National Program 101 Food Animal Production

National Program Annual Report: FY2020

NP 101 Mission Statement:

Conduct research to improve food animal production efficiency, industry sustainability, animal welfare, product quality and nutritional value while safeguarding animal genetic resources.

Introduction

Food animals contribute substantially to the U.S. economy. The United States gross domestic product in 2020 was $20.8 trillion. According to the National Agricultural Statistics Service, 2017 Census of Agriculture, which is the most recent census, 39.4 million cattle and calves were sold contributing $77 billion (0.4%), 9.5 million milk cows contributed $36 billion (0.2%), 235 million pigs contributed $26.3 billion (0.14%), 5.4 million sheep and goats contributed $1 billion (0.005%, includes meat, wool and milk), and poultry contributed $49.2 billion (0.25%, includes broilers and eggs), totaling $190 billion, which is slightly less than 1% of gross domestic product, although the figures are not strictly speaking comparable. The livestock figures includes animal product sales, and does not include sales associated with allied industries, like animal feeds, farm supplies, breeding companies, and animal health related sales. Along with this economic contribution, food animals convert plant materials into animal products that are excellent sources of high biological value protein and contain nutrients like vitamin B12 that are essential for human health. Some food animals (cattle and sheep) convert forages (e.g., grasses, alfalfa) that are unsuitable for human consumption, which are grown on marginal lands that are also unsuitable for human edible crop production, into human food products. However, even pigs and poultry convert high energy, protein and nutrient poor plant foods into protein and vitamin rich meat and egg products. The nutrient density of food animal products plays a vital role in the diets of people around the world as valuable sources of high quality protein, fatty acids, vitamins and minerals.

Despite these clear contributions, food animal production also has some real challenges. Recent reports draw attention to the potential negative impact of food animal production on the environment, including livestock contribution to greenhouse gas generation, contributions of livestock manure and feed production for livestock to nitrogen and phosphorus contamination of water resulting in algal blooms, degradation of wildlife habitat by livestock, and the contribution of animal wastes to the prevalence of pathogenic and antibiotically resistant microorganisms in the environment. Along with environmental concerns, there is a perception that technologies that improve the efficiency of animal production simultaneously compromise the health and well-being of food animals. However, cages for egg-laying hens, which are banned in some places because they are perceived to be too restrictive to free movement of birds, also reduce bacterial contamination of eggs compared to eggs laid on the floor in group housing. Gestation crates for pregnant sows, also banned in some regions because they are perceived to be too confining and restrict free movement of sows, also ensure that each sow is protected from negative interactions with herd-mates, and helps ensure that each sow receives individual attention regarding health problems and needed dietary adjustments. In addition, although use of antibiotics for growth promotion has been banned in the United States by FDA since 2017, some in the international human health arena, e.g. *WHO guidelines on use of medically important antimicrobials in food-producing animals*, have suggested that antibiotics used in human medicine should not be used for disease prevention in food animals. Should the ability to use antibiotics for disease treatment and prevention be restricted, the potential effects on animal well-being would be strongly negative.

Thus, research is needed to improve livestock production efficiency, which would reduce the feed and other environmental resources that are needed for livestock production, reducing environmental concerns and improving profitability. Better methods are needed to ensure that raising livestock does not contribute unnecessarily to environmental degradation and contamination. Viable alternatives to antimicrobials in food animal production are also needed to replace the production efficiencies that these compounds once offered to livestock production. Antimicrobial alternatives research has two goals: (1) restore the growth improvement that was once available through the use of antimicrobials and (2) reduce disease incidence, to reduce the need for preventive use of antibiotics. Finally, precision management technologies are needed to properly manage livestock in group settings.

Given the health benefits of food animal products, dramatic improvements in production efficiencies developed by ARS scientists will help ensure international food security and directly impact human health by reducing the real cost of nutritionally valuable animal products, making animal products more available to those populations most in need. Studies within this program that identify indicators of animal stress and methods to alleviate stress in the production environment will ensure that as production efficiency improves, so will animal well-being in those production systems. Improvements in food animal production efficiencies will reduce food animal wastes. Reductions in the numbers of breeding animals to maintain production reduce the livestock waste environmental footprint. Ongoing improvements in food animal nutrition and other production efficiencies reduce grain requirements and manure production, and science-based animal waste management strategies provide for the beneficial return of animal waste nutrients to the environment. Improvements in production efficiency will reduce microbial pathogen contamination of the environment and greenhouse gas emissions from livestock production systems and ensure that livestock production remains environmentally sustainable.

Some Standout Science

The Agricultural Research Service (ARS) provides solutions for agricultural producers, and by extension improvements in the efficiency of food production for consumers within the United States and beyond. The accomplishments provided below are presented in these terms, describing the impact of the accomplishment on the livestock production system and/or consumers. However, ARS scientists also contribute to the human scientific endeavor, and their contributions to science are often not presented, in favor of describing accomplishments in terms of “real world impact”. In this section, a couple of the accomplishments included below are presented in terms of their contribution to science.

The accomplishment entitled “A high-quality cattle gene atlas” describes a research effort to integrate ARS generated and publicly available tissue transcriptomic data, chromatin analysis data and genome wide trait analysis data to construct an “atlas” resource that can be used to propose the tissues, genes expressed in tissues, and chromatin modifications in tissues, that are putatively responsible for the differences in quantitative traits in cattle. This is an excellent example of important research that can be done with publicly available data, and provides a strong argument in support of making research data public for additional types of analyses. The effort is comprehensive given the data currently available, and one use for this work is to propose gene modifications that could be explored using gene editing technologies to specifically alter traits of interest. Another potential use would be to propose gene polymorphisms in areas of chromatin that display modification specific to tissues that are involved in controlling traits of interest, to potentially improve genomic analyses. Although this is a fantastic contribution to livestock genomic science, the transcriptomic and chromatin modification data remain limited, particularly for traits that are likely to be influenced by physiological state of the tissues (e.g., reproduction, lactation, nutrition, various health traits). Nevertheless, this is an excellent example of ARS contributing to the science of gene function.

The accomplishment entitled “Chromatin modification in placenta of swine varies with season” provides basic information that may finally begin to address the problem of seasonal reduction in reproductive performance in female pigs. Data from commercial production of pigs has clearly demonstrated that females mated during the summer experience a decrease in pregnancy rate ranging from 5 to 15 percent, causing huge problems in the scheduling of breeding animals. In addition, anecdotal information from producers suggests that the fault may lie in placental development. Producers describe a phenomenon called “slipping”, which is essentially an increase in the rate of abortion during the period in pregnancy when the placenta forms in the pig. Many genes that control placental development are “imprinted”, meaning that the expression of those genes is controlled by methylation patterns that originate from either the sire or the dam. This is the first report that chromatin methylation in placental tissue varies with season, and is entirely consistent with the characteristics of both the fertility phenomenon itself and the control of gene function in the placenta. Further research is needed to fully characterize the chromatin changes that occur with season, but this is a clearly important first step in understanding and potentially solving this very important reproductive inefficiency in pigs.

Some Future Directions

Animal genomics is a major emphasis of the Food Animal Production National Program. Much of our work up to now has focused on exploiting the additive genetic component of traits in various livestock species using sophisticated genomic technologies. The best example of this in livestock is dairy cattle, where the structure of the industry in the United States, along with relatively high individual animal value and long generation intervals, have combined to make genomic selection very successful. Research to add useful traits to dairy selection indices, and fully implement additive genomic selection in other livestock species will continue to be a focus going forward. A useful major step included in this report described below is the development of the ability to impute genome sequence level genotypes from low coverage genoytping (see

"Development of a verified algorithm to correctly assign sequencing level genotypes to crossbred cattle using low-cost, low-coverage genotypes"). But we will also need to go beyond additive genetic selection to incorporate interactions between environmental characteristics and the additive genetic component, to be able to best fit animals to their environment. Some work in this area has already been done, but much more is needed. In addition, we also need to go beyond the additive genetic component of inheritance and include components like epigenetics and heterosis in our selection methods. Fifty percent of beef cattle, and nearly all swine and poultry in the United States, are crossbred animals. Crossbreeding is done to take advantage of heterosis, which is the improvement in a trait that results from dominant effects of some gene alleles on other gene alleles at various genetic loci. It should be possible to optimize heterosis using genomic technologies, and research is needed to explore this possibility.

It has been typical of livestock research to consider the animal as a single individual, interacting with its environment, and controlled by its individual genome. However, it has always been true that individual animals exist as a collection of organisms consisting of the individual and its microbiome, and it is only recently that we have technologies that can address this fact. We have ongoing research in all livestock species to measure the effect of the microbiome on the function of the individual, and its consequences for health and production efficiency. An accomplishment that addresses this area of research is described below entitled "Genome sequencing of the weaning-associated fungus *Kazachstania slooffiae* to understand its potential role in piglet growth and health." This organism was found in a previous effort to characterize the fungal microbiome of the weaned piglet, and may contribute to the success of piglets transitioning from milk to feed during the weaning period. Methane production by cattle also falls into the category of important functions controlled by the microbiome. Methane is entirely a product of the cattle microbiome, and not only represents a potent greenhouse gas, it also represents wasted feed energy. Although it is likely to be challenging, our future goal will be to reduce cattle methane production to zero, adjusting the microbiome so that the feed energy that is currently lost to methane production will be incorporated into energy in the cow, without decreasing feed intake or growth rates of cattle.

Raising livestock is labor intensive. The production systems in which many of our food animal species are raised continue to grow larger, because the fixed costs of an operation are more economically distributed over larger numbers of animals. Expanding animal numbers and labor expense can combine to reduce the ability to optimally manage every animal. To make the production system work, farmers manage for the average animal, or manage so that a high percentage of the animals can produce optimally. The former results in reduced production of animals needing more resources, and the latter results in significant overapplication of resources to underperforming animals. Improvements in electronic technologies over the last 40 years are now beginning to make it feasible to monitor and manage individual animals to reduce these inefficiencies. The accomplishment entitled "Development of 3-dimensional (3D) imaging to predict the weight of pigs" is one of our initial forays into this type of research. However, to really make progress in the area of precision livestock management, new sensors, data infrastructure, and decision support tools are needed. Data handling capabilities have been increasing by 10-fold every 5 years over the last 4 decades and will likely continue at this rate, so what is not feasible now may be easy in 20 years. To take full advantage of these changes, more research is needed now to develop the individual precision livestock methods that will lead to the greatest improvements in livestock management.

Program staffing, funding, and collaborations

During FY 2020, National Program 101 (NP 101) had 75 full-time scientist positions working at 15 locations across the United States on twenty-seven appropriated research projects. In fiscal year 2020, appropriated funding for NP101 was $55 million; and total funding was approximately $56 million including extramural awards. One new invention was disclosed and 1 patent awarded. Additional technology transfer included ten Material Transfer Agreements.

In 2020 NP 101 scientists participated in research collaborations with scientists in:

Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Costa Rica, Denmark, Estonia, Ethiopia, France, Germany, India, Ireland, Israel, Italy, Kazakhstan, Malawi, Mexico, Mongolia, Netherlands, New Zealand, Nigeria, Northern Ireland, Norway, Pakistan, Poland, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Uganda, United Kingdom and Vietnam.

Outreach Activities:

Students working with ARS Scientists and Scientist Academic Outreach

Undergraduates	Graduates	Post-Docs	Scientist Advisors	Mentors	Adjunct Professors/Other
27	16	7	24	4	13

ARS Animal Production Program: Student-Related Outreach Activities

	Presentation to Schools	Science Fair Participation	Student Tours/Visits to ARS Locations
Number of Activities	3	1	9
Number of Students	65	200	127

Animal Production Program General Outreach to Stakeholders and the Public

Name of Activity	Number of Activities	Number of Participants
Tours	6	91
Presentation to Local/Community Groups	1	10
Training/Demonstration	5	72
Webinars	2	70
Presentation to Other Scientists	4	243
Presentation to Practitioner/Industry/Producer	8	896
Workshops	2	200
Stakeholder Meetings	10	88

New scientists in NP 101 2020:

Dr. Brittany Harlow, Research Animal Scientist, joined Forage-Animal Production Research Unit, Lexington, Kentucky.

Dr. Matthew Jorgensen, Research Animal Scientist, joined Animal Genomics and Improvement Lab, Beltsville, Maryland.

Dr. Carlos Vega Melendez, Support Scientist, joined Cell Wall Biology and Utilization Research Unit, Madison, Wisconsin.

Dr. Tansol Park, Post-Doctoral, joined the Cell Wall Biology and Utilization Research Unit, Madison, Wisconsin.

Dr. Sarah Pierce, Research Physiologist, joined National Laboratory Agriculture Environment Unit, Ames Iowa.

Dr. Sajjad Toghiani, Animal Scientist, joined Animal Genomics and Improvement Lab, Beltsville, Maryland.

The following scientists retired in 2020:

Dr. Jerry Hatfiled, Laboratory Director, National Laboratory for Agriculture and the Environment, Ames, Iowa.

Dr. Mark Peterson, Range Livestock Nutritionist, Fort Keogh Livestock and Range Research Laboratory, Miles City, Montana.

The distinguished record of these scientists is recognized world-wide and they will be missed at NP 101.

The following scientists in NP 101 received prominent awards in 2020:

Dr. Gary Bennett, received the 2020 American Society of Animal Science Fellow Award in research.

Dr. John Cole, received the 2020 Research Award from the National Association of Animal Breeders Research.

Drs. Timothy Smith, Ben Rosen and Derek Bickhart, received the 2020 Excellence in Technology Transfer Award from the Midwest Region of the Federal Laboratory Consortium for Technology Transfer in recognition for outstanding work in the process of developing federally developed technology.

Drs. Timothy Smith, Ben Rosen and Derek Bickhart, received the 2020 Partnership Award for their "Application of Interspecies Cross to Improve Efficiency of Genome Assembly" from the Mid-Continent Region of the Federal Laboratory Consortium for Technology Transfer.

Dr. Paul VanRaden, received the USDA ARS Employee Recognition Program Award for development and implementation of genomic prediction methodology that revolutionized animal breeding and advanced genetic progress for economically important traits of animals and plants worldwide.

Dr. Paul VanRaden, was inducted into the USDA Agricultural Research Service Science Hall of Fame.

Dr. Paul VanRaden, was inducted into the JDS Club 100 for authoring or co-authoring 100 or more papers in the Journal of Dairy Science.

Major Accomplishments in 2020

This section summarizes significant research results for Fiscal Year 2020 that addressed specific components and anticipated products of the 2018– 2022 Action Plan for the Food Animal Production National Program. Within each section, selected accomplishments of individual research projects in NP 101 are presented. These accomplishments are highlighted here due to their significance and alignment to action plan components and anticipated products. They are a subset of accomplishments within the program. To see all the accomplishments for each project within the program, please visit the USDA ARS National Program 101 website:

https://www.ars.usda.gov/research/project-reports-by-program/?npCode=101

Many of the projects are the result of significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for USDA - ARS research and allow scientists to tackle larger problems that could not be addressed without such collaborations. Improved food animal production efficiencies decrease the real cost of animal products, making the products more available to people worldwide, and decreasing the environmental footprint of animal production.

Accomplishments are listed below that correspond to each of the Components and Problem Statements of the *Action Plan National Program 101 Food Animal Production 2018 – 2022*. Following each accomplishment, the corresponding anticipated product from the NP 101 Action plan is indicated.

Component 1: Improving Production and Production Efficiencies while Enhancing Animal Well-Being across Diverse Food Animal Production Systems

Problem Statement 1A: Improving the Efficiency of Growth and Nutrient Utilization

Development of 3-dimensional (3D) imaging to predict the weight of pigs.

Continuously monitoring animal weight would benefit producers by ensuring all animals are gaining weight as expected and would assist in precision feeding of pigs. ARS scientists at Clay Center, NE, conducted research on commercially available 3D imaging to predict live animal weight in grow-finish pigs. They collected 920 3D images and weights from a population of grow-to-finishing pigs equally divided by sex across 3 commercial lines. The 3D images were used to calculate the volume of each pig, and scientists developed an equation to predict pig weight from the calculated volumes regardless of sire line or sex. Methods for monitoring the growth and physical condition of animals without animal handling will reduce labor, improve animal well-being, and increase the profitability and sustainability of production.

Anticipated product: Precision feeding systems for livestock and poultry that optimize nutrient availability to the animal while minimizing nutrient losses to the environment.

Genome sequencing of the weaning-associated fungus *Kazachstania slooffiae* to understand its potential role in piglet growth and health.

Weaning is a period of stress and environmental change for piglets, and they experience a greater incidence of diarrhea and other digestive problems. Recent studies indicate there are dramatic changes in gut fungal microorganisms after weaning, and this change may contribute to the growth and health of weaned piglets. ARS scientists at Beltsville, MD, isolated *Kazachstania slooffiae*, the most dominant post-weaning fungus in healthy piglets, and sequenced its genome. Genes identified from this sequence suggested that *K. slooffiae* has positive interactions with beneficial bacteria in the piglet gut, signifying a strong beneficial role. Sequencing this genome is a critical first step to investigate the effects of this microbe in piglet growth and health. These results support the concept that *K. slooffiae* can be used as a naturally derived probiotic to enhance piglet growth.

Anticipated Product: Identification of alternatives to antibiotics for improving growth performance in livestock.

Problem Statement 1B: Improving Reproductive Efficiency

Chromatin modification in placenta of swine varies with season.

Chromatin modifications are known to alter gene expression, and therefore contribute to changes in traits like fertility. In pigs, pregnancy rates are lower when breeding take place during the summer, but the reasons are not known. The swine industry controls temperature and photoperiod by using climate-controlled housing, nevertheless seasonal reductions in farrowing rate and litter size still occur. Producers offset these losses by increasing their summer breeding stock 20-25 percent and subsequently increasing number of breedings by 15 percent, all at significant cost to the industry. ARS scientists at Clay Center, NE, and University of Wisconsin collaborators found that placentas developed from summer breeding had greater expression of genes associated with chromatin modification than placentas from winter breeding. These data suggest seasonal differences in the expression of chromatin modification genes may contribute to seasonal infertility by altering the expression of key genes. Treatments that reduce unfavorable placental chromatin modification pathways during the summer could improve seasonal reproductive inefficiency losses estimated at more than $600 million annually.

Anticipated Product: Strategies to reduce seasonal effects on fertility and pregnancy maintenance of food animals.

Problem Statement 1C: Enhancing Animal Well-Being and Reducing Stress

Using nitrous oxide (laughing gas) to euthanize piglets is as effective as using carbon dioxide and may be more humane.

Pig farmers euthanize a significant number of piglets for a variety of animal welfare reasons, including injuries, hernias, or unexplained poor growth rates from which piglets won't recover. Most piglets are euthanized using carbon dioxide gas asphyxiation. ARS researchers in West Lafayette, IN, are looking for euthanasia methods that cause less distress for piglets. Key metrics are time required to lose consciousness and distress of the piglet while conscious. Piglets receiving carbon dioxide displayed more distressful behaviors prior to losing consciousness. Piglets exhibit less distressful behaviors with nitrous oxide before losing consciousness. These results indicate nitrous oxide may be a suitable alternative to carbon dioxide and a more humane alternative for pigs that are euthanized.

Anticipated Product: Species-specific, cost-effective strategies to mitigate animal stress and improve animal well-being and longevity in conventional production systems.

Grazing red clover reverses fescue toxicosis in cattle.

Fescue toxicosis, characterized by reduced blood circulation, affects cattle, sheep, and goats in large sections of the Mid-Atlantic region of the United States. It is caused by toxins produced by a fungus infesting fescue grass common in regional pastures. The pasture legume, red clover, contains isoflavones that can improve blood flow in animals affected by fescue toxicosis. Interseeding red clover into toxic tall fescue pastures is suggested to mitigate fescue toxicosis, but the direct impact of interseeding red clover on blood flow and performance has not been assessed. ARS scientists in Lexington, KY, evaluated the impact of interseeding red clover on cattle grazing toxic tall fescue. Cattle grazing pastures with interseeded red clover had greater growth performance and exhibited increased blood flow post-grazing. This research showed interseeding red clover in toxic tall fescue pastures can reverse some of the negative effects associated with fescue toxicosis. Notably, this is the first study that demonstrated cattle grazing interseeded red clover is an effective pasture management strategy to elicit the benefits of isoflavones on blood flow.

Anticipated Product: Comprehensive production system best management practices that improve production efficiencies while also maintaining or improving animal well-being, product quality, and economic competitiveness and sustainability.

Component 2: Understanding, Improving, and Effectively Using Animal Genetic and Genomic Resources

Problem Statement 2A: Develop Bioinformatic and other Required Capacities for Research in Genomics and Metagenomics.

Development of a verified algorithm to correctly assign sequencing level genotypes to crossbred cattle using low-cost, low-coverage genotypes.

Detecting all the DNA variation in each individual animal can be done by genome sequencing, but is too expensive for routine genomic analyses of traits. The full DNA variation of individuals is necessary to effectively predict trait differences caused by DNA variation. Methods to correctly assign complete-sequence-level DNA variation of key ancestors to offspring using low-cost genotyping would improve genomic predictions and save the industry the expense of sequencing every animal. ARS researchers at Clay Center, NE, assembled genomic sequences from individuals with many descendants in a crossbred population representing the eighteen most predominant beef breeds in the United States, and combined it with publicly available sequences representing beef and dairy breeds. In collaboration with Gencove, Inc., these sequences were analyzed to determine DNA variants that typically occurred together. Those relationships were then used to predict all the variants in the genome from a low-cost, low-coverage genome sequencing to generate a low number of initial genotypes. The low-cost sequencing approach to generate initial genotypes results in better accuracy of DNA variation assignment than genotypes obtained using SNP chips, the most common approach to genetic marker detection. This new method will enable more effective trait-genome associations at a lower cost than currently available SNP chips. Producers will include a larger portion of animals, at low cost, for genetic evaluation programs, and predict genotypes up to the genome sequence level. This will improve selection accuracy and increase genetic gain, and lead to a faster rate of improvement in valuable beef traits for the industry.

Anticipated Product: Development of comprehensive intensive and extensive phenomic and analytical tools to relate genomic and phenotypic data for development of improved genome based estimates of genetic merit including well- characterized and deeply phenotyped ARS, field and other research food animal populations.

Problem Statement 2B: Characterize Functional Genomic Pathways and their Interactions.

A high-quality cattle gene atlas.

The goal of genomic analyses in livestock is to make sense of the genome to understand and improve important livestock traits. With modern technologies, it is possible to localize variation in traits to regions of the genome, but it can be difficult to determine the gene, and the change in the gene, responsible for the trait. For some genes where the functions are not well characterized, it can also be difficult to determine what parts of the body are involved in controlling the trait. ARS scientists in Beltsville, MD, developed a comprehensive tissue-gene atlas for cattle by integrating their own information with publicly available information on gene regions associated with traits, genes expressed by tissues, and changes in gene chromosome structure that are known to control gene function. This high-quality cattle gene atlas links these three data sources for the first time and provides an important tool for discovering the tissues, genes, and genome structure that control traits in cattle.

Anticipated Product: Information relating the function and regulation of individual genes and their interaction with environmental and epigenetic effects contributing to economically important traits in food animals.

Problem Statement 2C: Preserve, Characterize and Curate Food Animal Genetic Resources.

Stored livestock germplasm is a valuable resource for livestock producers.

The livestock industry relies on the National Animal Germplasm Program (NAGP) collection to provide historical samples of genetic diversity and increasingly uses the collection to address threats such as disease and shrinking genetic diversity. To support this critical food security need in the future, ARS scientists in Fort Collins, CO, continue to add to the animal germplasm collection, which in FY 2020 reached the threshold of more than 1 million samples, and profoundly expanded its diversity. Demonstrating its use, Brangus breeders found a mutation that causes white eye disease. The NAGP collection contained the only sampling of an important key ancestor (born in 1982) that tested negative for the condition. Genomic testing can be used to eliminate such mutations, but comprehensive testing is cost-prohibitive. Testing key sires can indicate that their offspring do not need testing if the sire and dam are negative for the disease. The NAGP sample of a key sire reduced the number of cattle tested by 150,000 animals and saved the industry about $1.5 million. In a second example, the nation’s largest seller of beef bulls reintroduced 1980s-1990s genetics to restore genetic diversity to their breeding program. This breeder accessed the NAGP collection for bulls born in 1987 and 1993 with the desired genetics and produced approximately 70 embryos that were implanted in cows that will soon calve. These recent examples highlight the industry value of the NAGP with its diverse genetic collection to address current threats.

Anticipated Product: A publicly available database providing germplasm sample, phenotypic, and genomic information to industry and the research community.

Optimal donor age for transplantation of ovarian tissue in the turkey.

For most livestock species, frozen sperm effectively captures the entire genome because sperm contains both sex chromosomes (X and Y). However, in birds sex chromosomes are W and Z and males are ZZ. Sperm from male birds only contain a single sex chromosome, so frozen sperm does not preserve the unique W female sex chromosome. An alternative approach to the preservation of the entire genome in birds is to freeze immature ovarian tissue for storage, and then thaw and transfer it into recipients. Stem cells in the transplanted ovarian tissue then undergo meiosis to generate eggs derived from the tissue donor. ARS scientists in Beltsville, MD, in collaboration with scientists in Canada, took a step toward developing methods to preserve and transfer ovarian tissues in turkeys. Using fresh ovarian tissue, they determined the optimal age to recover and transplant ovarian tissue is 7 days post-hatch; 91 percent of grafts attach and grow if ovarian tissue from 7-day old donors is transplanted into 2-day old recipients. This result represents a major advancement in preservation of turkey germplasm, because turkeys are an agriculturally important species with historically poor sperm cryopreservation success.

Anticipated Product: Successful and efficient cryopreservation technologies and methods available for all livestock and poultry species.

Problem Statement 2D: Develop and Implement Genetic Improvement Programs using Genomic Tools.

New method to improve the identification of genetic markers for feed efficiency.

Typical studies to identify genetic markers for livestock traits include several thousand animals and thousands of genetic markers. Genotyping, analysis and interpretation costs associated with the large resulting data set is a challenge to producers wanting to implement genomic selection. To reduce genomic selection's cost and complexity, an improved ability to narrow genotyping to the most appropriate markers to test for association with specific traits is needed. Using tissues relevant to digestive processes from high and low feed efficient pigs, ARS scientists at Clay Center, NE, developed a methodology that used gene expression data to rank the likelihood that the genes contribute to feed efficiency. To provide a reduced set of markers for analysis, scientists selected 10 different groups of genes and markers for separate trait association analyses based on different relationships to feed efficiency related criteria. Scientists found 36 markers were associated with feed efficiency; 29 were linked with genes already known to have associations with feed efficiency, demonstrating prescreening helps select for relevant genes and markers. A less targeted approach using thousands of genes and markers had less discriminatory power, so the analysis resulted in identifying only two markers associated with feed efficiency. The novel strategy for using gene expression information to preselect markers for genomic analysis is a powerful approach to identify economically important livestock traits markers. The markers identified in this study are available to commercial genotyping companies for producers to improve pig feed efficiency.

Anticipated Product: Improved genetic evaluation and genetic selection programs for the food animal industries.

Problem Statement 2E: Improved Techniques for Genetic Modification and Genetic Engineering of Food Animals.

none

Component 3: Measuring and Enhancing Product Quality and Enhancing the Healthfulness of Meat Animal Products

Problem Statement 3A: Systems to Improve Product Quality and Reduce Variation in Meat Animal Products.

Classification of beef carcasses for top sirloin tenderness.

Recently developed certification standards for tenderness have given the beef industry added impetus to implement a tenderness-based marketing system. For retailers to effectively execute a tenderness-based marketing strategy, retailers must be able to market all meat derived from the loin and rib from a qualifying carcass as certified tender. Currently, the certification does not include top sirloins, which are derived from the loin and represent a substantial retail meat cut feature. ARS scientists in Clay Center, NE, determined that tenderness classes based on the VBG2000 beef grading camera allowed for identification of carcasses with more favorable top sirloin tenderness. This work showed that tenderness testing with a beef grading camera in combination with refrigerated aging for 28 days can produce consistently tender top sirloin steaks that qualify for a guaranteed tender marketing claim. This could lead to over $18,000,000 in added annual revenue for the U.S. beef industry.

Anticipated Product: Development of cost effective technologies to better predict and evaluate meat quality attributes on farm and during processing. Validated methodologies and instrumentation for on-line commercial industry use to determine product quality and yield.

Problem Statement 3B: Improving the Healthfulness and Nutritional Value of Meat Products from Traditional and Non-Traditional Production Systems.

none

NP101 Projects contributing accomplishments to this report:

PROJECT NO.	PROJECT TITLE	CITY	STATE
3012-31000-006-00D	National Animal Germplasm Program	Fort Collins	CO
3040-31000-095-00D	Improving Lifetime Productivity in Swine	Clay Center	NE
3040-31000-097-00D	Improve Nutrient Management and Efficiency of Beef Cattle and Swine	Clay Center	NE
3040-31000-100-00D	Developing a Systems Biology Approach to Enhance Efficiency and Sustainability of Beef and Lamb Production	Clay Center	NE
3040-31430-006-00D	Strategies to Optimize Meat Quality and Composition of Red Meat Animals	Clay Center	NE
5020-32000-013-00D	Protecting the Welfare of Food Producing Animals	West Lafayette	IN
5042-32630-003-00D	Optimizing the Biology of the Animal-Plant Interface for Improved Sustainability of Forage-Based Animal Enterprises	Lexington	KY
8042-31000-001-00D	Enhancing Genetic Merit of Ruminants Through Improved Genome Assembly, Annotation, and Selection	Beltsville	MD
8042-31000-110-00D	Development of New Technologies and Methods to Enhance the Fertility, Utilization, and Long-Term Storage of Poultry and Swine Germplasm	Beltsville	MD
8042-31440-001-00D	Alternatives to Antibiotics: Developing Novel Strategies to Improve Animal Welfare and Production Efficiency in Swine and Dairy	Beltsville	MD