NANP 2023 Summit

Producing Healthy Diets with Sustainable Animal Systems

National Academy of Sciences
Washington DC
April 12, 2023

NANP 2023 Summit

Producing Healthy Diets with Sustainable Animal Systems

Location:	National Academy of Sciences Building, Washington, DC |2101 Constitution Ave. NW, Washington, DC 20418
Date:	Wednesday, April 12, 2023 | 9:00 a.m.–4:30 p.m., followed by a reception (until 6:00 p.m.)
Mission:	To evaluate the use of animals to sustainably provide for healthy human diets

Agenda

9:00–9:15 a.m.	Introduction
9:15–9:45 a.m.	The era of opportunity for livestock sustainability Sara Place, Colorado State University
9:45–10:15 a.m.	Animal source foods in healthy and sustainable diets Ty Beal, Global Alliance for Improved Nutrition (GAIN)
10:15–10:30 a.m.	Coffee Break
10:30–11:00 a.m.	Meeting the grand challenges of animal agriculture on the environment and world food security Frank Mitloehner, University of California, Davis
11:00–11:30 a.m.	Foods of the future via cellular agriculture—Challenges and opportunities David Kaplan, Tufts University
11:30–12:00 p.m.	Morning Q and A
12:00–1:15 p.m.	Lunch and Graduate Student Poster Session
1:15–3:00 p.m.	Impact of food animals on the environment (climate change) | Moderator: Robin White, Virginia Tech Beef cattle: C. Alan Rotz, USDA-ARS Dairy cattle: Ermias Kebreab, University of California, Davis Poultry and swine: Peter Ferket, North Carolina State University Aquaculture: Dominique Bureau, University of Guelph Questions

3:00–3:15 p.m.	Coffee Break
3:15–3:45 p.m.	Use of life cycle assessment in food and agriculture (supply chains) Marty Matlock, University of Arkansas
3:45–4:15 p.m.	What is the role of optimizing animal nutrition to drive sustainability of future food systems? Melissa D. Ho, World Wildlife Fund-US
4:15–4:30 p.m.	Summary
4:30–6:00 p.m.	Reception

What is NANP?

The National Animal Nutrition Program (NANP) serves as a forum to identify high-priority animal nutrition issues and provides an integrated and systemic approach to sharing, collecting, assembling, synthesizing, and disseminating science-based information, educational tools, and enabling technologies on animal nutrition that facilitate high-priority research among agricultural species.

www.animalnutrition.org

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Speakers

The era of opportunity for livestock sustainability

Sara Place, Associate Professor, Colorado State University

Sara Place is an expert in livestock systems sustainability with over a decade of experience in academia, industry associations, and private industry. Most recently, Place has been the chief sustainability officer at Elanco Animal Health where she provided technical expertise on sustainability issues to customers and supported Elanco's Healthy Purpose. Prior to her work with Elanco, she was the senior director for sustainable beef production research at the National Cattlemen's Beef Association and an assistant professor in sustainable beef cattle systems at Oklahoma State University. She received her PhD in animal biology from the University of California, Davis, and a BS in animal science from Cornell University. Place is a native of upstate New York where she grew up on a dairy farm.

The era of opportunity for livestock sustainability

Sara E. Place,* Maya Swenson, and Kimberly Stackhouse-Lawson, Department of Animal Sciences and AgNext, Colorado State University, Fort Collins, CO
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Increasing global demand for animal source foods and interest in sustainably produced foods is driving new opportunities and innovation in livestock production. Sustainable production involves balancing economic viability, social responsibility, and environmental stewardship over the long term. The production practices and specific outcomes that encompass sustainable production vary across climates, cultures, resource bases, and time. As a result, universally defining sustainable production of animal-source foods with specific outcomes can be challenging. The adage "you manage what you measure" will be central to demonstrating progress in sustainable livestock production and presents a risk—important aspects to sustainability that are hard to measure, such as biodiversity and quality

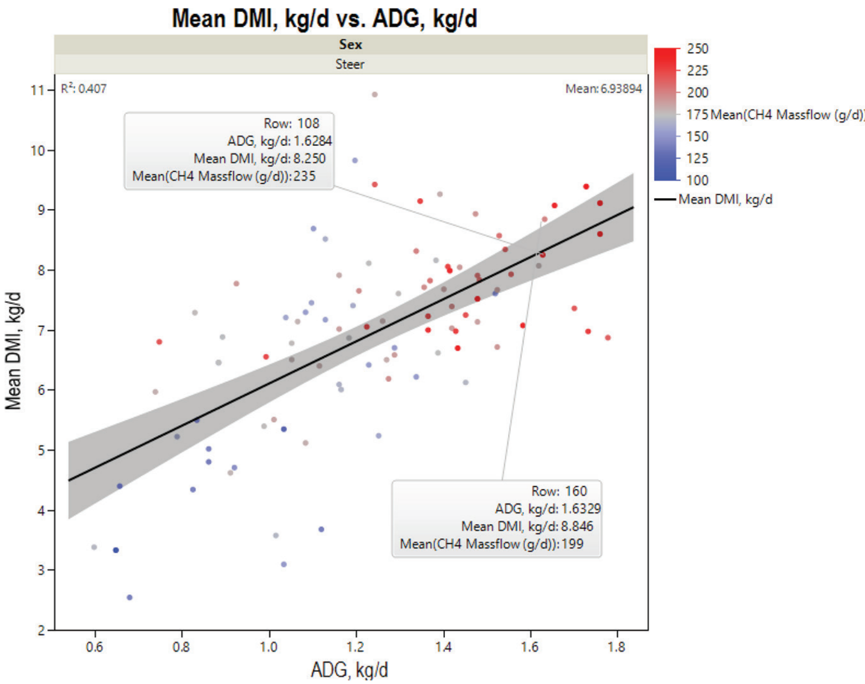

Figure 1. Mean average daily gain (ADG; kg/day), dry matter intake (DMI; kg/day), and methane emissions (g/day) for steers over 37 days. Animals of similar ADG and DMI can have different methane emissions, suggesting the potential for genetic selection for methane emissions independent of animal performance.

of life of livestock producers, may fall in importance relative to issues such as greenhouse gas emissions.

With those caveats, there are numerous promising areas of innovation and opportunity for sustainable livestock production. My presentation will focus on two of those areas: climate change mitigation, and improving the circularity of livestock systems.

The largest source of greenhouse gas emissions from global livestock production is the methane resulting from enteric fermentation (45.5% of global livestock emissions on a life cycle basis; FAO, 2022). Other key sources include feed production (22.4%), methane and nitrous oxide from livestock manure (12.8%), and land use change (10.9%).

Opportunities to mitigate enteric methane emissions include systems changes (e.g., optimizing efficiency), feed quality, feed additives, and genetics. Recent research at Colorado State University's AgNext demonstrates that animals of similar growth performance can have different methane emissions, pointing to the opportunity to use genetic selection to create permanent methane emissions reductions (Figure 1).

Circularity in livestock production is an issue that intersects with food security, feed-food competition, air and water quality, biodiversity and land use, and climate change. Increasing the use of non-human edible feedstuffs considered by- or co-products from the human food, biofuels, and fiber industries can ensure provision of high-quality animal source foods, while minimizing feed-food competition (Mottet et al., 2018). Additionally, optimizing flow and minimizing concentration of manure and feedstuffs nutrients can be beneficial for water quality and improving soil health.

Mitigating the climate impacts of livestock production and improving circularity may also provide new economic opportunities for livestock producers via carbon and ecosystems services markets.

References

FAO. 2022. GLEAM v3 Dashboard. Food and Agriculture Organization of the United Nations. Available at: https://www.fao.org/gleam/dashboard/en/.

Mottet, A., F. Teillard, P. Boettcher, G. De Besi, and B. Besbes. 2018. Review: Domestic herbivores and food security: Current contribution, trends and challenges for a sustainable development. Animal, 12:s188-s198. https://doi.org/10.1017/S1751731118002215.

Animal source foods in healthy and sustainable diets: Ensuring adequate nutrition while minimizing chronic disease and environmental impact

Ty Beal, Research Advisor, Global Alliance for Improved Nutrition (GAIN)

Ty Beal, PhD, is a global nutrition scientist focused on helping to achieve healthy and sustainable diets for all. His research seeks to understand what people eat and how it impacts their health and the planet. Beal has led quantitative global analyses on diets, nutrient density, and micronutrient deficiencies and context-specific studies on nutrient gaps and the complex determinants of child growth and obesity. He works across the food system to help identify strategies for how to transform food systems for human and planetary health. Beal is currently a research advisor on the Knowledge Leadership team at the Global Alliance for Improved Nutrition (GAIN) where he generates evidence to guide programs and mobilize knowledge related to global nutrition and food systems. He obtained a PhD from the University of California, Davis, where he was a National Science Foundation Graduate Research Fellow.

Animal source foods in healthy and sustainable diets: Ensuring adequate nutrition while minimizing chronic disease and environmental impact

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Animal source foods have health and environmental benefits and risks. They are rich in bioavailable essential nutrients commonly lacking globally including iron, zinc, calcium, vitamins B_{12} and D, choline, eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and essential amino acids (Beal et al., 2023). They also contain unique beneficial bioactive compounds including creatine, anserine, taurine, cysteamine, 4-hydroxyproline, carnosine, conjugated linoleic acid, and certain bioactive peptides (Beal et al., 2023). These essential nutrients and other beneficial compounds are bound together in an animal source food matrix that may have synergistic health benefits (Klurfeld, 2022). Randomized controlled trials and observational studies suggest unprocessed and minimally processed animal source foods have beneficial impacts on infant, child, and adolescent growth, development, cognition, and school performance, as well as fetal and infant outcomes through consumption by pregnant and lactating women (Beal et al., 2023). Further, similar evidence suggests moderate intakes of animal source foods can have beneficial impacts related to longevity in older adults, including improved muscle health, protection against sarcopenia and frailty and, for dairy, protection against dementia and Alzheimer's (Beal et al., 2023).

There are also health risks from animal source foods, particularly from excess consumption of processed meat, red meat, and saturated fat (Beal et al., 2023). Processed meat has been implicated in risk for noncommunicable diseases, due to high sodium content and other preservatives like nitrites and nitrates, saturated fat, and carcinogenic compounds introduced through heating meats at high temperatures or smoking, deep frying, or cooking well-done—heterocyclic amines, polycyclic aromatic hydrocarbons, and advanced glycation end products (Beal et al., 2023). Red meat has been implicated in risk for noncommunicable diseases due to heme iron, saturated fat, and similar carcinogenic compounds introduced through cooking (Beal et al., 2023). Saturated dairy fat that is separated from a beneficial food matrix, such as butter, also contributes to noncommunicable disease risk (Beal et al., 2023).

The environmental benefits and risks of animal source foods are both related to similar themes: land use, soils, water, biodiversity, climate change, and circularity (Beal et al., 2023). With all these themes, the method and scale of production and suitability to local context influences the potential benefits and risks (Beal et al., 2023). Where feasible, sustainable livestock production can be achieved through circular and diverse agroecosystems (Beal et al., 2023). When managed appropriately, ruminants are particularly useful for recycling waste, nutrient cycling, and making use of land unsuitable to crop production (Beal et al., 2023).

Many populations in Sub-Saharan Africa and South Asia could benefit from increased consumption of animal source foods. Where consumption is high, processed meat should be limited, and red meat and saturated fat should be moderated to lower the risk of chronic diseases—this could also have co-benefits for sustainability.

The amount and type of animal source food that is healthy and sustainable will depend on the local context and health priorities and will change over time. Efforts by governments and nongovernmental organizations to increase or decrease animal source food consumption should consider the health and environmental needs and risks in the local context and involve the people impacted by any changes. Policies, programs, and incentives are needed to ensure best practices in production, curb excess consumption where high, and sustainably increase consumption where low.

References

Beal, T., C.D. Gardner, M. Herrero, L.L. Iannotti, L. Merbold, S. Nordhagen, A. Mottet. 2023. Friend or foe? The role of animal-source foods in healthy and environmentally sustainable diets. J. Nutr. 153:409–425.

Klurfeld, D. M. 2022. The whole food beef matrix is more than the sum of its parts. Critical Rev. Food Sci. Nutr. 2022:1–9.

Meeting the grand challenges of animal agriculture on the environment and world food security

Frank Mitloehner, University of California, Davis

Frank Mitloehner is a professor and air quality specialist in cooperative extension in the Department of Animal Science at the University of California (UC) Davis. As such, he shares his knowledge and research, both domestically and abroad, with students, scientists, farmers and ranchers, policy makers, and the public at large. He is also director of the CLEAR Center, which has two cores—research and communications. The CLEAR Center brings clarity to the intersection of animal agriculture and the environment, helping our global community understand the environmental and human health impacts of livestock, so we can make informed decisions about the foods we eat and while reducing environmental impacts.

Mitloehner is committed to making a difference for generations to come. As part of his position with UC Davis and Cooperative Extension, he collaborates with the animal agriculture sector to create better efficiencies and mitigate pollutants. He is passionate about understanding and mitigating air emissions from livestock operations, as well as studying the implications of these emissions on the health of farm workers and neighboring communities. In addition, he is focusing on the food production challenge that will become a global issue as the world's population grows to nearly 10 billion by 2050.

Mitloehner received a master of science degree in animal science and agricultural engineering from the University of Leipzig, Germany, and a doctoral degree in animal science from Texas Tech University. He was recruited by UC Davis in 2002 to fill its first-ever position focusing on the relationship between livestock and air quality.

Meeting the grand challenges of animal agriculture on the environment and world food security

Frank Mitloehner, PhD

As the global community actively works to keep temperatures from rising beyond 1.5°C, predicting greenhouse gases by how they warm the planet—and not their CO_2-equivalence—provides information critical to developing short- and long-term climate solutions.

Livestock, and in particular cattle, have been broadly branded as major emitters of methane (CH_4) and significant drivers of climate change. Livestock production has been growing to meet the global food demand; however, increasing demand for production does not necessarily result in the proportional increase of CH_4 production. The presentation intends to evaluate the actual effects of the CH_4 emissions from livestock production on temperature and initiate a rethinking of CH_4 associated with animal agriculture to clarify long-standing misunderstandings and uncover the potential role of animal agriculture in fighting climate change.

The talk will consider two climate metrics, the standard 100-year Global Warming Potential (GWP100) and the recently proposed GWP*, developed at the University of Oxford, showing that GWP* should be used in combination with GWP to provide informative strategic suggestions on fighting short-lived climate pollutant (SLCP)-induced climate change. By continuously improving production efficiency and management practices, animal agriculture can be a short-term solution to fight climate warming that the global community can leverage while developing long-term solutions for fossil fuel carbon emissions.

Foods of the future via cellular agriculture—Challenges and opportunities

David Kaplan, Professor, Tufts University

David Kaplan is the Stern Family Endowed Professor of Engineering at Tufts University, a Distinguished University Professor, and Professor in the Department of Biomedical Engineering. His research focus is on biopolymer engineering, tissue engineering, regenerative medicine, and cellular agriculture. He has published over 1,000 peer-reviewed papers, is editor-in-chief of *ACS Biomaterials Science and Engineering*, and serves on many editorial boards and programs for journals and universities. He directed the NIH P41 Tissue Engineering Resource Center (TERC) that involves Tufts University and Columbia University for 15 years. His laboratory has been responsible for over 150 patents issued or allowed, and numerous start-up companies. He has also received a number of awards for his research and teaching and was elected as a Fellow of the American Institute of Medical and Biological Engineering and elected to the National Academy of Engineering.

Foods of the future via cellular agriculture—Challenges and opportunities

David Kaplan, Tufts University

The need for future foods for the ever-growing population requires consideration of alternative approaches toward food sustainability, nutrition, and security. To address this need, we pursue a cell-based, tissue engineering approach, eliminating animals from the process. Our central hypothesis is that sustainable, cost-effective, and scalable cultivated-meat and alternative proteins will provide new food availability options and healthier food alternatives, while decreasing environmental impact. Much progress has been made toward this goal, with cell and tissue biomanufacturing central to success. Further, there remain many challenges and opportunities ahead, from cell types and cell engineering, to media formulations, scale-up requirements, and nutritional issues, which will be discussed in the context of this emerging food frontier. The impact of this new approach to foods of the future is potentially transformative.

Impact of food animals on the environment (climate change)

Moderator: Robin White, Virginia Tech
Beef cattle: C. Alan Rotz, Agricultural Engineer, USDA-ARS
Dairy cattle: Ermias Kebreab, Professor, University of California, Davis
Poultry and swine: Peter Ferket, Professor, Interim Head, Prestage Department of Poultry Science, North Carolina State University
Aquaculture: Dominique Bureau, Professor, University of Guelph

Impact of beef cattle on the environment

C. Alan Rotz, Agricultural Engineer, USDA-ARS

Al Rotz is an agricultural engineer with the USDA's Agricultural Research Service. His research activities are diverse, but all have involved experimental evaluation of machinery systems and the development, evaluation, and use of mathematical models of agricultural production systems. Rotz grew up on a dairy farm in southern Pennsylvania. He holds a BA degree from Elizabethtown College and a BS in mechanical engineering and MS and PhD degrees in agricultural engineering from The Pennsylvania State University. He spent three years as an assistant professor at Michigan State University before joining the Agricultural Research Service. For 16 years, he led the East Lansing Cluster of the US Dairy Forage Research Center. For the past 25 years, he serves as a scientist at the Pasture Systems and Watershed Management Research Unit in University Park, Pennsylvania.

He is a registered professional engineer and a fellow of the American Society of Agricultural and Biological Engineers. He is also a member of the American Dairy Science Association, the American Forage and Grassland Council, and the Pennsylvania Forage and Grassland Council. He has published over 450 articles and papers on his work, which include 175 scientific journal articles, 2 patents, 17 book chapters, 190 proceedings papers, and 45 trade journal articles, extension bulletins, and fact sheets.

Impact of beef cattle on the environment

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Beef cattle production has several important impacts on the environment. Greenhouse gas (GHG) emission and fossil energy use are of global importance while nitrogen losses and water consumption can be of regional importance. Due to the many components in production systems and their interactions, a comprehensive life cycle assessment is needed to quantify and compare the impacts of production strategies.

The life cycle annual GHG emission related to beef production and consumption in the United States is about 250 Tg or 3.7% of the total national GHG emission inventory (Putman et al., 2023). Of this total, about 80% is related to producing the cattle. Within cattle production, about 58% is from enteric emissions, 23% is in feed production, and 7% is related to manure management (Rotz et al., 2019). Greenhouse gas emissions from beef production in the United States are decreasing. Compared with 50 years ago, we now produce 20% more meat using about 15% fewer cattle (NASS, 2022). The GHG intensity in cattle production has dropped 34% from 32 to 21 kg CO_2e/kg carcass weight produced, and the total GHG emission related to beef cattle production has decreased 21% from 323 to 255 Tg CO_2e.

One-hundred-year global warming potential (GWP100) factors are normally used to total the warming effect of different GHG compounds to CO_2 equivalents (Myhre et al., 2013). These factors have varied over the years, which has some effect on published GHG impacts. GWP100 factors do not properly represent the effects of methane, which is a short-lived gas that oxidizes in the atmosphere with a half-life of about 8 years. This has led to the development of a new relationship referred to as GWP* (Smith et al., 2021). Considering the change that has occurred over the past 50 years, using this model reduces the global warming impact of beef cattle by over 50% relative to the use of current GWP100 factors.

Various mitigation strategies are being considered to reduce GHG emissions in cattle production. Those considered for feedlot finishing include more efficient feeding, enteric methane inhibitors, anaerobic digestion of manure, and removal of manure storage. Use of a combination of these practices may reduce feedlot finishing emissions by 50%. Over the cattle production cycle, feedlot finishing only contributes about 14% of the total life cycle GHG emissions (Rotz et al., 2019), so a 50% reduction in the feedlot phase provides only a small 3% reduction in the total emission of cattle production. Reductions in the cow-calf phase would provide greater benefit, but mitigation in this phase, where cows are maintained on pasture and rangeland, is difficult. Carbon sequestration in pasture soils can be very beneficial in reducing GHG warming when this capture of carbon can be quantified.

Another important environmental consideration is ammonia emission from manure. We estimate the total ammonia emission in beef cattle production in the United States is about 908 Gg of nitrogen, which is around 30% of the total emission in the United States (Rotz et al., 2019). This large contribution to US inventory makes this an important need for mitigation. Nonprecipitation water use in cattle production is also important with about 6% of the total water consumption in the United States related to cattle production. Fossil energy use is always an important consideration for sustainability, but that used in cattle production is less than 1% of the total use in the United States. Perhaps one of the more important considerations in the sustainability of beef, as well as all foods, is consumer waste where an estimated waste of 20% increases all metrics or measures of the sustainability of beef consumption by 25% (Putman et al., 2023).

References

Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura, and H. Zhang. 2013. Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. T.F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, ed. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

NASS. 2022. Quick stats 2.0. National Agricultural Statics Service, US Dept. Agric. http://quickstats.nass.usda.gov.

Putman, B., C.A. Rotz, and G. Thoma. 2023. A comprehensive environmental assessment of beef production and consumption in the United States. J. Cleaner Prod. (in press).

Rotz, C.A., S. Asem-Hiablie, S. Place, and G. Thoma. 2019. Environmental footprints of beef cattle production in the United States. Agric. Systems. 169:1–13. https://doi.org/10.1016/j.agsy.2018.11.005.

Smith, M.A., M. Cain, and M.R. Allen. 2021. Further improvement of warming-equivalent emissions calculation. Climate and Atmospheric Sci. 4:19. https://doi.org/10.1038/s41612-021-00169-8.

Impact of dairy cattle on the environment (climate change): Role of nutrition on lessening of carbon footprint of food animals

Ermias Kebreab, Professor, University of California, Davis

Ermias Kebreab is associate dean and professor of animal science at the University of California, Davis. He holds the Sesnon Endowed Chair in Sustainable Agriculture. He conducts research in animal nutrition, mathematical modeling of biological systems, and impact of livestock on the environment. He is a contributing author to 2019 Intergovernmental Panel on Climate Change (IPCC) update on enteric methane emissions. He co-chaired the feed additive and methane committees of the Food and Agriculture Organization of the United Nations. He has authored over 250 peer-reviewed articles and received several awards including Excellence in Ruminant Nutrition and International Agriculture from the American Society of Animal Science, and the 2022 Chancellor's Innovator of the year award. He served on two committees of The National Academies of Sciences, Engineering and Medicine on methane and nutrition of dairy cattle. He is a regular invited speaker including a TED talk that has been featured as one of the must-watch climate talks of 2022 by ted.com. His research was in the top 10 of all research conducted at the University of California system in 2021. He holds a BS degree from the University of Asmara, Eritrea, and an MS and PhD from the University of Reading, UK.

Impact of dairy cattle on the environment (climate change): Role of nutrition on lessening of carbon footprint of food animals

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Dairy cattle play a key role in human food production by converting forages and poor-quality feeds into human-edible products. However, this conversion is associated with an environmental cost, which can be unavoidable (e.g., as a byproduct of a necessary fermentation process) or avoidable (e.g., nutrients consumed in excess of requirement). The most recent estimates from the US Environmental Protection Agency show that dairy cattle are responsible for 1.4% of total direct greenhouse gas emissions, which is equivalent to 15.4% of all agricultural emissions in the United States. Over half of those emissions are from enteric fermentation; therefore, a lot of effort has been focused on reducing emission from enteric sources.

Nutrition plays a considerable role in reducing absolute emissions (g/d), or per intake (yield; g/kg dry matter intake) and product (intensity; g/kg milk yield) basis. The nutritional strategies to reduce greenhouse gas emissions can be classified as (1) direct inhibition of methanogenesis, (2) providing alternative hydrogen sinks, or (3) modifying the rumen environment. Two of the most effective inhibitors are 3-nitrooxypropanol (3-NOP) and macroalgae. Recent meta-analysis showed an average reduction of 32.5% when dairy diets were supplemented with 70.5 mg/kg dry matter of 3-NOP but were affected by 3-NOP dose and fiber concentrations in the diet (Kebreab et al., 2023). Several experiments with red macroalgae *Asparagopsis taxiformis* showed reduction of up to 67% in dairy cattle and 98% in beef cattle, although further work is required to optimize the inclusion rate as a reduction in feed intake and elevated mineral concentrations in milk have been reported (Wasson et al., 2022).

Alternative electron acceptors such as nitrate have also been shown to reduce enteric emissions by up to 20% (Beauchemin et al., 2022). Unfortunately, due to toxicity issues they are currently not recommended for use. Intensification of animal production through improved feeding and management is recognized as the most immediate and universally applicable means of decreasing methane emission intensity. Considerable research on lipid supplementation indicates that where applicable and affordable it can be an effective methane mitigant. Other strategies include using tannins and essential oils as feed supplements. However, further research is required to optimize inclusion levels.

Key words: enteric methane, dairy, inhibitors, mitigation

References

Beauchemin, K.A., E.M. Ungerfeld, A.L. Abdalla, C. Alvarez, C. Arndt, P. Becquet, C. Benchaar, A. Berndt, R.M. Mauricio, T.A. McAllister, W. Oyhantçabal, S.A. Salami, L. Shalloo, Y. Sun, J. Tricarico, A. Uwizeye, C. De Camillis, M. Bernoux, T. Robinson, and E. Kebreab. 2022. Invited review: Current enteric methane mitigation options. J. Dairy Sci. 105:9297-9326.

Kebreab, E., A. Bannink, E. Pressman, N. Walker, A. Karagiannis, S. van Gastelen, and J. Dijkstra. 2023. A meta-analysis of effects of 3-nitrooxypropanol on methane production, yield, and intensity in dairy cattle. J. Dairy Sci. 106:927-936.

Wasson, D.E., C. Yarish, and A. Hristov. 2022. Enteric methane mitigation through *Asparagopsis taxiformis* supplementation and potential algal alternatives. Front. Anim. Sci. 3:999338.

Impact of poultry and swine on the environment (climate change): Role of nutrition on reducing carbon footprint and greenhouse gas emissions

Peter Ferket, Professor, Interim Head, Prestage Department of Poultry Science, North Carolina State University

Peter R. Ferket is a Williams Neal Reynolds Distinguished Professor of Nutrition and Biotechnology, interim head of the Prestage Department of Poultry Science, and director of the Animal Health and Nutrition Consortium in the College of Agriculture and Life Sciences at North Carolina State University. He earned BS and MS degrees in animal and poultry science at the University of Guelph in 1981 and 1983, respectively, and a PhD degree in animal nutrition and meat science from Iowa State University in 1987. In 1988, Ferket joined North Carolina State University where he is responsible for research, extension education and outreach, and undergraduate and graduate teaching. He has devoted much of his extension and research efforts on nutritional factors that affect growth and health of meat poultry. He is recognized for his work on perinatal nutrition and development, skeletal development and immune function, enteric health, pro-nutrient feed additives, nutritional factors that affect the yield and quality of meat, nutritional value of food industry co-products, and nutrient management. His teaching activities focus on vitamin metabolism, mineral metabolism, poultry nutrition, feed mill management, ingredient quality control, and advanced feed formulation. Ferket is a frequent speaker at animal and poultry conferences and has authored over 600 publications and eight patents and one software disclosure.

Impact of poultry and swine on the environment (climate change): Role of nutrition on reducing carbon footprint and greenhouse gas emissions

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The major greenhouse gases (GHG) from livestock include methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). According to the Food and Agriculture Organization of the United Nations (MacLeod et al., 2013), feed production contributes 60% of GHG emissions from the global pork production, followed by 27% for manure storage/processing, and 6% for post-farm processing and transport of meat, 3% for direct and indirect energy use, and 3% for enteric fermentation. In contrast, feed production contributes 78% and 68% of emissions from poultry meat and egg production, respectively, the difference due to higher soybean use for broilers sourced from areas where land use change occurs, but these models do not account for a crop-poultry manure system that is a net CO_2 fixation in crop biomass (Oryschak and Beltranena, 2020). Enteric fermentation contribution to GHG from poultry is negligible (Wang and Juang, 2005), but 20% of GHG emissions are CH_4 and N_2O emissions manure storage and processing.

As feed production contributes to the most GHG emissions from pig and poultry production, the efficiency to convert feed into edible products is a key determinant. Continuous improvements in growth rate and feed efficiency are made by advancements in genetic selection, feed formulation, diet digestibility, and management practices. Less intensive production systems of pigs and poultry have lower production efficiency than their commercial counterparts due to differences in breeds used, feed quality and availability, and management practices. Precision feeding and management strategies, where diets can be adjusted on a daily basis to minimize under-and over-supply of nutrients relative to requirements, may reduce GHG emissions but at increased technology costs (Moss et al., 2021). Feeding low protein diets supplemented with commercially available synthetic amino acids (LP-SAA) to meet requirements has been shown to reduce GHG emissions by 39% in pigs (Osada et al., 2011), primarily as due to reduced ammonia emission (Hansen et al., 2014). Reduction in GHG emissions is less (~30%) in poultry fed LP-SAA diets than pigs because of lower CH_4 emissions (Cappelaere et al., 2021). Dietary inclusion of food waste, food co-products, and insects in place of soybean meal further reduces overall GHG emissions (Shurson et al., 2022), especially when supplemented with enzymes and feed additives that improve nutrient digestibility and bioavailability (Bundgaard et al., 2014). Improvements in nutrient digestibility, and thus reduced GHG emissions, have also been observed by fine grinding of pig diets (Kerr et al., 2020) and course grinding of poultry diets (Xu et al., 2015). Dietary inclusion of phytogenic feed additives derived from *Quillaja saponaria* have been demonstrated to reduce ammonia emissions up to 26%, and CO_2 emissions/kg body weight gain of pigs by 9% (Bartos et al., 2016). Although pigs and poultry have much lower GHG emission than ruminants, feed formulation and feed manufacturing strategies can reduce environmental impact significantly.

References

Bartos, P., A. Dolan, L. Smutny, M. Sistkova, I. Celjak, M. Soch, and Z. Havelka. 2016. Effects of phytogenic feed additives on growth performance and on ammonia and greenhouse gases emissions in growth-finishing pigs. Anim. Feed Sci. Technol. 212:143-148.

Bundgaard, A.M., R. Dalgaard, C. Gilbert, and M. Thrane. 2014. Assessment of the potential of digestibility-improving enzymes to reduce greenhouse gas emissions from broiler production. J. Cleaner Prod. 2014:1-9.

Cappelaere, L., J. Le Cour Grandmaison, N. Martin, and W. Lamert, 2021. Amino acid supplementation to reduce enrivonmental impacts of broiler and pig production: A review. Front. Vet. Sci. 8:689259. https://doi.org/10.3389/fvets.2021.689259.

Kerr, B.J., S.L. Trabue, D.S. Andersen, M.B. Van Weelden, and L.M. Pepple. 2020. Dietary composition and particle size effects on swine manure characteristics and gas emissions. J. Environ. Qual. 49:1384-1395. https://doi.org/10.1002/jeq2.20112.

MacLeod, M., P. Gerber, A. Mottet, G. Tempio, A. Falcucci, C. Opio, T. Vellinga, B. Henderson, and H. Steinfeld. 2013. Greenhouse gas emissions from pig and chicken supply chains – A global life cycle assessment. Food and Agriculture Organization of the United Nations (FAO), Rome.

Moss, A.F., P.V. Chrstal, D.J. Cadogan, S.J. Wilkinson, T.M. Crowley, and M. Choct. 2021. Precision feeding and precision nutrition: A paradigm shift in broiler feed formulation? Anim. Biosci. 34:354-362. https://doi.org/10.5713%2Fab.21.0034.

Oryschak, M.A., and E. Beltranena. 2020. Reconsidering the contribution of Canadian poultry production to anthropognic greenhouse gas emissions: Returning to an integrated crop-poultry production system paradigm. Poult. Sci. 99:3777-3783.

Osada, T., R. Takada, and I. Shinzato. 2011. Potential reduction of greenhouse gas emission from swine manure by using a low-protein diet supplemented with synthetic amino acids. Animal Feed Sci. Technol. 166-167:562-574.

Shurson, G.C., R.E.O. Pelton, Z. Yang, P.E. Urriola, and J. Schmitt. 2022. Environmental impacts of eco-nutrition swine feeding programs in spatially explicit geographic regions of the United States. J. Anim. Sci. 100:skac356. https://doi.org/10.1093/jas/skac356.

Wang, S.Y., and D.J. Huang. 2005. Assessment of greenhouse gas emissions from poultry enteric fermentation. Asian-Australas. J. Anim. Sci. 19:873-878.

Xu, Y., C. R. Stark, P. R. Ferket, C. M. Williams, W. J. Pacheco, and J. Brake. 2015. Effect of dietary coarsely ground corn on broiler live performance, gastrointestinal tract development, apparent ileal digestibility of energy and nitrogen, and digesta particle size distribution and retention time. Poult. Sci. 94:53-60.

Impact of aquaculture species on the environment and climate change

Dominique Bureau, Professor, University of Guelph

Bureau is a professor at the University of Guelph where he leads a dynamic research program on the nutrition of aquaculture species with a focus on the efficiency of utilization of amino acids, phosphorus, and energy and on feed ingredient evaluation. He works very closely with aquaculture operations, feed manufacturers, and ingredient suppliers around the world. He was a member of the US NRC Committee on Nutrient Requirements of Fish and Shrimp (2009-2011). Since 2014, he has been leading the development of the International Aquaculture Feed Formulation Database (www.iaffd.com), a free online resource with detailed data on the composition of over 600 feed ingredients and nutritional specifications for over 30 species at different life stages. The IAFFD was developed to be highly compatible with most least-cost feed formulation programs. He is also co-founder of Wittaya Aqua International (wittaya-aqua.ca), a young and innovative Canadian company developing cutting-edge online tools for feed manufacturers, feed ingredient suppliers, and aquaculture farms.

Impact of aquaculture species on the environment and climate change

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Aquaculture is a diverse sector characterized by the farming of many different species under a wide variety of culture conditions differing in degree of technicity, intensiveness, and efficiency. This industry is relatively young and evolving rapidly. Due to their novelty and because some of the production occurs in public bodies of water, aquaculture operations are also often under a higher degree of scrutiny than many other livestock operations.

The waste outputs of aquaculture operations and their potential deleterious environmental impacts have been the focus of research and much debate. These issues are a major focus area for product certification programs. Research has shown that the waste outputs of aquaculture operations can easily be estimated using simple nutrient mass balance approaches (Bureau and Hua, 2010). Environmental impacts are not as pronounced as they are often made to be. For example, the environmental impacts of rainbow trout culture operation on an oligotrophic lake in Canada have been shown to be very limited and even beneficial to wildlife inhabiting the lake (Azevedo et al., 2011).

Focus has recently shifted to estimating greenhouse gas emissions of various aquaculture products. These products often have a lower carbon footprint than many wild seafood products. The production of feeds and their transport to farms was shown to contribute about 50% of the total CO_2 equivalent (CO2eq) emissions. Several other production inputs can contribute very significantly to carbon footprint. Chang et al. (2017) reported a carbon footprint for Pacific white shrimp of 6.9 kg CO2eq/kg, with electricity (2.0 kg CO2eq/kg), feed (1.6 kg CO2eq/kg), indirect raw materials (1.5 kg CO2eq/kg), waste treatment (0.8 kg CO2eq/kg), and transport and refrigerant (0.8 CO2eq/kg) as the main contributors in terms of emissions. The type of production system has very significant effects on emissions. For example, Liu et al. (2016) compared the carbon footprint of open net pen salmon aquaculture and land-based closed containment recirculating aquaculture systems (RAS). RAS-produced salmon had a footprint that was double that of the net pen-produced salmon (7.0 vs. 3.4 kg CO2eq/kg salmon). However, RAS could be located nearer to markets, and when transportation of the final product is accounted for, the two systems can have similar carbon footprints per kilogram of product delivered.

There is an important need for systems that could enable the efficient and accurate assessment of the environmental impacts of aquaculture products, from feed to farm to consumers. Ideally, systems should account for all inputs and processes. They should allow for seamless and confidential compilation of information from the entire production chain and the objective computations of emissions and other measures of sustainability. Innovative online tools are being developed by industry stakeholders and these could play a very important role in the future of the industry.

References

Azevedo, P.A. C.L. Podemski, R.H. Hesslein, S.E.M. Kasian, D.L. Findlay, and D.P. Bureau. 2011. Estimation of waste outputs by a rainbow trout cage farm using a nutritional approach and monitoring of lake water quality. Aquaculture 311:175-186.

Bureau, D.P., and K. Hua. 2010. Towards effective nutritional management of waste outputs in aquaculture, with particular reference to salmonid aquaculture operations. Aquaculture Res. 41:777-792.

Chang, C.C., K. C. Chang, W. C. Lin, and M. H. Wu. 2017. Carbon footprint analysis in the aquaculture industry: Assessment of an ecological shrimp farm. J. Cleaner Prod. 168: 1101-1107.

Liu Y., T. W. Rosten, K. Henriksen, E. Skontorp Hognes, S. Summerfelt, and B. Vinci. 2016. Comparative economic performance and carbon footprint of two farming models for producing Atlantic salmon (*Salmo salar*): Land-based closed containment system in freshwater and open net pen in seawater. Aquacultural Eng. 71:1-12.

Use of life cycle assessment in food and agriculture (supply chains)

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Marty Matlock is a professor in the Biological and Agricultural Engineering Department at the University of Arkansas. He served as senior adviser for Food Systems Resiliency at USDA from 2021-2022. Prior to joining USDA, he was executive director of the University of Arkansas Resiliency Center in the Fay Jones School of Architecture and Design. Matlock received his PhD in biosystems engineering, MS in botany, and BS in agronomy from Oklahoma State University, is a registered professional engineer, a board-certified environmental engineer, and a certified ecosystem designer. His research focus is measuring and managing complex ecosystem processes at local to global scales. His research team has led global development of food systems life cycle impact assessment for 15 years. Matlock serves on the National Academy of Science, Engineering, and Medicine Board of Agriculture and Natural Resources. He is the recipient of the 2018 CAST-Borlaug Agriculture Communications Award and the 2022 AEES Odom Award for lifetime achievement in ecosystem design. He has served on the USEPA Science Advisory Committee for Agriculture, the US Secretary of Agriculture's Committee for the 21st Century, and as sustainability science adviser with conservation organizations and agricultural producer groups. He is a member of the Cherokee Nation and served as chairman of the Cherokee Nation Environmental Protection Commission for the past 16 years.

Use of life cycle assessment in food and agriculture (supply chains)

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Understanding the impacts of the decisions we make in complex systems like agricultural supply chains is very difficult. Food and agriculture supply chains are best described as interconnected systems within systems, or metasystems. They are characterized by feedback and feedforward information flow that changes rapidly, with nonlinear and difficult-to-predict outcomes. The global scope of the agricultural supply chain amplifies this complexity. Life cycle assessment (LCA) is an accounting framework based on scientific and engineering principles of material and energy flows and is constructed as a set of linked unit processes. Each unit process accounts for the material and energy, raw materials, and emissions to the environment resulting from a product or service. Life cycle assessment is defined by a suite of international standards, the ISO 1404X series. ISO 14044 defines four stages of an LCA that include goal and scope definition, life cycle inventory (LCI) collection, life cycle impact assessment, and interpretation.

Life cycle assessment studies follow a common methodological approach involving four phases: goal and scope definition, inventory analysis, impact assessment, and interpretation. To assist industry, the Life Cycle Initiative, a global collaboration under the auspices of the United Nations, periodically makes recommendations about best practice impact assessment models (https://www.lifecycleinitiative.org/). The LCI phase is where discrete unit processes are parameterized in terms of mass and energy flows, impacts, and products. Life cycle inventories are often the most time consuming and expensive as food and agricultural production, processing, distribution, and consumption vary dramatically within and across regions.

We use crop systems models (EPIC/APEX) to parameterize unit processes in crop production. These unit processes are generated using an archetype sampling strategy for large areas like the US heartland crop region to capture the variability of inputs and outputs for different cropping systems, soil types, climates, and annual production cycles over multiple years. These calibrated and validated model outputs are converted to unit process characteristics for LCA analysis (Figure 1). Life cycle impact assessment quantifies the impacts across midpoint and endpoint categories. Next-generation

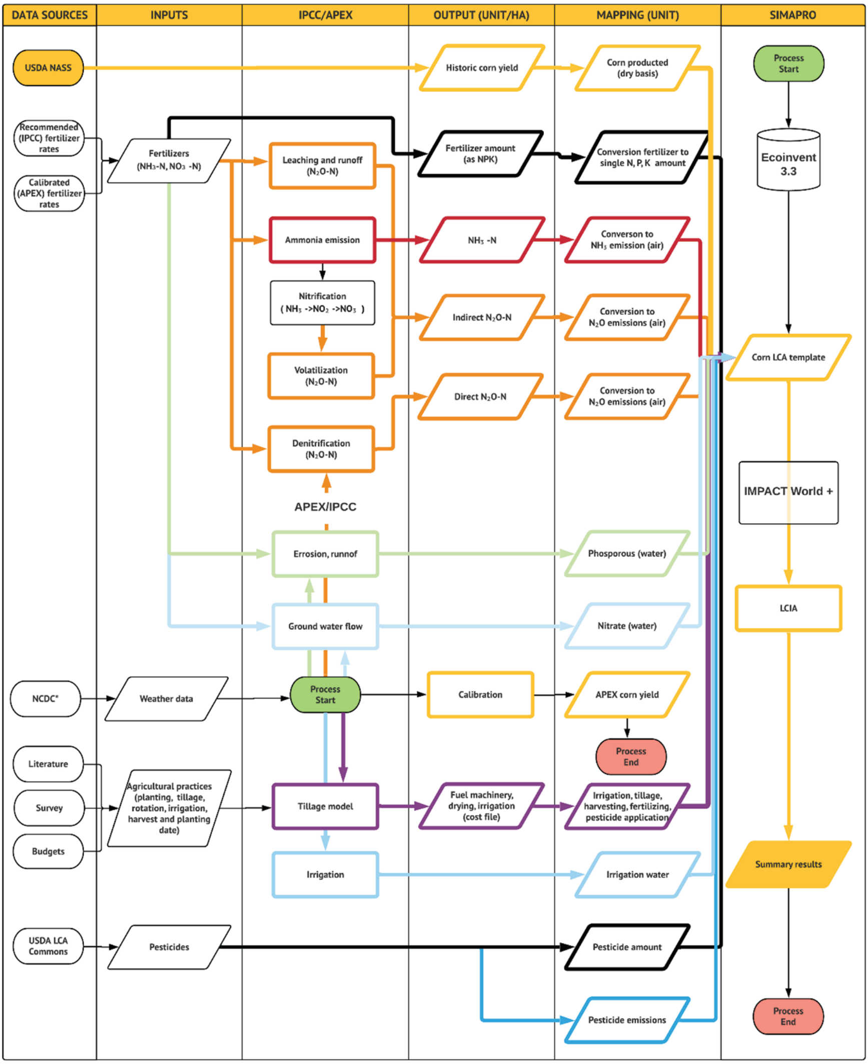

Figure 1. Flow diagram describing a summary of APEX to LCA modeling steps including data sources, data inputs, data outputs, data conversion, computing processes, and results.

LCA consider geospatial distribution of impacts, supply chain risk and resiliency, and regional consequential impacts from decision making, especially from land use.

What is the role of optimizing animal nutrition to drive sustainability of future food systems?

Melissa D. Ho, Sr. Vice President, Freshwater and Food, World Wildlife Fund

Melissa D. Ho, senior vice president for Freshwater and Food at World Wildlife Fund (WWF)-US, leads an integrated team working on place-based and market-based initiatives that aim to protect freshwater resources, conserve critical landscapes, and strengthen regenerative, resilient food systems.

She has over 20 years of experience as a scientist, policy adviser, and development professional and takes a systems approach to address the two biggest threats to nature and climate: agriculture and infrastructure. Throughout her career, she has leveraged a keen focus on the intersection of water and agriculture, and the connections to health, energy, and development. She has worked at the landscape level, with large-scale irrigation systems, agricultural value chain development, and community-based water resource management, as well as at the household level driving water technology adoption through the private sector and addressing gender inequity and child malnutrition through nutrition-sensitive agriculture interventions. She came to WWF from the Millennium Challenge Corporation (MCC), where she oversaw a $1.5 billion portfolio of public sector investments in energy, water, and agriculture infrastructure in West Africa. Prior to that, she served at USAID where she oversaw the technical team responsible for strategy development and integration for Feed the Future, the US government's global hunger and food security initiative. She was an early member of the Agriculture Development team at the Bill and Melinda Gates Foundation, where she led a portfolio of grants related to agricultural water management, extension, and data systems. She has also served in various capacities in the US Congress.

In 2021, Ho was appointed to the National Academies Climate Security Roundtable. She currently serves on the board of several domestic and international organizations. She has a PhD in plant physiology from The Pennsylvania State University, an MS in soil science (plant-water relations) from the University of California, Davis, and a BS in environmental systems from Cornell University. She enjoys hiking, biking, and baking, and especially savors seeking out specialty dishes and local cuisine from wherever in the world she may be. She lives with her family on Capitol Hill in Washington, DC.

What is the role of optimizing animal nutrition to drive sustainability of future food systems?

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The animal nutrition field has a timely opportunity and critical role to play in providing diets and feed for animals in ways that optimize the health and sustainability of both today's and tomorrow's food supply. Livestock have been a valuable part of the agricultural landscape for millennia and increases in production and consumption over recent decades draw attention to the impacts of animal agriculture. To stay within planetary boundaries and enable future food security, livestock systems must be sustainable, resilient, and regenerative. Feed production is a source of embedded impacts across all livestock species, representing 20-60% of the greenhouse gas footprint by species as well as a primary consumer of water. The target of a 1.5°C climate future is contingent on ending all commodity-driven deforestation and habitat conversion, including US cropland expansion that continues to plow up intact grasslands. How we feed livestock also impacts the animal footprint; advancements in animal nutrition have contributed to significant improvements in animal growth and performance to date.

Because of this critical position, feed systems can drive progress in the sustainability of animal agriculture by integrating and prioritizing regenerative processes, circular ingredients, and feeding innovations. Sustainable production practices can improve the resilience of feed systems by enhancing soil health and carbon sequestration while minimizing negative impacts of water use, chemical inputs, and threats to biodiversity. Many animal feeds already make use of by- and co-products; we can incorporate streams of food and feed surplus at a greater scale to further minimize waste. Upcycling with fermentation processes or insect production to create alternative feed sources creates additional sustainable options for applied animal nutrition that can reduce the animal production footprint with increased nutrition and efficiencies. Technological advances including precision manufacturing, quality control, and feed delivery systems go beyond simple ingredient innovations to improve animal productivity, diet consistency, and health as sustainable solutions.

Responsible sourcing is the cornerstone of all these paths forward, and animal nutritionists have a crucial role to play through incorporating sustainability criteria into the formulation of animal diets. We envision ration design that optimizes the environmental footprint of ingredients and inputs as well as animal health and performance: did this contribute to land-use change? What is the greenhouse gas or water impact of these feedstuffs? We are not alone in this vision, and the work has already begun. Academic teams are gathering and modeling data to the county level for commodity crop production, and industry players including AFIA and leading feed companies are creating databases and software to enable implementation. Food companies with commitments to reduce the climate impact of their supply chain are realizing that feed is a source of embedded emissions and are looking for ways to measure and mitigate that footprint. The feeds that animals eat have an influence on both feed and animal production, and sustainability is a relevant and important domain for the field of animal nutrition.

References

Dierenfeld, E., S. Wildman, and J. Adamchick. 2023. Solutions to meet the need for feed [White Paper]. WWF-US. https://www.worldwildlife.org/publications/solutions-to-meet-the-need-for-feed.

Pelton, R. E. O., S. A. Spawn-Lee, T.J. Lark, T. Kim, N. Springer, P. Hawthorne, D.K. Ray, and J. Schmitt. 2021. Land use leverage points to reduce GHG emissions in U.S. Agricultural supply chains. Environmental Research Letters 16:115002. https://doi.org/10.1088/1748-9326/ac2775.

Shurson, G. C. 2020. “What a waste”—Can we improve sustainability of food animal production systems by recycling food waste streams into animal feed in an era of health, climate, and economic crises? Sustainability 12:7071. https://doi.org/10.3390/su12177071.

Graduate Student Research Poster Competition

The goal of this summit is to evaluate the use of animals to sustainably provide for healthy human diets. Graduate students working in areas related to livestock sustainability practices were invited to submit an abstract to the NANP 2023 Summit Graduate Student Research Poster Competition.

The top 6 abstracts were selected to present their research during a poster session during the Summit. The posters will be on display during the day, and the poster session with the students will occur during the lunch break.

Thank you to TechMix Global (www.techmixglobal.com) for support of the Graduate Student Research Poster Competition.

Selected Posters

POSTER 1 Developing subspecies-based protein supplementation recommendations for beef cattle consuming low-quality forage

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ABSTRACT: Globally cattle convert low-quality forage to beef and milk; therefore, understanding the differences in protein utilization between *Bos taurus taurus* (Bt) and *Bos taurus indicus* (Bi) is critical to enhancing sustainability as over and under-supplementation of protein are economically and environmentally costly. We determined the effect of ruminal degradability and level of protein supplementation on forage utilization in ruminally cannulated Bt (Angus) and Bi (Brahman) steers fed hay (3.5% CP, 71.0% NDF). Treatments were arranged as a 2 × 2 factorial with steers receiving protein supplements (43% CP) having two levels of protein degradability (35 or 70% RDP) fed at two levels of supplementation, 1.26 or 2.53 g/kg BW. A control treatment providing no supplemental protein was also included (CON). In Bt, there was a tendency for a degradability × level interaction ($P = 0.09$) for total organic matter intake (TOMI). This interaction resulted from a linear ($P < 0.01$) increase in TOMI when steers were supplemented 70% RDP, and a tendency for a quadratic increase with 35% RDP supplementation. Increasing protein supplementation linearly ($P \leq 0.04$) increased forage OMI (FOMI) and total digestible OMI (TDOMI) in Bt steers. In Bi steers increasing supplementation linearly increased ($P < 0.01$) TOMI and TDOMI. In both Bt and Bi steers FOMI was greater ($P \leq 0.05$) when

supplements contained 70% RDP versus 35% RDP. Significantly greater TOMI ($P \leq 0.01$) was observed with 70% RDP supplements versus 35% RDP in Bt; however, this was a tendency ($P \leq 0.06$) in Bi. Organic matter digestion ($P \leq 0.40$) was not significantly affected by RDP content in both subspecies. Our data demonstrate differences between subspecies in their responsiveness to supplemental protein and the need to develop precise models to describe nitrogen utilization in cattle with varying levels of *Bos taurus indicus* genetics.

POSTER 2 Impact of an essential oil blend on enteric methane emissions and productivity of dairy cattle on a commercial farm

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ABSTRACT: Enteric methane (CH_4) constitutes approximately 70% of livestock greenhouse gas emissions and is an ideal target for reduction to achieve net zero emissions in the dairy industry by 2050. The objective of the study was to evaluate the effect of a commercially available essential oil blend (EOB) on CH_4 production (g/day), CH_4 intensity (g/kg milk yield), milk yield (kg), and milk components (% milk yield) in Holstein cows at a commercial farm. Seventy-two multiparous, mid-lactation cows were blocked by days in milk, parity, and milk yield. After a 2-week covariate period, cows within blocks were randomly assigned to one of the following treatments for 10 weeks: control (blank pellets) and EO (pellets with 2.63% EOB). To consider cows as experimental units, the pellets were administered daily via dual-hopper GreenFeeds (C-Lock Inc., Rapid City, SD), which were also used to measure individual CH_4 production. For EO cows, the GreenFeeds were programmed such that the first daily drop provided EO pellets (~1 g/cow/d of EOB), with remaining drops providing blank pellets. Milk yield and samples were obtained twice weekly. Data were analyzed using a linear mixed effects model with an autoregressive correlation structure in R (v4.2.2). The model included the covariate, treatment, week, and interaction between treatment and week. No significant differences were found for CH_4 production or intensity, milk yield, energy-corrected milk, or milk components (although lactose % tended to

be lower for EO; $P = 0.08$). Lack of significant differences may have been due to inherent limitations of administering the correct dose of EOB through the GreenFeeds. Additionally, detection of differences in CH_4 parameters may be limited due to under-sampling (>20/week) for some cows. In conclusion, the EO pellets did not compromise lactation performance, and more controlled treatment administration methods with adequate CH_4 samples per experimental unit could allow for more conclusive results.

POSTER 3 Precision ranching: Application of emerging technology to improve range management and optimize cattle performance

Elias V. Moreno, Hector M. Menendez III, Lily J. McFadden, Ira Parsons, Logan Vandermark, Anna K. Dagel, Krista Ehlert, and Jameson R. Brennan; Department of Animal Science, SDSU West River Research and Extension, South Dakota State University, Rapid City, SD, USA

ABSTRACT: Improving productivity and climate resilience of grazing livestock systems is a difficult aspect of sustainable livestock production. Precision livestock technology (PLT) provides an integral solution but comes with great unknowns regarding environmental and animal impacts. A pilot study (2021-2022) was conducted at the South Dakota State University Cottonwood Field Station as part of a broader project to evaluate the ability of PLT to enhance livestock production efficiency and environmental synergies on native rangelands. This encompasses the stocker and feedlot phases, ending at slaughter to evaluate PLT carry-over effects. Yearling Angus steers (n = 262) were fitted with virtual fencing collars (Vence) and allocated to native grass pastures equipped with individual animal weighing (SmartScale) and enteric emissions (GreenFeed) devices. Steers were assigned to either precision rotational grazing (PG) or continuous grazing (CG) at one of three stocking rates (low, medium, high) to evaluate the impact of PG versus CG on animal behavior, performance, and enteric emissions. During the 3.5-month grazing period, virtual fencing achieved 72% and 67% containment for 2021 and 2022, respectively, with slight differences in walking behavior and performance based on treatment group ($P < 0.05$). Animals visited GreenFeed units on average 2.15 ± 1.03 times daily, resulting in low sample sizes. Animals in medium stocking rate pastures produced more enteric methane emissions than animals in low stocking rates

(medium 187.98 ± 27.93, low 156.94 ± 36.84; $P < 0.01$). Virtual fencing appears to be a viable PLT for achieving rotational grazing. Low utilization indicates that additional training is needed to improve GreenFeed adoption. This pilot study serves as a vital step to solving the problem of sustainable livestock production through enhancing grazing nutrition and modeling on extensive rangelands, without which it is likely that livestock research and enhancing animal productivity and efficiency and environmental synergies will remain difficult.

POSTER 4 Impact of low-level tannin supplementation on enteric methane emissions and animal performance in organic dairy heifers

Ashley K. Schilling*, Sara E. Place, Kim R. Stackhouse-Lawson; CSU AgNext, Department of Animal Sciences, Colorado State University, Fort Collins, CO, USA

ABSTRACT: The objective of this study was to determine the impact of low-level tannin supplementation on enteric methane (CH_4) emissions and animal performance in organic Holstein heifers. Heifers were supplemented with Silvafeed ByPro, a *Schinopsis lorentzii* condensed tannin product, at increasing levels: 0% (control), 0.075% (low), 0.15% (medium), and 0.30% (high) of DMI. Based on a 28 d acclimation, 20 heifers (BW = 219 ± 17 kg) were randomly assigned into one of the four treatment groups and stratified based on initial BW. A 7 d pretrial gas analysis was performed prior to the study to account for individual animal emission differences. Daily, heifers were supplemented with 1 kg of sweet feed and tannin in accordance with the assigned treatment in individual feeding stanchions for 45 d and fed a basal TMR diet through four SmartFeed Pro systems (C-Lock Inc.) which allowed for measurement of individual animal feed intake. Daily, one GreenFeed (C-Lock Inc.) was used to continuously evaluate CH_4 production. Statistical analysis was conducted in R with the fixed effect of treatment. Daily CH_4 production ranged from 136.5 to 140.1 g CH_4/hd/d among treatments and was correlated to DMI ($R^2 = 0.42$). No significant difference was observed among treatments for daily CH_4 production ($P = 0.95$), carbon dioxide (CO_2) production (g/hd/d; $P = 0.95$), CH_4 as a percent of GE intake (Ym; $P = 0.85$), CH_4 yield (g CH_4/kg DMI; $P = 0.85$), or CH_4 emissions intensity (g CH_4/kg of average daily gain; $P = 0.70$). Similarly, a treatment effect was not observed for DMI ($P = 0.92$), average daily gain ($P =$

0.527), or feed efficiency (gain:feed; kg of BW gain/kg of DMI; P = 0.487). The results of this study would not indicate that low-level tannin supplementation alters CH_4 emissions or animal performance in organic Holstein heifers.

POSTER 5 Effects of poly-β-hydroxybutyrate on growth and immune responses of juvenile Nile tilapia *Oreochromis niloticus*, hybrid striped bass *Morone chrysops* × *M. saxatilis*, and red drum *Sciaenops ocellatus* based on in vivo and in vitro approaches

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ABSTRACT: The prevalence of aquatic disease outbreaks associated with intensive aquaculture requires further development of novel disease treatment and prevention strategies without dependence on antibiotics to enhance sustainability of aquaculture. Poly-β-hydroxybutyrate (PHB), a naturally occurring biopolymer synthesized by specific bacteria, is one compound with potential immunostimulatory capabilities and bacterial inhibition characteristics as demonstrated in this study. Multiple in vitro nonspecific immune assays characterizing respiratory burst, bactericidal ability, and phagocytic activity/index of head-kidney-derived leukocytes isolated from Nile tilapia and hybrid striped bass (HSB) were conducted using graded doses of 3-hydroxybutryate, a metabolite of PHB. Additionally, in vitro immunological effects of increasing levels of PHB presented significant positive quadratic responses in Nile tilapia, but significantly decreasing innate immune responses of HSB. Multiple in vivo feeding trials were performed to assess the efficacy of dietary PHB supplementation on growth performance and health of juvenile Nile tilapia, HSB, and red drum. PHB-synthesizing bacteria, *Zobellella denitrificans*, were produced on site and analyzed for PHB concentration, with lyophilized whole cells supplemented incrementally to species-specific basal diets to produce isonitrogenous and isolipidic experimental diets from practical feedstuffs. In three separate feeding trials, juvenile Nile tilapia, HSB,

and red drum of similar initial weight were stocked in 38-L aquaria configured as recirculating systems, and each dietary treatment was randomly assigned to fish in four replicate aquaria. Nile tilapia exhibited significant positive linear and quadratic relationships in terms of weight gain, feed efficiency, and protein conversion efficiency as dietary PHB supplementation increased. In contrast, HSB and red drum exhibited limited growth responses to dietary PHB. These observations suggest an increased metabolic utilization of the bacteria-produced PHB molecule by Nile tilapia that was not apparent in HSB or red drum. Bacteria-derived PHB appears to be an effective dietary supplement to enhance weight gain and immune responses of Nile tilapia.

POSTER 6 Can alfalfa nutrient concentrate serve as a feed ingredient for feeding juvenile yellow perch (*Perca flavescens*)?

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ABSTRACT: The aquaculture of yellow perch, a cool-water fish native to the Great Lakes region, is growing but cost-effective feed for this fish is lacking. This study evaluated the potential of alfalfa nutrient concentrate (ANC) as fishmeal protein replacement in feed for yellow perch and investigated a new income avenue that benefits alfalfa producers. We assessed the potential of ANC based on the pellet functionality, palatability, digestibility, and growth performance of the perch, which were fed with diets including various levels of ANC (0, 5, 10, 15, and 20 g/100 g diet) to replace the fishmeal in a control diet. The feeding trials lasted for 9 weeks with three replications for each diet. The bulk density, durability, water stability, and oil retention capacity of pellets were increased with the fishmeal replacement. The growth rate, feed conversion ratio, satiation feed intake, and protein retention were similar ($P > 0.05$) for fish fed different diets. Fish fed the ANC-20 diet had lower contents of ash, phosphorus, calcium, and manganese than those fed the ANC-0 diet ($P < 0.05$). A lower phosphorus apparent digestibility coefficient was determined in the ANC ingredient when compared with menhaden fishmeal. This partially explained the reason for

the low phosphorus content in fish fed the ANC-20 diet. A second 9-week feeding trial determined the growth performances of yellow perch fed the ANC-20 diet supplemented with phytase. The highest growth rate was achieved in the fish fed with 2,000 FTU phytase/kg diet, demonstrating the benefit of phytase supplementation in an ANC-based diet. This study suggests that ANC can be used as partial protein source in perch feed, but more research is needed to address the concern of decreased nutrient digestibility and utilization. Research on other species and long-term feeding trials are warranted to evaluate the capacity of ANC in aquatic feed.

Honorable Mentions

NANP recognizes the effort, time, and money needed for good science. Reporting good science to aid in building the knowledge base of our scientific community is just as important, and the commitment to put together an abstract is a good beginning in that reporting process.

Because of the submission of multiple excellent abstracts for this Poster Contest, NANP would like to acknowledge all those individual students who took the time and consideration to submit an abstract.

Administering an appeasing substance to optimize performance and health responses in feedlot cattle

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Effects of replacing canola meal with extruded soybean meals on lactational performance and enteric gas emissions in dairy cows

Sergio F. Cueva[1], Leoni F. Martins[1], Nadiia Stepanchenko[1], Derek E. Wasson[1], Daniel M. Kniffen[1], Rick A. Fabin[2], and Alexander N. Hristov[1]; [1]Department of Animal Science, The Pennsylvania State University, University Park, PA, USA, [2]Fabin Bros. Farms Indiana, PA, USA

Individual precision feeding as a tool to reduce the environmental impact of pig production

Berta Llorens[1], Candido Pomar[1], Bernard Goyette[1], Rajagopal Rajinikanth[1], Ines Andretta[2], Maria Àngeles Latorre[3], and Aline Remus[1]; [1]Agriculture and Agri-Food Canada, Sherbrooke R&D Centre, Sherbrooke, Québec, Canada, [2]Universidad Federal do Rio Grande do Sul, Departamento de Zootecnia, Agronomia, Porto Alegre, State of Rio Grande do Sul, Brazil, [3]Facultad de Veterinaria, Universidad de Zaragoza, Departamento de Producción Animal y Ciencia de los Alimentos, Zaragoza, Aragón, Spain

Enhancing net food production by using “leftover” feeds for dairy cows

Morgan N. Mills, Sarah R. Naughton, James Liesman, and Michael J. VandeHaar; Department of Animal Sciences, Michigan State University, East Lansing, MI, USA

Environmental impact data in multi-objective feed formulation for broilers

Breanna P. Modica, Howard B. Schechter; College of Management and Human Potential, Walden University, Minneapolis, MN, USA

Low-temperature rendering of chicken offal protects food and feed safety for animals and upcycles inedible carcass materials

Aime L. S. Mvuyekure[1], Matthew Taylor[1], Rosana Moreira[2]; [1]Department of Animal Science, Texas A&M University, College Station, TX, USA, [2]Department of Biological and Agricultural Engineering, College Station, TX, USA

Evaluation of site and extent of protein digestion of ingredients commonly fed to beef cattle

Jarret A. Proctor[1], Matthew R. Beck[2], Zachery A. Kasuske[2], Ryan C. Foster[1,3], Nathan S. Long[1], Tryon A. Wickersham[1], Vinícius N. Gouvêa[1,3], and Jason K. Smith[1,3]; [1]Department of Animal Science, Kleberg Animal and Food Sciences Center, Texas A&M University, College Station, TX, USA, [2]USDA Agricultural Research Service, Bushland, TX, USA, [3]Texas A&M AgriLife Research and Extension, Amarillo, TX, USA

Production performance, nutrient digestibility, and enteric methane emissions in grazing dairy cows fed an extruded flaxseed-based supplement

M. A. Rahman, K. V. Almeida, D. C. Reyes, A. L. Konopoka, M. A. Arshad, and A. F. Brito; Department of Agriculture, Nutrition, and Food Systems, University of New Hampshire, Durham, NH, USA

Isoacids supplementation in dairy cows diet: A viable option for enteric methane mitigation coupled with improved performances

Md Rahat Ahmad Redoy[1], Sumon Ahmed[1], Marcela Bulnes[1], Jorge Bonilla Urbina[1], Daryl H. Kleinschmit[2], and Md Elias Uddin[1]; [1]Dairy and Food Science Department, South Dakota State University, Brookings, SD, USA, [2]Zinpro Corporation, Eden Prairie, MN, USA

Effect of dietary protein levels and growth promotants in dairy-beef cross steers on nitrogen utilization efficiency

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