2012, and was named an Outstanding Alumni by the Department of Animal Science at Texas A&M in 2014. Hollis was one of the founding members of the PNC. He has demonstrated his commitment to the future of animal science by establishing the Klett Family Beef Nutrition and Livestock Judging Team Endowments at TAMU. He also supports a graduate assistantship in beef cattle nutrition, hosts the Jim Theeck Beef Cattle Tour at his feedlot, and provides the NSA scholarship at TAMU.

Jack Edward Martin

Jack Martin was born in 1931 and raised on a general livestock farm in northwest Missouri. Jack's education began in a one-room school in Carrollton, Mo., and continued through earning Bachelor of Science and Master of Science degrees in Animal Sciences at the University of Missouri in 1953 and 1959, respectively, and his Ph.D. in Animal Sciences from the University of Florida in 1963. Jack married Norma Remely in 1955 and together they had three sons: Keith, Grant and Paul. Norma passed away in 2010. Jack served in the US Army from 1954 to 1956 and was stationed in Germany at the 98th General Hospital.

Upon completion of his graduate studies, Jack began his professional career working in product development and marketing for the Monsanto Chemical Company in St. Louis, Mo. While at Monsanto, Jack worked with Gene Erwin and Bob Granger. In 1967 he joined the Ralston-Purina feedlot consulting group in St. Louis, which was directed by Dean Hodge and also included Kenneth Eng and Mel Karr, among others. In 1969 Jack moved on to the Ceres Land and Cattle Company where, among other responsibilities, he was involved in feedmill design and construction of three feedyards in the Soviet Union.

Desiring to more directly apply his interest, education, and training in ruminant nutrition, Jack Left Ceres in 1970 to found Sterling Nutritional Services, which he and Norma operated out of Sterling, CO. Jack's first client as an independent consultant was A. Glenn Cluck of Columbus, NE, and over the next 40 years he served clients in NE, KS, the TX panhandle, NM, CO, WY, SD and IA, as well as in international locations such as Australia, Malaysia, Ecuador, France, and the Soviet Union. Jack feels fortunate to have been active during a time of rapid expansion of commercial cattle feeding and when feed additives, such as monensin, significantly altered feeding practices and formulation of diets for feedlot cattle. He was at the forefront of many cattle feeding practices, including slick bunk management and limit-feeding of light weight calves. Like many of his contemporaries, Jack was an accomplished pilot, logging over 7,000 flying hours during his career.

Drawn by the organization's dedication to high standards and ethics in the consulting business, Jack joined the American Society of Agricultural Consultants in 1970, and served as its president in 1987, a distinction shared with M.E. Ensminger, James Nofziger, J.D. Aughtry and John Algeo. Jack is also a long-time member of the American Society of Animal Science and the Plains Nutrition Council and has served on consultant advisory boards for several pharmaceutical companies.

Jack closed Sterling Nutritional Services in 2010 and now resides in Oro Valley, AZ with Colleen and their four puppies.

2017 Inductees - Academic

Irwin Allen Dyer

Irwin A. Dyer was born in Dahlonega, GA on February 8, 1921. He attended Jr. College for two years, West Georgia College for one year, and then entered the University of Georgia. During his undergraduate studies, he left for three years to serve in the Navy including 20 months in the Pacific during World War II. Following his time in the service, he returned to the University of Georgia and completed his B.S. in 1946 and M.S. in 1947. He then attended the University of Illinois at Urbana earning a Ph.D. in 1950.

Dyer began a teaching and research appointment on the faculty at the University of Georgia in 1950. In 1952, he became the Advisor to the Ministry of Agriculture in El Salvador, and in 1955 returned to join the faculty of Washington State University. Dyer became the Chairman of the Graduate Program in Nutrition in 1968 and was appointed Associate Dean of the Graduate School in 1970. He then went on to become the Chief of the WSU Party and Head of the Department of Animal Production and Protection at the University of Jordan, Amman in 1975. In 1977, he returned to Washington State as Professor and Associate Dean but left again in 1978 to become Dean of the College of Agriculture at Texas A&I in Kingsville, TX.

While at Texas A&I, Dyer was instrumental in the expansion of the College of Agriculture. Through his inventiveness, good humor, and capacity for work, he led the College to expand the faculty, institute a new horse program, organize Beef and Horse Advisory Boards, and develop student-to-student recruiting programs.

During his career, Dyer was a highly productive researcher and writer with over 100 technical articles and many bulletins, popular articles, and extension publications. He received the most acclaim for 3 books that he co-authored: *Animal Growth and Nutrition* published in 1969, *Commercial Beef Cattle Production* published in 1972, and *The Feedlot* also published in 1972. Dyer was also a talented and popular teacher and graduate advisor. Under his direction, 18 students received Ph.D.'s and 31 received M.S. degrees.

Dyer's professional affiliations included being a member of the American Association for the Advancement of Science, the American Institute of Nutrition, the American Society of Animal Science, and the Council for Agricultural Science and Technology. The Washington Cattle Feeder's Association presented him the Friend of the Industry Award in 1974. Additionally, he received the Distinguished Service Award from the Western Section of the American Society of Animal Science in 1975. Outside of his work-life, he was an active member of the Presbyterian Church and the Kiwanis.

Dyer suffered from ALS, Lou Gehrig's disease. Even as the disease progressed and took its physical toll, he remained active, alert, and in good humor. Dr. Dyer passed away on Christmas Day, 1979, at the age of 58 years.

Adapted from Memorial. 1980. Irwin Allen Dyer. J. Anim. Sci. 50(4): 765.

2017 Inductees - Academic

Marion E. Ensminger

Dr. Ensminger (1908-1998) was a native of Missouri whose career spanned over 60 years, across the USA, and eventually across the world. He was the first manager of the University of Illinois Dixon Springs Experiment Station. He went on to serve on the faculty at the University of Illinois, the University of Massachusetts, the University of Minnesota, and Washington State University. At WSU he also served as the department head and under his leadership the department transitioned from the Department of Animal Husbandry to the Department of Animal Science and began offering the Ph. D. degree.

Several notable events of interest to the cattle industry occurred while Dr. Ensminger was at WSU. It was during that time that he developed the concept of the International Stockman's School which was a new approach to outreach and producer education. This was the forerunner of several such programs Dr. Ensminger put together in his career and these schools spanned decades. Interestingly, several of the Legends of Feedlot Nutrition were in Pullman during his tenure there. Looking back, this seems to have been an incubator for what we have come to know as feedlot consulting.

One of those LOFN overlaps was with Dr. Jim Nofziger, who collaborated with Dr. Ensminger to form the American Society of Agricultural Consultants. The organization outlined the template for what consulting services should be and developed a Code of Ethics that remains as relevant today as they were in 1963. Dr. Ensminger served as the first president of American Society of Agricultural Consultants. He also served as president of the Western Section ASAS, as vice president of ASAS, and on the ASAS Board of Directors.

Dr. Ensminger has over 500 publications to his credit, including 22 books. He served as editor of the Feeds and Feeding textbook originally published by W.A. Henry. The Ag Tech schools that Dr. Ensminger developed and led reached out to over 70 countries. In 1995, the schools in Russia and Ukraine were jointly sponsored with Iowa State University.

Dr. Ensminger was awarded the Honorary Doctor of Humane Letters by Iowa State University (1996). His portrait is hung in the Saddle and Sirloin Club. The beef teaching and research facility at Washington State University was named the Ensminger Beef Cattle Research Center in 1984 and Iowa State University dedicated the Marion Eugene Ensminger and Audrey Helen Ensminger International Room in Kildee Hall in 1998. The Animal Science Department at Iowa State University has copies of Dr. Ensminger's autobiography available for those who may want to know more about this interesting career in livestock production and outreach.

2017 Inductees - Academic

William (Bill) N. Garrett

Bill Garrett was born on June 8, 1926 in Munster, PA. Upon graduation from Cresson High School in 1944, he enlisted in the U.S. Navy where he served on the USS Tarawa and in a TBM Avenger torpedo bomber. Following his service, he enrolled in The Pennsylvania State University in 1946 earning a B.S. degree in Animal Husbandry in 1950 and a M.S. degree in 1951. He then earned his Ph.D. in 1958 at the University of California-Davis working with Glen P. Lofgreen and James H. Meyer. Garrett's graduate studies focused on evaluating energy utilization in cattle and sheep, and this would be the area of study he would pursue for the rest of his career.

Upon completion of his Ph.D. program, Garrett was appointed Assistant Animal Husbandman in the Department of Animal Husbandry at UC-Davis where he oversaw cattle operations at the Imperial Valley Field Station. During this time, he continued his nutritional work with feedlot cattle but also worked on housing designs to keep cattle cooler in hot environments. He moved back to UC-Davis in 1963 and began teaching along with continuing his research program. During this time, he was the major professor for 29 M.S. students and 7 Ph.D. students.

Garrett and co-worker Lofgreen are best known for their research and subsequent development of the California Net Energy System for stating the net energy requirements of ruminants and the associated net energy values for feedstuffs. Many of the publications related to this system are among the most frequently cited references for the Journal of Animal Science. The significance of this work cannot be understated and is evident based on its widespread use in research and commercial settings some 50 years after the first publications. In honor of his accomplishments, Garrett received the American Feed Manufacturer's Award in 1975 and the highest honor from ASAS in 1986 when he received the Morrison Award for distinguished service.

Garrett served as Secretary-Treasurer, Vice-President, and President of the Western section of the American Society of Animal Science and then as President of the ASAS from 1983-1984. He served on the Editorial Board for the Journal of Animal Science, chaired the Ruminant Nutrition Program Committee, and represented ASAS to the Board of Directors of the Council for Agricultural Science and Technology. He also served on various committees of the National Academy of Science National Research Council and was the North American representative to the Organizing Committee for the Ninth Symposium on Energy Metabolism. From 1987 to 1990, Garrett stepped up and served as the Department of Animal Science Chair at UC-Davis and retired from this position. He was honored as an ASAS Fellow in 2001.

Garrett was a devoted family man and was preceded in death by his beloved wife Ida of almost 60 years. He spent his retirement years fishing and enjoying the outdoors. Even during retirement, he served as a mentor and colleague continuing to inspire subsequent generations. By those that knew him well, he was characterized as an

outstanding scientist, educator, leader, and person. William N. Garrett passed away at the age of 90 on September 18, 2016.
Adapted from Oberbauer, A.M. and C.A. Old. 2017. William N. Garrett (1926-2016): A brief biography. J. Anim. Sci. 95: 511-512.

Fredric N. Owens

Born in Wisconsin, Fred grew up on a beef and swine farm near River Falls. Fred received his B.S. in animal science and his PhD in ruminant nutrition from the Univ. of Minnesota under the guidance of noted beef cattle nutritionists Dick Goodrich and Jay Meiske. In 1968 he joined the faculty at the University of Illinois where he started his research program on chemical and physical factors regulating synthesis of microbial protein in the rumen. While there he received the Midwestern Section of ASAS Outstanding Young Scientist Award for Research.

In 1974 Fred moved to the Animal Science department at Oklahoma State University where he continued his basic ruminant nutrition research program. He worked closely with Don Gill and many graduate students and post-doctoral fellows on feedlot nutrition. He also taught courses in beef cattle nutrition, fat and carbohydrate metabolism, rumenology, and vitamins and minerals. He developed widely recognized research programs on protein nutrition, feed intake control, grain processing, rumen function, and feed additives.

While at OSU, Fred served as the Ruminant Nutrition Section Editor for the Journal of Animal Science and later as its Editor-in-Chief. He also served on the National Research Council committees that compiled the 1984 Nutrient Requirements of Beef Cattle that is still used by a few traditional (or obsolete) nutritionists and the 1985 NRC publication on Nitrogen Metabolism of Ruminants. In 1986 he received the American Feed Industry Association award for research in animal nutrition, and he served as President of ASAS in 1992-93. In 1995 he was named a Fellow of the ASAS and in 1996 received the Morrison Award – the highest honor given by ASAS, and in 2010, the Plains Nutrition Council presented Fred with its Professional Excellence Award.

Fred has authored or coauthored over 200 referred journal papers including significant review papers on grain processing, acidosis, starch digestion, growth and development, carcass traits, and nitrogen metabolism. Together with Don Gill, Don Wagner, Keith Lusby, Gerald Horn, and others, he helped organize and edited symposia on Beef Cattle Feed Intake, Protein Nutrition, Grain Processing, and Growth Promoting Implants, each composed of chapters written by invited scientists from around the world. At OSU, he was named the Sarkeys Distinguished Professor in Animal Sciences and Regents Professor, and at his first retirement in 1998 was named Professor Emeritus.

After 24 years at OSU, Fred began a new career as a senior research scientist at DuPont Pioneer. He moved to Iowa with the child bride he had acquired and their three children in two minivans plus a semitrailer stuffed with their belongings; a considerably greater accumulation than he had in his Porsche filled roadster when he moved to OSU. At Pioneer his research focused on modifications of grains, oilseeds, and ensiled feeds to enhance their nutritional value and to improve production efficiency. In 2016 Fred involuntarily retired from Pioneer and become a private consultant freely dispensing advice, occasionally even being paid. He currently is moving his family to be near his boyhood home in Wisconsin. With his dry wit, Fred has been known to sprinkle his presentations with disarming and surprising humorous sidelights attempting to ridicule politicians, administrators, and those nutritionists who work with non-ruminant or, as he calls them, sub-ruminant animals. His discussion of “How to lengthen the day from 24 to 25 hours to increase egg production” for the Journal of Irreproducible Results, illustrates that the wacky side of his brain once functioned as well as the analytical side.

Fred indicates that he is humbled and deeply honored by this recognition from the PNC and accepts it with the proviso that the honor truly belongs to the many exceptional students and colleagues with whom he has had the privilege of working over many years.

Rodney L. Preston

Rod Preston received the B.S. degree in Animal Nutrition with High Distinction from Colorado State University (1953). He studied under Wise Burroughs for his M.S. (1955) and Ph.D. (1957) degrees in Animal Nutrition and Veterinary Physiology from Iowa State University. After graduating, he served in the USAF working in the Space Program on nutritional consideration for astronauts. Dr. Preston was Professor of Animal Science at the University of Missouri (1959-1969) and The Ohio State University (1969-1975), and was Chairman, Animal Sciences Department at Washington State University (1975-1982). At Texas Tech University (1982-1996), he held the Thornton Endowed Chair in Animal Science, was Director of the Burnett Center for Beef Cattle, Horn Distinguished Processor (1994), and Professor Emeritus (1997).

Dr. Preston is most widely known for his investigations into growth and anabolic technologies for cattle. He has published results of studies spanning from the tissue residue assays that supported the original FDA approval of oral DES through the development of estradiol and trenbolone acetate implants and somatotropins in beef cattle. Along with S Koch, he developed the urea space technique to allow repeated measure determinations of the body composition of cattle during growth. Nutrition research on N metabolism, dietary energy, and minerals nutrition complimented the studies of growth. Perhaps most recognizable to PNC members are the studies on CP withdrawl late in the finishing phase, the use of Limited Maximum Intake when starting cattle on feed, and the available starch assay they developed while at TTU. Many of his

2017 Inductees - Academic

38 graduate students are fixtures in PNC and prominently involved in the feedlot cattle industry. All of them will attest to his perception that there is an inexhaustible supply of red pens in the universe.

Dr. Preston has an extensive record of service with an abbreviated list that includes: Editor of the Applied Section of the Journal of Animal Science, President of ASAS, the National Academies of Science NRC Committee on Animal Nutrition, the CAST Board of Directors, the AALAC Board of Trustees, and the FASS Food Safety, Animal Health and Animal Drug Committee. Eight years after retiring, he and Dr. T Elam co-authored the white paper “Fifty Years of Pharmaceutical Technology and Its Impact on the Beef We Provide to Consumers”. This is in addition to the 113 journal articles, 163 abstracts, 14 book chapters, and 434 lay reports to his credit. He also wrote a biography of Colorado cattleman and governor, Dan Thornton, published in 2006.

The university, national and international honors and acknowledgements are too extensive to list here. Notably, Dr. Preston received the Professional Excellence Award from PNC in 2006. It is most fitting because his colleagues and advisees will tell you that he is one of their best examples of professional excellence.

Rod continues to keep abreast of the cattle industry and new research as it emerges. He continues to maintain his Typical Composition of Feeds table published annually by Beef Magazine. Rod is an invaluable resource to graduate students looking for the root of concepts that are still important to us today. In retirement, Rod and Barb have moved to the Washington coast.

2017 Inductees - Allied Industry

Dean Evan Hodge

Dean Hodge was born on August 18, 1927 and grew up on a family grain and livestock farm in Arlington, Indiana. Hodge took on responsibility of the farm at an early age after his father passed away when he was 7 years old. After graduating from high school in 1945, he managed the family farm for 2 years before attending Purdue University. Hodge married Freda Maxine Johnting in 1949, and they had 3 daughters: Elizabeth (Hoffman), Nancy (Cole), and Jane.

Hodge received a Bachelor of Science in Agriculture from Purdue University in 1951 and then a Master of Science in Meat Science from Ohio State University in 1952. Hodge then returned to Purdue University and had appointments in beef cattle extension and teaching and served as manager of the university's beef cattle herds. While on staff at Purdue, Hodge pursued a Ph.D. which he earned in 1962. Hodge then joined Kern County Land and Cattle Company of Bakersfield, California in 1962 as a research specialist for their cow-calf and feedlot operations.

In 1965, Hodge joined Ralston-Purina as Manager of Beef Cattle and Sheep Research and Technical Services Program and later became Director of Ruminant Nutrition and Research. During his 26-year career with Ralston-Purina, which later became Purina Mills, Hodge was instrumental in bringing about significant technological advancements in beef production. Hodge was involved in the development of chemically-hardened molasses blocks and roughage-reducing, intake-modifying supplements for feedlot cattle. Hodge also holds 4 major feed patents that have significantly impacted the beef cattle industry. Through Dr. Hodge's innovative foresight and leadership, unique nutritional and management tools have been created that have helped change the raising of beef cattle and the standards by which feed products and services are measured. After retirement in 1992, Hodge started a consulting firm and continued with patent development.

Hodge was president of the American Registry of Professional Animal Scientists. Hodge was named a Fellow of the American Society of Animal Science in 2005 and was inducted into the American Feed Industry Association's Liquid Feed Hall of Fame in 2007. Hodge also received the Distinguished Professional Animal Scientist Award in 2011.

Outside of his career, Hodge was very active in church as an elder and in the horse industry. Hodge served as president and board member of the Missouri Horse Shows Association from which he received both the President's Award and the Jeff Shikles Distinguished Service and Lifetime Achievement Award. Hodge was also the founding president of St. Louis National Charity Horse Show from which he received the August A. Bush Award. Hodge passed away on August 2, 2013.

2017 Inductees - Allied Industry

Arthur (Art) P. Raun

Born in Upland, Nebraska, in 1934, he attended elementary school in the country near Upland and high school in Minden, Nebraska. His undergraduate degree was from the University of Nebraska (1955), where he majored in technical science-agriculture. His undergraduate advisor was Dr. Johnny Matsushima, a well-respected animal scientist. His graduate degrees are from Iowa State University, where his major professor was Dr. Wise Burroughs (another well-respected animal scientist). He received his M.S. in animal nutrition in 1956 and his Ph.D. in animal nutrition in 1958.

Dr. Raun then served in the United States Air Force (1958–1962) with the rank of First Lieutenant/Captain (reserve). His professional civilian career was spent at the Lilly Research Laboratories, Eli Lilly and Co., Inc. (1962–1992), where his first position was as senior scientist in charge of ruminant nutrition research. He conducted development research on use of several drug- and feed-additive treatments for beef cattle, including diethylstilbestrol, progestins, other steroids, and antibiotics. He did research defining the greater activity of diethylstilbestrol in cattle and sheep. Dr. Raun directed the efficacy research on the use of Tylan for control of liver abscesses in feedlot cattle. His most notable accomplishment was discovery of the utility of the ionophorous antibiotics for modifying the production of propionic acid in the rumen and, in turn, improving the efficiency of feed utilization by ruminants (cattle and sheep). This work discovered monensin (Rumensin) as a cattle feed additive. Rumensin has been used in the cattle feedlot industry since its registration by the Food and Drug Administration in 1975.This discovery led to recognition in the Silver Anniversary issue of BEEF magazine as one of the 25 people who have made a difference in the beef industry in the preceding 25 years.

He also served as Head of Animal Science Field Research (US), Head of Animal Nutrition and Physiology Discovery Research, Director of Animal Science Research, Director of Animal Science Development Research, and Technical Director of Elanco Animal Health. Dr. Raun is a member of ARPAS and is board certified in nutrition. He has served multiple times as Director, was President of ARPAS in 1995–1996, and was honored with the Distinguished Professional Animal Scientist Award in 2014.

He has been involved in several professional and community organizations, including ASAS (having served on numerous committees, as Director of the Midwest Section, and 2 terms as National Director). He was recognized as a Fellow of ASAS in 1993. He was a member of the Nutrition Council of the American Feed Industry Association (served as committee chairman, Chairman of the Council, and is a life member). Community organizations served by Dr. Raun include the Presbyterian Church and The Boy Scouts of America (worked in various roles for over 17 years and received the award of Silver Beaver.) He has authored over 50 scientific publications, reviews, and abstracts, and holds 8 patents.

With his wife Ruth, and sons Greg and Tim, he currently operates a cow-calf operation in Colorado and Nebraska producing F1 Hereford × Angus replacement heifers. Since starting the ranching operation they have received the District Conservationist of the Year Award.

Leo F. Richardson

Leo was born and raised on a general farm south of Okolona, KY. He attended St. Xavier High School, Bellarmine College (BS 1964; Biology/Chemistry), and Iowa State University (MS 1968; Biochemistry). Leo worked in the Rumen Discovery/Development area at Eli Lilly and then Elanco from 1968 through 2002. He participated in the discovery and development of rumen-active molecules, among which were monensin and narasin. He was also a part of the Elanco portion of the Beef Feedlot Consultant Advisory Board and similar outreach to individual Feedlot Consultants and Consultant groups from 1985 through 2000. During the last two years of his career, he worked with the Elanco swine research group studying the effects of stressors in swine. Leo retired at the end of 2002, and has participated in consultant-ships, both formal and informal, since that time.

Starting in 2004, he has volunteered at the local hospital in the Medical Record area. As a volunteer, his immediate supervisor is his wife, Betty; same as at home. He and his wife continue to reside in the Greenfield, IN, area where Elanco is based.

Leo married Margaret Hallahan (Betty) in 1965, and they have seven children and 18 grandchildren. They continue to play tennis, Betty more avidly than Leo.

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