NC2040 Regional Group
2022 Meeting Minutes and Annual Report

***Project/Activity Number*:** NC-2040

***Project/Activity Title*:** Metabolic relationships in supply of nutrients for lactating cows

***Period Covered*:** October 1, 2021 to September 30, 2022

Date of this Report: November 21, 2022

Annual Meeting Dates: October 20-21, 2022

***Participants*:**

In person:

1.	Sebastian Arriola Apelo	University of Wisconsin, Madison
2.	Barry Bradford (secretary)	Michigan State University
3.	Katie Bradley	Land O'Lakes
4.	Shane Cronin (student)	University of Delaware
5.	Veridiana Daley	Land O'Lakes
6.	Kevin Dill	Land O'Lakes
7.	Tanya Gressley (chair)	University of Delaware
8.	Tim Hackmann	University of California, Davis
9.	Mark Hanigan	Virginia Tech
10.	Alexis Hruby (student)	Virginia Tech
11.	Paola Piantoni	Cargill
12.	Olivia Schroeder	Land O'Lakes
13.	Zheng Zhou (incoming sec.)	Michigan State University

Virtual:

14.	Luciano Caixeta	University of Minnesota
15.	Jeff Firkins	Ohio State University
16.	Chris Hamilton (administrative)	University of Wisconsin
17.	Kevin Harvatine	Penn State University
18.	Francesca Hopkins	University of California, Riverside
19.	Bruce Richards	Utah State University
20.	Agustin Rius	University of Tennessee
21.	Heidi Rossow	University of California, Davis
22.	Steve Smith (administrative)	USDA NIFA

***Minutes of Annual Meeting*:**

Administrative updates were provided by Steve Smith (handout shared). An update of information related to the project renewal was provided by Christine Hamilton (slides shared). It was noted that continuing members do need to complete an Appendix E form this year to be part of the renewal project submission.

We had a discussion related to the 2023 annual meeting. The meeting will be held in Minnesota and partially sponsored by Cargill (Paola Piantoni). The meeting will likely take place September 24-26, 2023 (alternative of September 17-19 if any major conflicts with the first dates arise, such as Discover Conference). In addition to a Cargill site tour, it was suggested that we might visit the University of Minnesota and/or a local dairy herd. The suggestion was made that these be scheduled as optional and at the end of the meeting.

We had a discussion on databases for uniform sharing of data from across sites. It was suggested that we put a group together to write a grant for a database manager, and it was suggested that we pull Steve Smith and members of NC2042 into the discussion. The concern was brought up that funding a database manager on grant money would pose a consistent challenge and may make continuity difficulty. It was suggested that perhaps this could be a joint effort with one of our journals.

We had a synthesis discussion at the end of the meeting. It was brought up that many people spent the majority of their time for their station reports presenting data, and this minimized the time available for discussion of future collaborative efforts. It was recommended that we make more clear suggestions in the future (for example: no introduction, very brief methods, at least 50% of the time for discussion, etc.). It was also suggested that we make it clear that instead of the traditional station report people could use their time to discuss a particular topic of relevance to the group or forgo their allotted time. Another person suggested that we should ask everybody to indicate the topic of their presentation (either challenge, new data, or discussion topic). They would have to respond with what they will present to get a time slot. It was also suggested that we have some dedicated time at the meeting for us to break into subgroups for each objective to brainstorm about future collaborative efforts.

Agenda items for 2023 meeting:

- Allot time to continue database discussion
- Barry will send out call for agenda items
- Allot time for breakouts by objective to brainstorm future collaborations

Station reports were presented for:
Veridiana Daley (Purina); Mark Hanigan (Virginia Tech); Kevin Harvatine (Penn State); Jeff Firkins (Ohio State); Barry Bradford (Michigan State); Francesca Hopkins (UC Riverside); Sebastian Arriola Apelo (University of Wisconsin, Madison); Tim Hackmann (UC Davis); Paola Piantoni (Cargill); Luciano Caixeta (University of Minnesota); Tanya Gressley (University of Delaware); Heidi Rossow (UC Davis); Zheng Zhou (Michigan State); Augustin Rius (University of Tennessee)

***Annual Report*:**

<u>Accomplishments</u>

OBJECTIVE 1: To quantify supply, availability, and interaction of nutrients and bioactive compounds utilized for efficient milk production while reducing environmental impact.

Joint work between CA and PA has been aimed at predicting nitrogen excretion across diets and mitigating methane emissions to meet climate targets. Models based on DM or N intake can be used to predict fecal and total manure N excretion with good accuracy, and urinary N excretion with satisfactory accuracy. Prediction accuracy may be somewhat further improved by adding diet composition or milk parameters to intake parameters in complex models. In absence of intake data, models using diet composition and milk performance parameters could be used to predict fecal, urinary, and total manure N excretion, but with greater prediction error and occurrence of MB or SB, or both. Intercepts and slopes of variables in optimal prediction equations developed on intercontinental, European, and North American bases differed from each other, and region-specific models are preferred to predict N excretion. Agricultural methane emissions must be decreased by 11 to 30% of the 2010 level by 2030 and by 24 to 47% by 2050 to meet the 1.5 °C target. We identified three strategies to decrease product based methane emissions while increasing animal productivity and five strategies to decrease absolute methane emissions without reducing animal productivity. Globally, 100% adoption of the most effective product-based and absolute methane emission mitigation strategy can meet the 1.5 °C target by 2030 but not 2050, because mitigation effects are offset by projected increases in methane.

Collaborative work between DE and Purina has aimed to elucidate the potential for feed buffers to alleviate hindgut acidosis brought on by high starch diets. Results have demonstrated that buffers can alter the fecal microbiome and fecal LPS, indicating their potential to modify intestinal fermentation and potentially gut health.

IA and CA compiled a research grant proposal (USDA-NRCS-Partnership for climate-smart commodities) that focuses on enhancing feed efficiency and mitigating enteric methane emissions from dairy cows with Camelina meal.

Collaborative work between OH and PA is ongoing to understand the contribution of rumen microbial AA to milk protein synthesis.

Collaborative work between OH and VT is ongoing to understand the effects of VFA on microbial protein synthesis and fiber digestibility.

OBJECTIVE 2: To identify and quantify molecular, cellular, and organismal signals that regulate intake, partitioning and efficient utilization of nutrients

To identify the unique differences in metabolic efficiency and metabolite profiles among animals, a joint project at MI, WI, IA, and FL collected blood concurrently from the mammary vein and the tail vessel to determine mammary nutrient uptake. We found that Low RFI (feed efficient) cows had enhanced mammary gland proteogenic amino acid (AA; i.e. threonine) extraction and higher mammary gland AA utilization efficiency. Specifically, low RFI cows tended to have a lower ratio of AA uptake to milk output for essential, branched-chain, and total AA. The increase in mammary AA extraction efficiency likely contributes to the improved efficiency of milk protein synthesis in low RFI cows. We also examined the association between feed efficiency and liver function and amino acid (AA) metabolism biomarkers. Using an untargeted metabolomics approach, we quantified 922 metabolite concentrations in the blood from a set of feed efficient (Low RFI) and inefficient (High RFI) dairy cows. From the metabolites identified, concentrations for a biomarker of liver function (bilirubin) and markers of AA metabolism (arginine and creatinine) were distinct between feed efficient and inefficient cows. In conclusion, cows with divergent phenotypes for FE had distinct organ and whole-body metabolism. These metabolic discrepancies between feed efficient and inefficient cattle are impacted by the workload placed on visceral organs and signified by changes in metabolic biomarkers. Therefore, these biomarkers, either alone or combined, could potentially be used as indicators of feed efficiency to differentiate efficient and inefficient lactating dairy cows.

OBJECTIVE 3: To use this knowledge of feed properties and metabolic and molecular quantitative relationships to challenge and refine nutrient requirement models leading to more accurate feeding systems for dairy cattle

Members from VA, OH, WI, MI, and CA concluded 7 years of collaborative work to update text and models for a new version the Nutrient Requirements of Dairy Cattle (NASEM, 2021). In fact, 8 of the 12 members of the NASEM-appointed committee that produced the revised edition are current or former members of NC2040. The 482-page book updates recommendations across the spectrum of nutrients required by dairy cattle but offered substantial revisions in several key areas. Committee members played crucial roles in deriving the first diet-responsive dry matter intake prediction model employed in this resource; creating an entirely new model framework for predicting amino acid requirements of dairy cattle; refining predicted impacts of feed intake level on diet digestibility; and substantially improving the size and accuracy of the feed composition database that accompanies the requirements text.

Impacts

OBJECTIVE 1: To quantify supply, availability, and interaction of nutrients and bioactive compounds utilized for efficient milk production while reducing environmental impact.

Joint work between PA and CA has resulted in development of complex, region-specific models to predict total manure N excretion. These models should be used when inputs are available, whereas simple location-specific models based on DM or N intake should be used for fecal and urine N excretion prediction. On a regional level, Europe but not Africa may be able to meet their contribution to the 1.5 °C target by implementing methane mitigation opportunities. We highlighted the different challenges faced by high, middle- and low-income countries.

Collaborative work between VA and OH has demonstrated that interconversions among VFA were not affected by pH, acetate, or propionate treatments, suggesting that thermodynamics might not be a primary influencer of metabolic pathways used for VFA formation (Li et al., 2022).

OBJECTIVE 2: To identify and quantify molecular, cellular, and organismal signals that regulate intake, partitioning and efficient utilization of nutrients

In the past year, a collaboration among MI, WI, IA, and FL has continued on a project to increase feed efficiency. The primary, overall goal of this project is to improve genomic selection for feed efficiency, towards which we are making notable progress (Khanal et al., 2022). MI and WI have also started elucidating tissue-level sources of individual animal variation in feed efficiency through nutrient use. Results from these collaborative efforts will allow us to reduce the negative impacts of metabolic disease during early lactation and identify metabolic markers and pathways that are different between cows of high vs low residual feed intake, thereby providing tools for farmers to select cows towards higher feed efficiency. Additionally, as a part of these efforts, we are using sensors and infrared milk spectrum analysis to predict feed intake, and determine the relationship between feed efficiency and metabolic health, feed bunk competition, feeding behavior and parity.

OBJECTIVE 3: To use this knowledge of feed properties and metabolic and molecular quantitative relationships to challenge and refine nutrient requirement models leading to more accurate feeding systems for dairy cattle

The Nutrient Requirements of Dairy Cattle is the consensus standard for understanding dairy cattle nutrition in the U.S. as well as much of the world. As such, the newly revised book (NASEM, 2021), which was produced largely through the efforts of NC2040 committee members, will have a tremendous impact on practical feeding of dairy cattle over the coming decade or more. Furthermore, the novel modeling approaches used in this revision will spur much research to test the models, particularly the new protein model that predicts impacts of amino acids that have not been emphasized in the past. In addition to the tremendous contributions by numerous NC2040 committee members who served on the Nutrient Requirements committee, most other NC2040 committee members provided data that was used in the meta-regression and model parameterization work required to develop and validate the new models. This product therefore epitomizes the purpose and value of this multi-state research project.

Publications (peer-reviewed articles only)

Arndt, C., A. N. Hristov, W. J. Price, S. C. McClelland, A. M. Pelaez, S. F. Cueva, J. Oh, J. Dijkstra, A. Bannink, A. R. Bayat, L. A. Crompton, M. A. Eugene, D. Enahoro, E. Kebreab, M. Kreuzer, M. McGeek, C. Martin, C. J. Newbold, C. K. Reynolds, A. Schwarmm, K. J. Shingfield, J. B. Venemann, D. R. Yanez-Ruiz, and Z. Yu. 2022. Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5°C target by 2030 but not 2050. PNAS 119:20 e2111294119. DOI: https://doi.org/10.1073/pnas.2111294119. (CA, PA)

Bougouin, A, A. Hristov, J. Dijkstra, M. J. Aguerre, S. Ahvenjärvi, C. Arndt, A. Bannink, A. R. Bayat, C. Benchaar, T. Boland, W. E. Brown, L. A. Crompton, F. Dehareng, I. Dufrasne, M. Eugène, E. Froidmont, S. van Gastelen, P. C. Garnsworthy, A. Halmemies-Beauchet-Filleau, S. Herremans, P. Huhtanen, M. Johansen, A. Kidane, M. Kreuzer, B. Kuhla, F. Lessire, P. Lund, E. M. K. Minnée, C. Muñoz, M. Niu, P. Nozière, D. Pacheco, E. Prestløkken, C. K. Reynolds, A. Schwarm, J. W. Spek, M. Terranova, A. Vanhatalo, M. A. Wattiaux, M. R. Weisbjerg, D. R. Yáñez-Ruiz, Z. Yu, and E. Kebreab. 2022. Prediction of nitrogen excretion from data on dairy cows fed a wide range of diets compiled in an intercontinental database: A meta-analysis. J. Dairy Sci. 105:7462–7481. https://doi.org/10.3168/jds.2021-20885 (CA, PA).

Congio, G. F.S., A. Bannink, O. L. Mayorga, J. P.P. Rodrigues, A. Bougouin, E. Kebreab, R. R. Silva, R. M. Maurício, S. C. da Silva, P. P.A. Oliveira, C. Muñoz, L. G.R. Pereira, C. Gómez, C. Ariza-Nieto, H. M.N. Ribeiro-Filho, O. A.Castelán-Ortega, J. R. Rosero-Noguera, M. Pazop, P. H.M. Rodrigues, M. I. Marcondes, L. Astigarraga, S. Abarca, and A. N. Hristov. 2022. Prediction of enteric methane production and yield in dairy cattle using a Latin America and Caribbean database. Science of the Total Environment 153982. (CA, PA)

Li, M. M., S. Ghimire, B. A. Wenner, R. A. Kohn, J. L. Firkins, B. Gill, and M. D. Hanigan. 2022. Effects of acetate, propionate, and pH on volatile fatty acid thermodynamics in continuous cultures of ruminal contents. J. Dairy Sci. 105:8879-8897. doi: 10.3168/jds.2022-22084. (VA, OH)

Khanal, P., K. L. Parker Gaddis, M. J. Vandehaar, K. A. Weigel, H. M. White, F. Penagaricano, J. E. Koltes, J. E. P. Santos, R. L. Baldwin, J. F. Burchard, J. W. Durr, and R. J. Tempelman. 2022. Multiple-trait random regression modeling of feed efficiency in US Holsteins. J Dairy Sci 105(7):5954-5971. (MI, WI)

Martin, M.J., Pralle, R.S., Bernstein, I.R., VandeHaar, M.J., Weigel, K.A., Zhou, Z., and White, H.M. 2021. Metabolomic biomarkers indicate differences in high and low residual feed intake Holstein dairy cows. Metabolites. 2021 Dec 14;11(12):868. (MI, WI)

NASEM. 2021. Nutrient Requirements of Dairy Cattle, Eighth Revised Edition. The National Academies Press, Washington, D.C. (VA, OH, WI, MI, CA)