

ARS NP101 External Panel Retrospective Assessment Report (2015-2020)

USDA Agricultural Research Service
National Program 101
FOOD ANIMAL PRODUCTION
External Panel Retrospective Review: 2015-2020

December 18, 2020

Executive Summary

The NP 101 Retrospective Review Panel consisting of the panelists listed above was convened on Thursday, December 3, 2020. National Program Leader, Dr. Jeff Vallet, provided detailed information about the program, the three components of the program, the problem statements under each component, and highlights of the outputs as evidence of overall program productivity.

The National Program for Food Animal Production continues to play an important role in supporting research directly applicable to food animal species, and ARS scientists contribute to advances in related initiatives within the national and international research communities. The mission of NP 101 is to “improve food animal production efficiency, industry sustainability, animal welfare, product quality, and nutritional value while safeguarding animal genetic resources.”. The retrospective report that was prepared and reviewed by this panel provides substantial support for accomplishments in each of the stated Component areas.

The NP 101 program groups their research work into 3 general component areas. As noted by the NPL, the bulk of the accomplishments during this review period occurred in Components 1 and 2.

1. Component 1: Increasing Production and Production Efficiencies while Enhancing Animal Well Being across Diverse Food Animal Production Systems
2. Component 2: Understanding, Improving, and Effectively Using Animal Genetic and Genomic Resources
3. Component 3: Measuring and Enhancing Product Quality and Enhancing the Healthfulness of Meat Animal Products

The scientists working in NP 101 have added depth and breadth to the body of scientific knowledge represented by these three components. This information underpins the fundamental understanding of biological processes in livestock and poultry and forms the foundation for the application of this knowledge at the farm level. Applied research is targeted to problems, derived from stakeholder inputs, that are both industry- and region-specific. Basic research has much broader applications and impact. The report provides ample evidence of high quantity and quality in scholarship as evidenced by the publication of their research in the highest impact, most relevant peer-reviewed journals in the animal and poultry sciences

The review panel has highlighted the most impactful of these accomplishments in the following report. Likewise, the panel has identified areas where additional work may be fruitful. This includes collaborative work on the healthfulness of meat that could and should have a future impact on the USDA dietary guidelines. Also, data on the healthfulness of meat from genetically modified animals should be utilized to determine FDA/USDA guidance on the marketability and labeling of such products.

Did NP101 achieve what it set out to achieve?

- The National Program for Food Animal Production continues to play an important role in supporting research directly applicable to food animal species, and ARS scientists contribute to advances in related initiatives within the national and international research communities.
- NP 101 has a mission to “improve food animal production efficiency, industry sustainability, animal welfare, product quality, and nutritional value while safeguarding animal genetic resources.” and their retrospective report provides substantial support for accomplishments in each of the stated mission areas. Many goals were achieved within each of three components – with accomplishments in some areas much greater than others.
- The NP 101 program groups work into 3 general research areas, with the bulk of the accomplishments occurring in Components 1 and 2. The NPL indicates that approximately 50% of their effort falls under Component 2, whereas the greatest output/accomplishments occurred in Component 1.
- Without data on SY/Component or budget expended/Component or other indicators of prioritization, it is difficult to assess how efficiently accomplishments were generated in each Component. To assess this as well it would be good to know for each component the amount of outside funding attracted by the NP staff.
- Project goals and subsequent research were responsive to food animal production and addressed current and emerging issues. Stakeholder inputs were incorporated into research that is being conducted by ARS labs.
- Component 3 addressed a recent industry problem (two-toned or halo effect in hams). The committee was impressed to learn how the NPL was informed of this pressing issue by the industry and immediately began working on the problem. An excellent example of NP 101 research being responsive to industry needs.
- Accomplishments occurred during a period of understaffing (and likely reduced research funds), which should be considered when evaluating accomplishments. In light of this fact, the NP 101 has done very well in achieving objectives for Components 1 and 2. The program also saw attrition of scientists as they were enticed to other laboratories - this is OK as the development of scientists is a goal for all of the ARS laboratories.
- Significant advances were made in genomics-related areas, especially in basic knowledge generation. Functional application lagged behind, but this is to be expected as the conversion of genome sequence knowledge to functional mechanisms is not yet a mature area of scientific discovery. Emphasis on “Genome to Phenome” goals, as well as the application of gene editing and other technologies should continue for future advancement of food animal production agriculture.
- Multiple projects related to growth efficiency and reproductive efficiency contributed new knowledge enabling progress relevant for future food security.

- Research in Meat Healthfulness was not addressed to the extent originally anticipated. It was found that there is not enough variation in levels of fats within meat products to significantly alter human health. This component remains a high priority for the animal agriculture industries and should be continued but with revised objectives and maybe more focused objectives developed with industry input. Work is needed in this area so that positive, science-backed messages can be delivered to consumers. This is critical because of the increasing development of plant- and cell-based protein products.
- Nutritional profiling and selection for nutrient composition in meat and poultry is an important goal. However, meat is already a healthful product, and with limited variance in many components, the ability to alter these characteristics is limited. Yet, this research is desired by industry.
- Meat Healthfulness should be addressed through collaborations with other institutions. The USDA ARS Children's Nutrition Research Center (CNRC) in the Texas Medical Center have excellent resources. Two Land Grant Institutions with resources and programs in the food and animal sciences are close to the CNRC.
- The number of accomplishments in the area of meat quality was low. Output was reflected more in partnerships/collaboration and was directed by University-based resources rather than ARS. Meat quality research does appear responsive to industry issues, but also needs to be undergirded by fundamental research and the generation of new knowledge.
- The use of precision agricultural applications in animal agriculture is important and work in these areas should be further developed and expanded in consultation with industry.
- Absent from the presentation and report was a summary of training efforts for undergraduate internships, graduate student training, postdoctoral fellows, and visiting scientists in support of the next generation of scientists. Education of these "trainees" is an important accomplishment of NP 101 because of its great impact on the agricultural science workforce.

Relevant to the highest priority problems?

Did it meet the needs of partners and stakeholders?

- Components and accomplishments were not presented in the context of priority (either stated or by the number of SY or budget expended) - only in relation to activity by component area and anticipated product.
- Work on the ham halo effect work showed that the NP 101 is willing and capable of adjusting work and priorities based upon industry needs.
- Significant accomplishments addressing antimicrobial resistance were reported.
- Alternatives to antibiotics were identified and evaluated.
- Impact of colostrum intake as measured through ARS-developed immunocrit assay on subsequent sow fertility provides tools for selection of breeding stock.
- Genomic research outcomes will foster new, innovative research in and across other

disciplines. This work is a real strength and obvious emphasis of the NP 101.

- Statistical and computational research outcomes focusing on genomic tools have high relevance to multiple species' organizations and genetic suppliers, addressing complex questions related to genetic improvement.
- Expanded and improved genome assembly, annotation, and functional genomics were evident.
- "FSAV" trait identified to enable selection of efficient dairy stock and further sustainability of the dairy industry.
- Continued development of the National Germplasm Resource Center serves research and animal enterprises nationally and internationally.
- National Germplasm Resource Center contributed to the restoration of two Y chromosomes to the Holstein breed.
- The profitability of utilizing a prolific breed of sheep in a crossbreeding program under western range conditions was compared and recommendations prepared.
- Analysis of distiller's grains in poultry diets and canola meal for dairy identified applications for use of these available products as alternative feedstuffs to benefit partners and stakeholders.
- Poultry housing innovations demonstrated parameters where airflow improved egg production and animal welfare.
- Component 3 work is underrepresented and should be expanded in future work. However, meat quality efforts, particularly the halo effect in hams and color stability in beef address pressing needs for producers and consumers.
- There is also the need to develop, train, and advance the next generation of scientists in these animal agriculture areas. NP 101 is doing this as evidenced by the scientists that have moved from ARS to other labs.

Relevant to the highest priority problems?

Was it responsive to emerging issues?

- Development of genomic tools and resources has greatly assisted the research community and has the potential to impact the future of production agriculture.
- Research is generating new and substantially better genome assemblies for cattle, pigs, and goats that have fewer errors. Development of Trio binning strategies has facilitated improved genome sequences. The impact of this novel approach is extending beyond animal agriculture.
- Cattle tissue atlas publication offers an unparalleled assessment of loci, genes, tissue, and chromatin changes, facilitating similar research in pigs, poultry, fish, and small ruminants.
- Collaborative work between USDA, industry, and university scientists led to the development of a new trait, "feed saved" (FSAV), which will be included in the next

update of the \$NETMerit index planned for April 2021. The trait will aid genetic selection for more feed-efficient dairy cattle, thereby improving sustainability of this sector.

- Swine Genome-Wide Association Studies identifying factors affecting teat number have implications on current industry challenges of piglet size per litter and subsequent piglet survival in highly fecund commercial breeding females.
- Ham-Halo research has provided timely data and theories supporting future research into solving this complex pork quality issue.
- Identifying the underlying mechanisms of gestation heat stress on progeny performance in livestock is critical for raising animals in warm or hot environments.
- Identification of potential biomarkers of growth and nutrient efficiency (ghrelin and leptin in beef cattle and acid 1 glycoprotein in swine) was a step toward understanding genetic mechanisms regulating feed efficiency.
- Alternatives to growth-promoting antibiotics were identified and evaluated. Identification of alternatives to antibiotic use for growth promotion in pigs was responsive to the broad need to reduce antibiotic use in animal agriculture.
- Establishing the relationship between immunocrit and subsequent sow productivity offers opportunities for producers to refine their sow replacement selection decisions.

Able to meet the highest standards of quality?

Did it generate new knowledge?

- The report provides ample evidence of high quantity and quality in scholarship as evidenced by the publication of their research in the highest impact and most relevant peer-reviewed journals in the animal and poultry sciences. In addition, there were several publications in high impact journals in the Nature family of journals (Nature, Nature Genomics, Nature Biotechnology, and Nature Communications).
- The relationship between Acid 1 Glycoprotein and growth rates of nursery age piglets is the result of proteomic analyses of proteins associated with piglet growth, followed by the development of an ELISA to measure the protein more easily in piglets.
- Gene expression studies in duodenum, jejunum, and ileum tissues provide basic information to understand gene expression differences between cattle with differences in feed efficiency.
- Transcriptomic analysis of rumen epithelium provides clear evidence that butyrate plays a role in ruminal epithelial maturation, which could help improve feed efficiency in ruminants.
- Metagenomic analyses of the rumen identified unique microbial populations associated with feed efficiency in cattle.
- Viral DNA was characterized in the rumen, raising the possibility that viruses may be used to manipulate specific microbiota within the rumen.
- A fungal mycobiome was identified in neonatal pig feces, with an identified dramatic change between nursing and weaned pig stages.

- Understanding of allelic variation within and across breeds allows for more precise genetic selection.
- Genotyping arrays/chips have enhanced genomic selection accuracy in multiple species.
- Transcriptomic analyses in various tissues of cattle with different phenotypes provided a basis for future hypothesis-driven research investigations. Characterizing the transcriptomes of different tissues in the animal will contribute to a greater understanding of how specific gene polymorphisms influence quantitative traits.
- GWAS, chromatin alterations, and transcriptome analyses in response to butyrate in the rumen establish a base of data that will drive future research questions.
- Programs to preserve, curate, and recover food animal genetic resources are essential to provide resources for future work. Continued research support for this program, particularly in avian genomes for the recovery of poultry species, is essential and a critical need for the future.

Able to meet the highest standards of quality?

Was it innovative?

- The relationship between ovarian antral follicle number, uterine function and fertility in cattle is an interesting preliminary observation that could evolve into a diagnostic tool for veterinarians and producers.
- The use of ultrasound to diagnose varicocele in boar testis is an easily applied technique.
- Development and validation of immunocrit assay as a measure of colostrum intake in pigs revealed critical links between colostrum intake and subsequent fertility in adult animals that will aid in the selection of more efficient replacement gilts.
- Long-term ARS genetic resources within multiple species of food animals have been used extensively and continue to support innovative research outcomes, offering valuable means to compare industry-level populations while resulting in unique and valuable outcomes to drive innovation and discovery.
- Nitrous oxide gas utilization offers an improved euthanasia method for pigs – an innovative and highly relevant improvement in management practices aimed at improving animal welfare.
- Trio binning analysis and long- and short-read sequencing and assembly technologies will improve other genomics-based research providing greater power and accuracy for facilitating identification of parental haplotypes.
- Identifying the effects of GNRHR2 knockdown on testosterone production in boars provides a novel approach to potentially eliminate the need for surgical castration.

Able to meet the highest standards of quality?

Did it create cutting-edge methods and technologies?

- Trio binning in combination with long- and short-read sequencing and assembly will allow assembly and annotation of higher quality reference genomes with greater information on allelic variation.
- The use of color doppler ultrasound to study the effects of endophyte toxins on arterial contraction and fertility in males is a novel and useful approach.
- Establishing the relationship between neonatal colostrum consumption, neonatal serum immunoglobulin immunocrit, and adult uterine function provides a potential biomarker for sow fertility.
- The use of lectins to understand the glycobiology of poultry semen could lead to improved semen extenders.
- Expansion of genetic evaluation procedures to include novel data on traits supporting improvements in animal health and reproduction address on-going industry needs.
- Pork loin grading research offers promise for a line-speed, less invasive, and cost-effective classification and sorting system, assigning pork to optimum markets.
- New genetic analysis algorithms for dairy traits and genotyping arrays for turkey and swine will be utilized broadly.
- Several novel bioinformatics tools were developed that will be widely utilized.
- The introduction of a new trait, “feed saved” (FSAV), will improve genetic selection for dairy cattle efficiency.
- Glucosamine supplementation, particularly in older sows, provides an opportunity to improve fertility in swine production.
- GNRHR2 knockdown in boars was identified as a potential method to improve efficiency and welfare in the swine industry by eliminating the need for surgical castration.
- Use of glutamine was better than antibiotics in improving growth in stressed pigs suggesting a novel alternative to antibiotic use.
- Research helped define the optimal stage of production for using commercially available lactobacillus fermentation products to improve weight gain and gain to feed ratios in swine.

Successful in producing outcomes with meaningful impact?

Did it solve, mitigate, or ameliorate agricultural or environmental problems?

- The efficacy of utilizing alternative feed sources in poultry and milk production was demonstrated.
- Applied strategies to mitigate the effects of fescue toxicosis were identified. Utilizing different varieties, herbicide treatments to suppress seedheads, and companion planting with red clover were effective strategies.
- Heat stress mitigation could have an impact on production management strategies important for environments where elevated temperatures are prevalent.
- Identification of glutamine as an alternative to antibiotics in stressed swine may help reduce the use of antibiotics for growth promotion.

- Reconstitution of lost Y chromosome lineages in Holstein cattle will help restore genetic variability in dairy cattle.
- “Feed saved” (FSAV) trait provides a way to select for feed efficiency and increase sustainability.

Successful in producing outcomes with meaningful impact?

Did it change production practices in agricultural industries?

- The efficacy of utilizing alternative feed ingredients in poultry and milk production was demonstrated.
- Applied strategies to mitigate the effects of fescue toxicosis were identified. Utilizing different varieties, herbicide treatments to suppress seed heads, and companion planting with red clover were effective strategies.
- Dairy cattle genetic selection programs will be including the “feed saved” (FSAV) trait in the April 2021 update of the \$NetMerit Index based on published research.
- Experimental data demonstrated methods that could be immediately adopted to reduce heat stress in cattle and pig production.
- Improved annotation of animal genomes is a force multiplier by facilitating research by other animal scientists.
- ARS research showing the effects of length of storage on turkey egg quality, will reduce wastage and improve reproductive efficiency.
- The National Animal Germplasm Program provided sperm that was used to reconstitute and modernize lost Holstein male lineages.
- Sequencing of founder animals at MARC identified 64,232 polymorphisms that were predicted to alter the protein-coding genes. These polymorphisms have now been incorporated into a genotyping chip available from Illumina.

Successful in producing outcomes with meaningful impact?

Did it provide the scientific basis for policy or regulation?

- Research demonstrated negative impacts of zilpaterol use, supporting the industry’s voluntary discontinuation of this product.
- Alternatives to antibiotic use for growth promotion in swine provides a scientific approach to managing production changes required by policy/regulatory directives.

Successful in producing outcomes with meaningful impact?

Did it impact other research programs?

- Development of genomic tools and resources has greatly assisted the research community and has the potential to impact the future of production agriculture.

- Research is generating new and substantially better genomes sequences for cattle, pigs, and goats that have fewer errors and improperly assembled genes. Development of Trio binning strategies has facilitated improved genome sequences.
- Gene expression studies in duodenum, jejunum, and ileum tissues provide basic information to understand gene expression differences between cattle with differences in feed efficiency.
- Transcriptomic analysis on rumen epithelium suggests butyrate may play a role in ruminal epithelial maturation and could provide information to improve feed efficiency in ruminants.
- Metagenomic analyses of the rumen identified unique microbial populations associated with feed efficiency in cattle.
- Viral DNA was identified in the rumen, raising the possibility that viruses may be used to manipulate specific microbiota within the rumen.
- A fungal mycobiome was identified in neonatal pig feces that changed dramatically at weaning.
- Genetic discoveries related to disease resistance offer significant promise for new approaches to maintain herd and flock health.
- Identification of tools to more precisely identify genetic variation within and across breeds offers promise for additional germplasm preservation and use of existing germplasm resources to elucidate additional sources of valuable alleles.
- Identification of potential antibiotic alternatives and the reduction of the need for the use of antibiotics through pre- and probiotic usage will affect many other ARS and land grant projects in these areas.

Successful in producing outcomes with meaningful impact?

Did it result in new directions for the field's research?

- Development of genomic tools and resources has greatly assisted the research community and has the potential to impact the future of production agriculture.
- Gene expression studies in duodenum, jejunum, and ileum tissues provide basic information to understand gene expression differences between cattle with differences in feed efficiency.
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- Research is generating new and substantially better genomes sequences for cattle, pigs, and goats that have fewer errors and improperly assembled genes.
- Identification of potential biomarkers of growth and nutrient efficiency (ghrelin and leptin in beef cattle and acid 1 glycoprotein in swine) was a step toward understanding genetic mechanisms regulating feed efficiency.
- Trio binning analysis method is novel and will have an impact on other areas of research with application across species.
- Microbiome sequencing outcomes support new research efforts.
- Discovery of the relationship between antral follicle number and fertility in dairy cattle could lead to new predictive tools for selecting for greater fertility.