**NC2042 Annual Meeting Minutes**

**Dates: 10/13 – 10/15/2022**

UC Davis Veterinary Medicine Teaching and Research Center
Address: VMTRC, 18830 Rd. 112, Tulare, CA 93274-9537

**Contacts:**
Host: Noelia Silva Del Rio, nsilvadelrio@ucdavis.edu cell: (559)708-8556
Chair: Jackie Boerman, jboerma@purdue.edu, cell: (585) 610-7591
Secretary: Joao Costa, costa@uky.edu, cell: (859) 270-3132

**Meeting Program:**

**Wednesday, October 12**

Arrival and dinner on own

**Thursday, October 13**

| | |
|---|---|
| **Breakfast** | At the hotel or on your own |
| **8:30 a.m.** | Welcome and Introductions – Large Seminar Room Tulare<br>Introductions of VMTRC Faculty |

Veterinary Medicine Teaching & Research Center - Visitor Information (ucdavis.edu)
The picture in this link shows the main entrance. Parking is free. If you want to park under the shade, drive to the back. As soon as you cross the main entry door, you will find the large meeting room (left) and front desk staff (right).

| | |
|---|---|
| **9 – 10 a.m.** | Business Meeting (approve minutes; advisor comments; University research/extension discussion; project re-write, future secretary, and meeting location) – |

**Join from PC, Mac, Linux, or mobile device: https://uky.zoom.us/j/81593005345**

| | |
|---|---|
| **10 a.m. - noon** | Re-write – group discussion |
| **12 – 1:30 p.m.** | Lunch and Tour of Dairy Experts Inc.<br>17721 Rd 112, Tulare, CA 93274 |
| **1:30 – 3:15 p.m.** | Re-write - break into groups (with co-leads for each objective) |

**3:15-3:30 p.m. break**

| | |
|---|---|
| **3:30 – 5:30** | Station Reports (6 slides 15-minute highlights) |

| | |
|---|---|
| **7:00 p.m.** | Group Dinner - Sequoias Brewing Company<br>Visalia Menu - Sequoia Brewing Company<br>124 W. Main St. Visalia, CA 93291 |

**Friday, October 14**

| | |
|---|---|
| **Breakfast** | At hotel or on your own |
| **8:30 – 12:30 p.m.** | Station Reports (6 slides 15-minute highlights) |
| **12:30 – 1:30 p.m.** | Lunch brought in |
| **2:00 – 4:30 p.m.** | Tour of dairy farm |
| **6:00 pm** | Group Dinner **-** Tommy's Restaurant<br>http://www.tommysdowntown.com/dinner-menu<br>130 N Encina St, Visalia, CA 93291 |

**Saturday, October 15**

| | |
|---|---|
| **Breakfast** | At hotel or on your own |
| **8 a.m. – 11 a.m.** | **Walnut and pistachio harvest and processing** |

Attendees:

Joao Costa (UKY)
Jackie Boerman (Purdue)
Noelia Silva Del Rio (UC - ANR)
Marcia Endres (UMN)
Mike Schutz (UMN)
Brad Heins (UMN)
Mirele Chahine (U of Idaho)
Albert DeVries (UF)
Ken Kalscheur (ARS -WI)
Kate Creutzinger (UW-RF)
Gonzalo Ferreira (VT)
Matias Jose Aguerre (Clemson)

Zoom:
Peter Erickson (UNH)

Guests:
Dr Terry W Lehenbauer (UC Davis – VMTRC)
Dr Sharif Aly (UC Davis – VMTRC)
Dr Heidi Rossow (UC Davis – VMTRC)

**NC-2042 –Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises**

**Minutes from 2022 Business Meeting**
**October 13th, 2022**

Introduction from Dr Terry W Lehenbauer (UC Davis – VMTRC), welcome and presentation of the VMTRC duties. After, Dr Sharif Aly and Dr Heidi Rossow presented their research laboratory and research group.

Meeting called to order by Dr Boerman (chair) at 9.10 AM

**Review of minutes from previous meeting**
- Dr Brad Heins moved to approve the minutes. Dr Marcia Endres seconded. Motion passed. Minutes were approved.

**Introductions and Meeting schedule**
Dr. Boerman asked the group for each member to introduce themselves and went over the schedule for the meeting.

**Mike Schutz – NCRA administrative advisor**
- Overview of the role of the administrative advisor.
- Focus of annual report is on multi-state activities and objectives to collaborate between stations.
- Re-write of objectives needs to be submitted by October 15th, 2022. Rewrite needs to be in by December 1st, 2022.
- Update the list serve to ensure that all members are present and new faculty members are invited. Everyone will need to be re-assigned to the group after the re-start.
- Reports should include (highlight) the collaboration and the true multistate objectives of the project should be presented in the NC report.

**Next year Business Meeting**

- Dr Boerman volunteered to host in 2023 at Purdue University.
- Dr Ward volunteered to host in 2023 at North Carolina State by email, a motion was passed to Raleigh, NC to be the location for the 2023 NC2042 meeting.

- Dates: Oct 12-14, 2023 will be the suggested date. Thursday Morning until Saturday noon.
- Annual meeting 2024 – As 2023 is going to be the 1st year of the new project the plan to go to Atlantic Veterinary College on Prince Edward Island is delayed to 2024. We need to have deliverable outputs in order to hold outside of the US.

**New Secretary Discussion:**

**Elected position**

It was moved and seconded to nominate Dr Albert DeVries as the next secretary. All agreed with the motion. Motion passed.

**Other business**
Discussion about new members to be invited to the new project.
A list was made of potential experts to be invited to join the group.

**Re-write and objectives discussion**

First the group reviewed the comments received after last submission. Dr Gonzalo Ferreira lead the discussion. The summary of this discussion was:

- CRIS search should be performed and as a group we should make sure that we have no overlap with any other Multistate group.
- Google Scholar Search and highlight publications with collaborating stations in the re-write
- Collaboration and justification for leveraging funds in the next period.

The objectives of the new project were set after a discussion with the full group.

**End of the meeting**

It was moved and seconded to adjourn. Motion passed. Meeting adjourned at 12:50 pm.

**Reports: Contributing Agricultural Experiment Stations and Alphabetical Order of Reports**

## Virginia Tech:

# Annual Progress Report
# Multistate Research Project NC-2042
# 2020-2021

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

- Gonzalo Ferreira (principal investigator)
- Ahmerah Thompson (graduate student)
- Milton Schultz (graduate student)
- Adrianna Hughes (undergraduate student)
- Luke Wallace (undergraduate student)
- Sabrina Debree (undergraduate student)
- Chrissy Putman (undergraduate student)
- Anna Cappelina (undergraduate student)
- Mackenzie Kovack (undergraduate student)
- Madison Sifford (undergraduate student)
- Joseph Real (undergraduate student)

## III. Collaborators

- Matias Aguerre (Clemson University)
- Mireille Chahine (University of Idaho)
- Laban Rutto (Virginia State University)
- Hernan Tejeda (University of Idaho)

## IV. Progress and Principal Accomplishments within one or more objectives

- Objective 2
  - A peer-reviewed manuscript about our greenhouse study evaluatating the effects of drought stress on fiber (NDF) digestibility was submitted for publication to *JDS Communications*.
  - A peer-reviewed manuscript is in preparation for the evaluation of fiber (NDF) digestion kinetics and characterization of undigestible NDF of winter grasses, summer grasses, and alfalfa..
  - A peer-reviewed manuscript was published in *Animals* about fiber (NDF) digestion kinetics of summer annual crops.
  - A peer-reviewed manuscript about evaluating the use of alfalfa in diets for dry cows in the prepartum was submitted for publication to *Journal of Dairy Science*.
  - We finished the harvesting time of small grains to characterize ruminal NDF digestion kinetics. Laboratory work in progress.
- Objective 3.
  - In collaboration with University of Idaho, we delivered educational workshops to farmers. In these workshops, we showed how to analyze the investment of automatic milking systems.
  - A peer-reviewed manuscript about the detection of abortions using pedometers (AfiAct) has been accepted for publication in *JDS Communications.*

## V. Impact of research to the group's objectives

- Drought stress has minimal effects of fiber digestibility (Objective 2)
  - *Issue*. Limited and confusing information exists about the impact of drought stress on corn silage digestibility. In the US, there is a belief that water stress increases the digestibility of the fiber. However, controlled studies comparing the nutritional quality of drought-stressed and non-drought-stressed corn are limited.
  - *Action*. We performed a greenhouse study in which we subjected corn plants to a water abundant or water restricted irrigation regime. After collecting stem and leaf tissues, we analyzed the digestibility of the fiber and determined ruminal digestion kinetics of the fiber.
  - *Outputs and Results*. The conclusions of this study are that drought-stressed corn had a marginal increase in fiber digestibility of leaves but not in stems, that drought stress had no effects on the effective ruminal degradation of fiber, and that the effect of drought stress on fiber digestibility of corn for silage is still inconclusive.
  - *Impact*. From this study, we learned that drought stress does not affect fiber digestibility as much as previously believed. We also learned that drought stress

affects forage yield much more than forage quality. This information will help dairy farmers make better decisions at the moment of harvesting corn for silage.

- Fiber digestibility of summer annual grasses (Objective 2)
    - *Issue*. Some summer annual grasses, such as corn, sorghum, and pearl millet, can contain the brown midrib (BMR) mutation in their genome. Compared to conventional plants, plants containing the BMR mutation can have greater fiber digestibility. However, our research team hypothesized that this is true only between plants of the same species but among plants of different species.
    - *Action*. We performed a field study in which we grew corn, sorghum, and pearl millet containing or not the BMR genotype. After collecting whole plants and stem and leaf tissues, we analyzed the digestibility of the fiber and determined ruminal digestion kinetics of the fiber.
    - *Outputs and Results*. From this study, we concluded that BMR genotypes typically have greater fiber digestibility within a same plant species. However, when comparing different species, BMR genotypes do not always have greater fiber digestibility. For example, a conventional corn will likely have similar fiber digestibility than a BMR sorghum or a BMR pearl millet.
    - *Impact*. From this study, we learned that forages containing the BMR mutation do not always have the greatest fiber digestibility. This information helps dairy farmers make better decisions at the moment of programing the forage management and nutritional plans.
- Educational workshops: Financial analysis of robotic milking systems (Objective 3)
    - *Issue*. The use of robotic milking systems is increasing at fast rates in the dairy industry. Despite this trend, there is still a lot to learn and to improve about their management. Even more, there are several cases in which the use of these systems failed.
    - *Action*. We developed an educational workshop to provide farmers a better understanding of the financial implications of migrating to robotic milking systems.
    - *Outputs and Results*. We delivered the program to 105 attendees, most of which were farmers. The curriculum included the main assumptions needed to analyze the investment for robotic milking systems. The curriculum also included the analysis of 3 different scenarios and substantial discussion among participants.
    - *Impact*. This workshop helped several farmers deciding whether or not purchasing robotic milking systems is a good opportunity from a financial perspective. Several farmers decided they were not yet ready for such a big investment.

## VI. Work planned for next year

- Objective 2
    - We will continue evaluating the effects of harvesting time of small-grain crops on ration formulation, cow performance, and income over feed costs.
- Objective 3.

- In collaboration with University of Idaho, we will deliver educational workshops to farmers in Virginia about hedging milk prices.

## VII. Publications/products

- **Ferreira, G.**, C.L. Teets, A.M. Kingori, and J.O. Ondiek. 202#. Effect of drought stress on neutral detergent fiber degradation kinetics of corn for silage. ***J. Dairy Sci. Com.*** (Under Review).
- Galyon, H., S. Vibostok, J. Duncan, **G. Ferreira**, A. Whittington, and R. Cockrum. 202#. Long-term in situ ruminal degradation of biodegradable polymers in Holstein dairy cattle. ***J. Dairy Sci. Com.*** (Accepted).
- Chen, C.P, and **G. Ferreira**. 202#. Short Communication: Evaluation of walking activity data during pregnancy as an indicator of pregnancy loss in dairy cattle. ***J. Dairy Sci. Com.*** (Accepted).
- **Ferreira, G.**, and N. Thiex. 202#. Symposium review: Fiber and in vitro methods, analytical variation, and contributions to feed analysis. ***J. Dairy Sci.*** (In Press).
- **Ferreira, G.**, H. Galyon, A.I. Silva-Reis, A.A. Pereyra, E.S. Richardson, C.L. Teets, P. Blevins, R.R. Cockrum, and M.J. Aguerre. 2022. Ruminal fiber degradation kinetics within and among warm-season annual grasses as affected by the brown midrib mutation. ***Animals*** 12:2536.
- Galyon, H., S. Vibostok, J. Duncan, **G. Ferreira**, A. Whittington, K. Havens, J. McDevitt, and R. Cockrum. 2022. Digestibility kinetics of polyhydroxyalkanoate and poly(butylene succinate-co-adipate) after in vitro fermentation in rumen fluid. ***Polymers*** 14:2103. https://doi.org/10.3390/polym14102103.
- Richardson, E.S., **G. Ferreira**, K.M. Daniels, H.H. Schramm, and R.J. Meakin. 2021. Effect of feeding polyhalite as an acidogenic product to induce a metabolic acidosis in pregnant and non-lactating dairy cows. ***Anim. Feed Sci. Techn.*** 282:115119. https://doi.org/10.1016/j.anifeedsci.2021.115119.

# Clemson University
# Annual Progress Report
# Multistate Research Project NC-2042
# 2020-2021

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

PI: Matias J. Aguerre, Animal and Veterinary Sciences-Clemson University
Personnel: Omar Manuel Peña Peña (graduate Student); Chandler Compton (graduate Student); Cesar Velasquez Rios (graduate student)

## III. Collaborators

***Clemson University***
Dr. Thomas Jenkins, Dr. Bulent Koch, Dr. Ahmed Ali, and Dr. D. Jachowski

***Virginia Tech***
Dr. Gonzalo Ferreira

***USDA-Dairy Forage Research Center***
Dr. Elizabeth French

**Zinpro Corporation**
Dr. Adam J. Geiger

## IV. Progress and Principal Accomplishments within one or more objectives

- *Monitoring Pasture Quality and Quantity Using Field Robotics.* During the fall of 2021 and spring/summer of 2022, we conducted aerial surveys (RGB and NDVI images) using an unmanned aerial vehicle and compressed biomass height estimations using the measurement mechanisms mounted on an unmanned ground vehicle on research plots with different forage species (alfalfa, ryegrass, bermudagrass, and tall fescue). Wet and dry biomass prediction models were developed utilizing the change in crop height determined from crop surface models using Structure from Motion, normalized difference vegetation index, and growing degree days . Forage biomass estimation models were developed based on the compressed height measurements collected with the compressed biomass height estimation mechanism mounted on the unmanned ground vehicle.

- *A comparison of ionophore sources in continuous cultures of ruminal microorganisms.* We conducted a study to determine the effect of different ionophores sources (Rumensin and Monovet) at two different doses ( 300 and 500 mg per cow per day) on volatile fatty acid production and nutrient utilization in a continuous culture system.

- *Efficacy of using a concentrated, whey-based colostrum to achieve passive transfer of immunity in neonatal Jersey calves.* The objective of this study was to evaluate the ability of a concentrated, whey-based CR to achieve PTI in newborn Jersey calves compared with a dried maternal colostrum CR.

- *Effect of feeding forages with contrasting fiber digestibility on lactation performance and nutrient digestibility of Jersey and Holstein cows.* Between December of 2021 and April of 2022, we conducted a study to evaluate the effect of feeding forages with reduced lignin content (BMR Pearl millet and reduced lignin alfalfa) on milk production and composition and nutrient digestibility.

## V. Impact of research to the group's objectives

- *Monitoring Pasture Quality and Quantity Using Field Robotics.* Results from study the indicated a good correlation between crop surface models (aerial images) reconstructed with a structure for motion algorithm and forage biomass collected by clipping. We are currently analyzing the information collected with the ground rover.

- *A comparison of ionophore sources in continuous cultures of ruminal microorganisms*. Rumensin produced more total volatile fatty acids and had a greater concentration of propionate compared to Monovet. Regardless of monensin dose level, adding Rumensin or Monovet to the diet had no effect on culture pH or nutrient digestibility. In this study, Rumensin was more effective than Monovet in shifting VFA patterns toward propionate production.

- *Efficacy of using a concentrated, whey-based colostrum to achieve passive transfer of immunity in neonatal Jersey calves.* Calves fed concentrated whey-based colostrum achieved 43.7% greater serum IgG levels at 24 hours of life and experienced a 32.0% improvement in apparent efficiency of absorption of IgG compared with dried maternal colostrum. Data from this study suggest that a whey-based colostrum can be used to successfully achieve passive transfer of immunity in newborn Jersey calves and that it may be more effective than traditional colostrum replacement formulas.

- *Effect of feeding forages with contrasting fiber digestibility on lactation performance and nutrient digestibility of Jersey and Holstein cows.* We are currently analyzing the data collected in this study.

## VI. Work planned for next year

- We are starting the third year of our USDA grant looking at remote sensing technology (ground and aerial) to estimate pasture biomass and quality.

- We are currently conducting a study to measure the impact of milk permission changes on stress indicators and milk production in automatic milking systems.

- We are currently conducting a study to evaluate the effects of trace mineral source supplementation (Zn and Cu) on nutrient digestibility and rumen fermentation of lactating dairy cows.

## VII. Publications/products

***Refereed journal***

Ferreira, G., H. Galyon, A. I. Silva-Reis, A. A. Pereyra, E. S. Richardson, C. L. Teets, P. Blevins, R. Cockrum, and M. J. Aguerre. 2022. Ruminal fiber digestion kinetics within and among summer annual species as affected by the brown midrib (BMR) genotype. Animals 12(19) 2536; https://doi.org/10.3390/ani12192536.

Titus, K., T. Scott, M. J. Aguerre, G. J. Lascano, and D. Jachowski. 2022. Using multidisciplinary, conflict-based experiential learning to train students on how to address controversy at the public-private land interface: Teaching at the public-private land interface. NACTA Volume 66.

Bougouin, A., A. Hristov, M. J. Aguerre, et al. 2022. Prediction of nitrogen excretion from data on dairy cows fed a wide range of diets compiled in an intercontinental database: a meta-analysis. Journal of Dairy Science 105:7462-748.

***Other peer review scholarly publications***

Silva, L., Marshall M., Greene J., Aguerre M. Alfalfa establishment and management. Clemson (SC): Clemson Cooperative Extension, Land-Grant Press by Clemson Extension; 2022 August. 1152. http://lgpress.clemson.edu/alfalfa-establishment-and-management.

***Peer reviewed proceedings and abstracts***

Compton, C., O. M. Peña, C. Velasquez, G. J. Lascano, G. D. Mechor, T. C. Jenkins, M. J. Aguerre. 2022. A comparison of ionophore sources showed differences in volatile fatty acid changes but equal effects on digestibility in continuous cultures of ruminal microorganisms. J. Dairy Sci. Vol. 105, Suppl. 1:71.

Plata, G., D. Susanti, G. D. Mechor, C. Compton, O. M. Peña, C. Velasquez, G. J. Lascano, T. C. Jenkins, M. J. Aguerre. 2022. Differences in composition and dynamics of rumen microbial

cultures fed two different monensin sources. J. Dairy Sci. Vol. 105, Suppl. 1:155.

Colburn, C. S., O. M. Peña, C. Velasquez, R. Miller, M.J. Aguerre, and A.J. Geiger. 2022. Investigating the efficacy of using a concentrated, whey-based colostrum to achieve passive transfer of immunity in neonatal Jersey calves. J. Dairy Sci. Vol. 105, Suppl. 1:269.

Koc, B., B. MacInnis, , M. J. Aguerre, J. P. Chastain, and A. P. Turner. 2022. Biomass Estimation of Alfalfa using UAV-based Crop Surface Models. American Society of Agricultural and Biological Engineers, Huston, TX, United States. (July 18, 2022).

Titus, K. L., Jachowski D. S., Aguerre M. J., Hagan D. L., Lascano G. J., and Scott T. 2022. Using multidisciplinary, conflict-based experiential learning to train students on how to address controversy at the public-private land interface. Oral Presentation at the Biennial Conference on University Education in Natural Resources.

# University of California Davis
# Annual Progress Report Multistate Research Project NC-2042
# 2021-2022

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

**Objectives (as listed on the Project's webpage)**

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3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

Ed DePeters, Department of Animal Science, University of California, Davis CA 95616

## III. Collaborators

Katherine Swanson and Daniel Putnam, Department of Plant Sciences, University of California, Davis CA 95616

Frank Mitloehner, Department of Animal Science, University of California, Davis CA 95616

## IV. Progress and Principal Accomplishments within one or more objectives

**Aim:** Determine the Missing 20% in the chemical composition of almond hulls.

**Background:** Almond hulls (AH) are a common feedstuff in the diet of lactating dairy cows in California. Almond hulls are a unique feedstuff because AH are being used as both a concentrate ingredient and a forage ingredient in the diets of dairy cattle. The rail transportation issues into California have greatly increased the price of corn grain that is eventually steam-flaked and fed to dairy cattle. Almond hulls are replacing a portion of the concentrate ingredients in diets because AH are high in sugars. The water restrictions in the Central Valley impacted corn silage production. Almond hulls are being used as a forage ingredients to replace silage because AH are high in fiber. In the past decade feeding amounts of AH have increased from 3.5 to over 5.0 pounds AH daily (survey 2019). Research supported by the ABC, Biomass Workgroup, part of NC-2042, found that AH could be fed up to 12 pounds per cow daily. These findings were reported previously in NC-2042 reports as well as published in the Journal of Dairy Science.
Rations fed to dairy cows are formulated with computer software that is based on the chemical

composition of each feed ingredient to predict the nutrients and energy available to support milk yield – often called Precision Feeding. The amount of a feedstuff used in a ration is restricted when there is a "missing" information on chemical composition. All feeds have "missing" information on chemical composition. However, the "missing" information for AH is large. The nonfiber carbohydrate composition of AH is 65% while the nonstructural carbohydrate composition is 35%. These two estimates will not be identical, but they should be somewhat similar and they are not. That large amount of "missing" chemical composition for AH restricts their use in the diet of lactating dairy cows. The "missing" chemical composition contributes to ration variability as well as variability in animal performance. **Approach:** Twenty-one samples of AH were analyzed. Varieties included Nonpareil (6), Independence (2), and 13 categorized as Other. Samples were hand-sorted to remove debris (stick and shell) creating two samples. **Whole** contained AH + debris. **Pure** contained only AH. The Whole sample reflects commercial AH fed to dairy cattle in California.

***Lignin:*** Lignin is a polyphenolic compound. Lignin is indigestible and provides no energy to the animal. Lignin interacts with fiber (cellulose and hemicellulose) to reduce digestibility. As the lignin content of AH increases, fiber digestibility decreases. Nutritionists measure lignin as acid-detergent lignin (ADL). However, biofuels scientists measure lignin as Klason lignin (KL) because ADL does not measure all of the lignin in plant material. Difference between KL and ADL is referred to as soluble lignin. *Question*: does soluble lignin account for a portion of the "missing" 20%?

Table 1. Soluble lignin accounted for approximately 9% units of the Missing 20% for AH.

| Item | Nonpareil Whole | Nonpareil Pure | Other Whole | Other Pure |
|---|---|---|---|---|
| KL, % | 14.6 | 14.3 | 16.8 | 14.9 |
| ADL, % | 5.4 | 4.9 | 8.0 | 6.1 |
| Soluble L, % | 9.2 | 9.4 | 8.8 | 8.8 |

***Pectin:*** Pectin is a part of the fiber fraction (cellulose, hemicellulose, lignin). Pectin is not measured in feedstuffs by commercial laboratories. In the literature, the pectin content of AH is highly variable (4 to 26%). Pectin is water soluble, which contributes to analytical error. Fiber is typically measured as neutral-detergent fiber (NDF). The NDF method measures the cellulose and hemicellulose but not pectin. Thus, NDF underestimates fiber. Fiber is also measured as acid-detergent fiber (ADF). In contrast to NDF, pectin remains in the ADF estimate. Our approach was to measure ADF using two methods. Method 1 measured ADF directly (ADF-D), which contains pectin. Method 2 measured ADF sequentially (ADF-S), which contains no pectin. *Question*: does pectin account for a portion of the "missing" 20%?

Table 2. Pectin accounted for approximately 2 to 4% of the Missing 20% for AH.

| Item | Nonpareil Whole | Nonpareil Pure | Other Whole | Other Pure |
|---|---|---|---|---|
| ADF-D, % | 17.1 | 15.2 | 25.3 | 18.0 |
| ADF-S, % | 14.9 | 13.4 | 21.1 | 15.1 |
| Pectin, % | 2.2 | 1.8 | 4.2 | 2.9 |

This study also measured the *in vitro* rumen fermentation of Whole and Pure AH at 24, 30, and 48 hours of fermentation. The samples of Whole and Pure AH were also analyzed using NIR spectroscopy to compare wet chemistry determinations with NIR determinations. The California Department of Food and Agriculture (CDFA) samples AH on a case by case approach to ensure that AH meet the State definition of "almond hull products" in the Food and Agriculture Code. Commercial Feed Law 2773.5 states for AH: "They shall not contain more than 13.0 percent moisture, nor more than 15.0 percent crude fiber, and not more than 9.0 percent ash". In the past the crude fiber determination by CDFA was by wet chemistry methodology. The CDFA recently began to use NIR approaches. The relationship of determining crude fiber by wet chemistry compared with NIR technology is not well defined for AH in California.

## V. Impact of research to the group's objectives

Approximately half of the missing 20% chemical composition for AH was explained by soluble lignin while pectin only accounted for a small portion of the missing composition. These findings will be related to changes observed in the *in vitro* rumen digestibility of AH to increase the use of AH in dairy diets.

Beginning to identify the chemical constituents in AH that are missing. The majority of feedstuffs that are analyze by typical chemical approaches will have missing fractions. The composition of feedstuffs often dos not add up to 100%. However, AH have a large portion of the composition, 20 to 30%, that is unknown. The lack of chemical information impacts how AH are used in Precision Feeding. Precision Feeding is one approach to reduce enteric gas emissions in California. The unknown fraction of AH impacts the use of AH because AH are increasing in their contribution to the diet and AH are being used as both a concentrate and a forage ingredient.

Demonstrated that the feeding value of commercial almond hulls is dependent on the amount of total debris (sticks, shells, and dirt). This was the first study to evaluate "pure" almond hulls. The chemical composition of commercial almond hulls reflects hulls, stick, shells, and dirt and is not truly representative of "pure" hulls. The retrospective analysis of the regulatory data indicate that the quality of commercial almond hulls is highly variable. Dairy farmers and nutritionists should be sampling and testing commercial almond hulls for chemical quality. Feeding almond hulls that do not meet the legal definition has implications. One implication is that dairy farmers are not getting what they paid for. Almond hulls greater than 15% crude fiber are defined by California regulations as almond hull and shell, which is a lower priced product and a lower nutritional value product. Another implication is the errors contributing to ration formulation by nutritionist. If the chemical composition of almond hulls is variable and found in violation of definitions at a rate of 50%, the accuracy of rations based on energy content and microbial protein flow are inaccurate. The high variability in chemical composition of commercial almond hulls adds uncertainty to ration formulation approaches. Research demonstrate that high quality, commercial almond hulls can be fed as a concentrate ingredient at amounts as high as 12 pounds per cow daily. This level is approximately two to three times the average feeding amount. As expected, the sticks and shells, that are debris contaminates in almonds hulls, lower the fermentability and energy value of commercial almond hulls. Finally, essential oils offer the potential to reduce enteric emission of methane. In California, essential oils will be one strategy to a variety of approaches to reduce methane emission to meet the regulations of Senate Bill 1383.

## VI. Work planned for next year

Compete current research.

## VII. Publications/products

Almond hull composition paper will be prepared once the chemical analyses are completed.
No products were developed from this research.

# University of Florida
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

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## II. Personnel

Albert De Vries, Department of Animal Sciences, University of Florida. devries@ufl.edu

## III. Collaborators

Pratiksha Sharma, PhD student. Agricultural and Biological Engineering, UF
Nikolay Bliznyuk, associate professor. Agricultural and Biological Engineering, UF
Pablo Pinedo, associate professor. Colorado State University

## IV. Progress and Principal Accomplishments within one or more objectives

We are working on software that calculates optimal replacement and insemination decisions for dairy heifers and cows. We calculate optimized cash flows for real cows and heifers using dynamic programming and take differences of these cash flows and present them as keep values and insemination values. The software allows these cash flows to be accurate given biological performance (future milk production, fertility etc.) is accurately estimated, while maintaining calculation speeds. One application is to determine beef, conventional dairy, and sexed dairy semen in next weeks breedings. Because many dairy farms need a certain minimum number of dairy heifer calves, we use linear programming to determine which animals should be bred with sexed or conventional dairy semen. A reasonably good model exists, but many improvements are possible.

## V. Impact of research to the group's objectives

We are testing the software with some dairy farms. Their feedback is that they like the decision support it provides. All three objectives are touched.

## VI. Work planned for next year

Continue to develop the software to make replacement and insemination decisions. Publish some manuscripts.

## VII. Publications/products

De Vries, A., N. Bliznyuk, P. Sharma, Y. Han, and P. Pinedo. 2022. Insemination values to support mating decisions under dairy heifer calf herd size constraints. Proceedings World Congress on Genetics Applied to Livestock Production. 57_012: 4 pages

De Vries, A., P. Pinedo, N. Bliznyuk, R. H. Fourdraine, and J. S. Clay. 2022. Application of insemination values to support cow mating decisions. J. Dairy Sci. 105 (Suppl. 1):48 (abstract 1127)

# UNIVERSITY OF WISCONSIN-MADISON, Animal and Dairy Science
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

## Objectives (as listed on the Project's webpage)

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Progress and Principal Accomplishments within one or more objectives

***Investigating the effect of temporal, geographic, and management factors on US Holstein lactation curve parameters***

Li, M., K. Reed, G. Rosa, and **V. E. Cabrera**

We fit the Wood's lactation model to an extensive database of test-day milk production records of US Holstein cows to obtain lactation-specific parameter estimates and investigated the effects of temporal, spatial, and management factors on lactation curve parameters and 305-d milk yield. Our approach included 2 steps as follows: (1) individual animal-parity parameter estimation with nonlinear least-squares optimization of the Wood's lactation curve parameters, and (2) mixed-effects model analysis of 8,595,413 sets of parameter estimates from individual lactation curves. Further, we conducted an analysis that included all parities and a separate analysis for first lactation heifers. Results showed that parity had the most significant effect on the scale (parameter *a*), the rate of decay (parameter *c*), and the 305-d milk yield. The month of calving had the largest effect on the rate of increase (parameter *b*) for models fit with data from all lactations. The calving month had the most significant effect on all lactation curve parameters for first lactation models. However, age at first calving, year, and milking frequency accounted for a higher proportion of the variance than month for first lactation 305-d milk yield. All parameter estimates and 305-d milk yield increased as parity increased; parameter *a* and 305-d milk yield rose, and parameters *b* and *c* decreased as year and milking frequency increased. Calving month estimates parameters *a*, *b*, *c*, and 305-d milk yield were the lowest values for September, May, June, and July, respectively. The results also indicated the random effects of herd and cow improved model fit. Lactation curve parameter estimates from the mixed-model analysis of individual lactation curve fits describe well US Holstein lactation curves according to temporal, spatial, and management factors.

***Predicting daily milk yield for primiparous cows using data of within-herd relatives to capture genotype-by-environment interactions***
Zhang, F., K. A. Weigel, and **V. E. Cabrera**.
This study develops and illustrates a hybrid *k*-medoids, random forest, and support vector regression (K-R-S) approach for predicting the lactation curves of individual primiparous cows within a targeted environment using monthly milk production data from their dams and paternal siblings. The model simulation and evaluation were based on historical test-day (TD) milk production data from 2010 to 2016 for 260 Wisconsin dairy farms. Data from older paternal siblings and dams were used to create family units (n = 6,400) of individual calves, from which their future performance was predicted. Test-day milk yield (MY) records from 2010 to 2014 were used for model training, whereas monthly milk production records of Holstein calves born in 2014 were used for model evaluation. The K-R-S hybrid approach was used to generate MY predictions for 5 randomly selected batches of 320 primiparous cows, which were used to evaluate model performance at the individual cow level by cross-validation. Across all 5 batches, the mean absolute error and the root mean square error of the K-R-S predictions were lower (by 24.2 and 23.4%, respectively) than that of the mean daily MY of paternal siblings. The K-R-S predictions of TD MY were closer to actual values 74.2 ± 2.0% of the time, as compared with means of paternal siblings'. The correlation between actual TD MY and K-R-S predictions was greater (0.34 ± 0.01) than the correlation between the actual yield and the mean of paternal siblings (0.08 ± 0.01). The results of this study demonstrate the effectiveness of the K-R-S hybrid approach for predicting future first-lactation MY of dairy calves in management applications, such as milk production forecasting or decision-support simulation, using only monthly TD yields of within-herd relatives and in the absence of detailed genomic data.

***Addressing Data Bottlenecks in the Dairy Farm Industry***
Fadul-Pacheco, L., S. R. Wangen, T. E. da Silva, and **V. E. Cabrera**.
A survey to explore the challenges and opportunities for dairy farm data management and governance was completed by 73 farmers and 96 non-farmers. Although 91% of them find data sharing beneficial, 69% are unfamiliar with data collection protocols and standards, and 66% of farmers feel powerless over their data chain of custody. Although 58% of farmers share data, only 19% of them recall having signed a data share agreement. Fifty-two percent of respondents agree that data collected on farm belongs only to the farmer, with 25% of farmers believing intellectual property products are being developed with their data, and 90% of all said companies should pay farmers when making money from their data. Farmers and non-farmers are somewhat concerned about data ownership, security, and confidentiality, but non-farmers were more concerned about data collection standards and lack of integration. Sixty-two percent of farmers integrate data from different sources. Farmers' most used technologies are milk composition (67%) and early disease detection (56%); most desired technologies are body condition score (56%) and automatic milking systems (46%); most abandoned technologies are temperature and activity sensors (14%) and automatic sorting gates (13%). A better understanding of these issues is paramount for the industry's long-term sustainability.

***Graduate Student Literature Review:* Considerations for nutritional grouping in dairy farms***
Barrientos-Blanco, J., H. White, R. D. Shaver, and **V. E. Cabrera**.
Each cow in a group has different nutritional requirements even if the group is formed by cows of similar age, number of lactations, and lactation stage. Common dairy farm management

setup does not support formulating a diet that accurately matches individual nutritional requirements for each cow; therefore, a proportion of cows in the group will be overfed and another proportion underfed. Overfeeding and underfeeding cows increases the risk of metabolic diseases, decreases milk production, and increases nutrient waste. Consequently, profitability of dairy farms and the environment are negatively affected. Nutritional grouping is a management strategy that aims to allocate lactating cows homogeneously according to their nutritional requirements. Groups of cows with more uniform nutritional requirements facilitates the formulation of more accurate diets for the group. Current availability of large data streams on dairy farms facilitates the design of algorithms to implement nutritional grouping. Our review summarizes important factors to consider when grouping cows, describes nutritional grouping approaches, and summarizes benefits of implementing nutritional grouping in dairy farms.

**Economics of using beef semen on dairy herds**
**Cabrera, V. E.**
The economic value of using beef semen in dairy herds depends on the market value of calves (crossbred beef and dairy), market price of semen (beef, conventional, and sexed), herd reproductive performance, and semen combination strategies. Due to the complex interaction among all these factors and their inherent changing conditions, the quest for an optimal strategy is best served by the application of an integrated model and a decision support tool adaptable to ever-changing farm and market conditions. We have developed a model and a decision support tool to calculate the income from calves over semen costs (ICOSC) in response to user-defined beef semen crossbreeding strategies in combination with sexed and conventional semen utilization. The model follows a Markov-chain approach in which animal (heifer and cow) statuses (age, months after calving, lactation, pregnancy, calving) are simulated monthly. Replacement balance is calculated as the difference between demand and supply of calves in function of selected semen utilization protocols, which could include beef, sexed, or conventional semen. A case study was performed in a 1,000-cow virtual Holstein herd with 35% turnover rate and 7% stillbirth rate. Five strategies of beef semen utilization on adult cows (0 to 100% in 25-percentage-unit intervals) were combined with 6 strategies of sexed semen use [none (NS), first service in heifers (1H), first and second services in heifers (2H), 2H + 20% top genetic cows (TOP), 2H + first service in primiparous (1C), and 1C + first service in second-lactation cows (2C)]. All animals not bred to either sexed or beef semen were bred to conventional semen. Having a price of beef calves ~4 times greater than the price of a dairy calf and having the price of sexed semen ~2.3 times greater than the conventional or beef semen determined that the optimal breeding semen protocols that concurrently maximized the ICOSC and produced enough replacements were 100% beef semen use after 2C sexed semen protocol (ICOSC = $2,001) for medium reproductive performance (~20% 21-d pregnancy rate) and 100% beef semen after 1H sexed semen protocol (ICOSC = $6,215) for high reproductive performance (~30% 21-d pregnancy rate). These strategies were consistently the best options under several feasible market conditions for herds with medium and high reproductive performance. However, the optimal ICOSC was negative or marginally low for low-performance herds (~15% 21-d pregnancy rate), for which the opportunity to use beef semen is minimal or nonexistent.

**Data Governance in the Dairy Industry**
Cue, R., M. Doornik, R. George, B Griffiths, M. W. Jorgensen, R. Rogers. A. Saha, K. Taysom,

**V. E. Cabrera**, S. R. Wangen, and L. Fadul-Pacheco.
Data governance is a growing concern in the dairy farm industry because of the lack of legal regulation. In this commentary paper, we discuss the status quo of the available legislation and codes, as well as some possible solutions. To our knowledge, there are currently four codes of practice that address agriculture data worldwide, and their objectives are similar: (1) raise awareness of diverse data challenges such as data sharing and data privacy, (2) provide data security, and (3) illustrate the importance of the transparency of terms and conditions of data sharing contracts. However, all these codes are voluntary, which limits their adoption. We propose a Farmers Bill of Rights for the dairy data ecosystem to address some key components around data ownership and transparency in data sharing. Our hope is to start the discussion to create a balanced environment to promote equity within the data economy, encourage proper data stewardship, and to foster trust and harmony between the industry companies and the farmers when it comes to sharing data.

**LEVERAGE (***dollars and other resources – because of your work in this project you've been able to leverage resources from what other sources, amounts?***):**

1. **Cabrera, V. E.** 2022-2023. The EZ Dairy Enviro-Money: A high level environmental and economic assessment tool for dairy farmers. UW-Dairy Innovation Hub Short Term High Impact program. $50,000.
2. **Cabrera, V. E.** 2021-2025. Developing the next-generation dairy farm decision support tools relying on the UW-Dairy Brain and the US Ruminant Farm System Model: A case study of genetic progress, semen selection, and culling policies. USDA Hatch Multistate Single Investigator. **$146,000**.
3. **Cabrera, V. E.**, and J. Van Os. 2021-2025. The Ruminant Farm Systems (RuFaS) Model: (1) Initiation of an Animal Welfare Module (Van Os) and (2) Commercial Farm Data Integration to Streamline Scenario Development and Model Evaluation (Cabrera). Gift General Mills Inc. $200,000
4. **Cabrera, V. E.**, and K. Nielsen. 2020-2023. UW-Madison-Nestle Dairy Farm Institute Collaborative Training Agreement. $227,000.
5. Fricke, P. M., **V. E. Cabrera**. 2021-2024. An Integrated Approach to Optimize Use of Sexed Semen in Dairy Herds. USDA-NIFA-CARE. $300,000
6. **Cabrera, V. E.,** M. Ferris, M. Livny, J. Patel, K. A. Weigel, H. White. 2019-2023. Developing a Dairy Brain: The Next Big Leap in Dairy Farm Management Using Coordinated Data Ecosystems. USDA-NIFA-Food and Agriculture Cyberinformatics. **$1,000,000**.

## VI. Work planned for next year

My lab group is geared to continue full speed the "Dairy Brain" initiative with emphasis on farm data integration techniques and development of decision support tools that are based on live aggregated data streams. [Https://DairyBrain.wisc.edu](Https://DairyBrain.wisc.edu). This work is being leveraged and integrated with my lab participation in the Ruminant Farm System Model initiative ([RuFaS.org](RuFaS.org))

## VII. Publications/products

**Peer-reviewed research and extension Journal papers**

1. Gorr, A., **V. E. Cabrera**, J. Meronek, and K. A. Weigel. 2022 (*accepted*). Decision-support tool for global allocation of dairy sire semen based on regional demand, supply constraints, and genetic profiles. Journal of Dairy Science 00:00-00.

2. Li, M., K. Reed, G. Rosa, and **V. E. Cabrera**. 2022. Investigating the impact of temporal, geographic, and management factors on US Holstein lactation curve parameters. Journal of Dairy Science 105:7525-7538. https://doi.org/10.3168/jds.2022-21882.

3. Zhang, F., K. A. Weigel, and **V. E. Cabrera**. 2022. Predicting daily milk yield for primiparous cows using data of within-herd relatives to capture genotype-by-environment interactions. Journal of Dairy Science 105:6739-6748. https://doi.org/10.3168/jds.2021-21559.

4. Fadul-Pacheco, L., S. R. Wangen, T. E. da Silva, and **V. E. Cabrera**. 2022. Addressing data bottlenecks in the dairy farm industry. Animals 12(6):721. https://doi.org/10.3390/ani12060721.

5. Silva-Boloña, P., J. Upton, **V. E. Cabrera**, E. Tedward, and D. J. Reinemann. 2022. A simulation model of quarter milk flowrates to estimate quarter and cow milking uration nd automated milking system's box duration. Journal of Dairy Science 105:4156-4170. https://doi.org/10.3168/jds.2021-20464.

6. Barrientos-Blanco, J., H. White, R. D. Shaver, and **V. E. Cabrera**. 2022. Graduate Student Literature Review: Considerations for nutritional grouping in dairy farms. Journal of Dairy Science 105:2708–2717. https://doi.org/10.3168/jds.2021-21141.

7. **Cabrera, V. E.** 2022. Economics of using beef semen on dairy herds. Journal of Dairy Science Communications 3:147-151. https://doi.org/10.3168/jdsc.2021-0155.

8. Cue, R., M. Doornik, R. George, B Griffiths, M. W. Jorgensen, R. Rogers. A. Saha, K. Taysom, **V. E. Cabrera**, S. R. Wangen, and L. Fadul-Pacheco. 2021. Data governance in the dairy industry. Animals 11(10):2981. https://doi.org/10.3390/ani11102981.

**Contributed papers or abstracts research and extension**

1. Zhang, F., K. A. Weigel, and **V. E. Cabrera**. 2022. Month-ahead daily milk yield prediction for individual cows using test-day and genomic evaluations data. 3rd International Conference on Precision Dairy Farming, Vienna, Austria, 30 Aug - 2 Sep 2022.
2. Gong, Y., M. Li, M. A., Sotirova, K.F. Reed, and **V. E. Cabrera**. 2022. Animal life cycle submodule on Ruminant Farms Systems (RuFaS) model: a sensitivity analysis to evaluate heifer reproductive protocols. American Dairy Science Association Annual Meeting (ADSA), Kansas City, MO, 19-22 June 2022.
3. Da Silva, T., J. Van Os, K. F. Reed, **V. E. Cabrera**, N. Cook. 2022. Lameness and its impacts on dairy herds: the welfare sub-module in the Ruminant Farm Systems model. 18th International Conference on Production Diseases (ICPD) in Farm Animals, Madison, WI, 15-17 June 2022.
4. Li, M. K. F. Reed, and **V. E. Cabrera**. 2022. A time-series analysis of milk productivity changes in US dairy states. 2022 ICAR/Interbull Conference. Montreal, CA, 30 May- 2 June 2022.

5. **Cabrera, V. E.**, and L. Fadul-Pacheco. 2022. Understanding data access and flow. DHI System Leadership Sessions and 57th National DHIA Annual Meeting. 22-24 February 2022. San Antonio, TX.
6. Fadul-Pacheco, L., and **V. E. Cabrera**. 2022. Data governance in the dairy industry. Data Science Research Bazaar, UW-Madison 2 February 2022.
7. Fadul-Pacheco, L. and **V. E. Cabrera**. 2021. Exploring integrated data as a tool for better understanding health-associated issues in dairy farms. Conference of Research Workers in Animal Diseases (CRAWD), Chicago, IL,3-7 December 2021.
8. Silva, T., J. Van Os, **V. E. Cabrera**, and K. Reed. 2021. Predicting lameness and its impact on dairy herds: the welfare sub-module in the Ruminant Farm Systems (RuFaS) model. Conference of Research Workers in Animal Diseases (CRAWD), Chicago, IL, 3-7 December 2021.
9. Reed, K. F., D. V. Nydam, M. Li, and **V. E. Cabrera.** 2021. Application of the Ruminant Farm Systems model (RuFaS) to assess the environmental impact of reproductive strategies in dairy farms. Annual Conference of the American Association of Bovine Practitioners. Salt Lake City, Utah. 7-9 October 2021.

# Cornell University
# Annual Progress Report
# Multistate Research Project NC-2042
# 2022-2023

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

### Objectives

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

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Dr. Thomas Overton
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## III. Collaborators

Dr. Dave Barbano, College of Agriculture & Life Sciences, Cornell University
Dr. Barry Bradford, Michigan State University
Dr. Victor Cabrera, University of Wisconsin-Madison

## IV. Progress and Principal Accomplishments within one or more objectives

Our work in the past year has focused on Objective 2 of this Multistate Project. In one project, we continue to focus on the relationship between Fourier transform infrared (FTIR) spectroscopy estimated milk constituents and individual and herd-level health. We completed data analysis from a large field trial on a 5,000-cow dairy in central New York collecting daily composite milk samples from 1,024 cows for the first 14 days in milk that underwent mid-FTIR analysis. From this study we have two manuscripts in review, one assessing parity differences in early lactation estimated milk constituents and the second defining the ability to classify cows as health or sick based on single-day milk analysis. Results from these two works were presented at the 2022 American Dairy Science Association Annual Meeting in Kansas City, Missouri. The second work will also be presented at the 2022 American Association of Bovine Practitioners Annual Conference in Long Beach, California. In the past year, we also conducted an additional study enrolling 300 multiparous dairy cows in three commercial dairy herds to assess the ability to classify cows as hypocalcemic at day 3 or 4 in milk based on milk FTIR analysis. Laboratory and data analysis for this project are ongoing.

In a second project, we continued our research theme on understanding the association of prolonged hypocalcemia with economically detrimental outcomes on commercial dairy farms. We determined that cows with hypocalcemia at 4 days in milk have reduced pregnancy risk to first insemination and take longer to become pregnant than cows that have recovered normocalcemia by 4 days in milk.

We evaluated an adapted liver health index based upon single timepoint concentrations of bilirubin, cholesterol, and albumin in postpartum cows, and determined that cows with higher LHI (higher denotes better liver health) had higher milk yield, tended to have higher postpartum DMI, had lower prepartum and postpartum NEFA concentrations, and had lower circulating haptoglobin concentrations postpartum. In a larger (n=72 herd) study, we determined that cows with higher LHI had lower risk for metabolic disorders, produced more milk in lactation, and had improved reproductive performance, particularly in multiparous cows.

## V. Impact of research to the group's objectives

Our group is using FTIR technology to continually asses cow health in the immediate postparturient period and identify changes in milk composition that are associated with reduced performance and wellbeing. Use of this technology will allow us to monitor management changes that improve dairy cow performance and well-being. Other work conducted demonstrates how we can further use blood-based markers to evaluate opportunities for improved transition cow management..

## VI. Work planned for next year

Over the next 12 months, we will continue to focus on analytical work and manuscript preparation associated with our summer 2022, multi-herd trial assessing blood calcium status through the milk of early lactation dairy cows. Additional focus will go to revision and publication of two manuscripts and presentation of results at two conferences in 2023, the American Dairy Science Association Annual Meeting (Ottawa, Canada) and the

American Association of Bovine Practitioners Annual Conference (Milwaukee, Wisconsin).

We will also continue work on a large, commercial farm based study in which we will evaluate relationships of feeding management prepartum and dietary strategy postpartum on markers of inflammation and energy metabolism.

## VII. Publications/products

Seely CR, McArt JAA. The association of blood calcium dynamics and reproductive outcomes in multiparous Holstein cows. *JDS Communications*; June 2022; in revision.

Callero KR, Teplitz EM, Barbano DM, Seely CR, Seminara JA, Frost IR, McCray HA, Martinez RM, Reid AM, McArt JAA. Patterns of Fourier-transform infrared estimated milk constituents in early lactation Holstein cows. *J Dairy Sci*; July 2022; in revision.

Seminara JA, Callero KR, Frost IR, Martinez RM, McCray HA, Reid AM, Barbano DM, McArt JAA. Calcium dynamics and associated patterns of milk constituents in early lactation multiparous Holsteins. *J Dairy Sci*; September 2022; in review.

McArt JAA, Teplitz EM, Callero KR, Seminara JA, Frost IR, McCray HA, Martinez RM, Reid AM, Barbano DM. Assessing differences in early lactation milk constituent estimates between Holstein cows of varying health outcomes. *J Dairy Sci*; September 2022; in review.

Kerwin AL, Burhans WS, Mann S, Nydam DV, Wall SK, Schoenberg KM, Perfield KL, Overton TR. 2022. Transition cow nutrition and management strategies of dairy herds in the northeastern United States: Part II-Associations of metabolic- and inflammation-related analytes with health, milk yield, and reproduction. J. Dairy Sci. 105:5349-5369.

Kerwin AL, Burhans WS, Mann S, Tetreault M, Nydam DV, Overton TR. 2022. Transition cow nutrition and management strategies of dairy herds in the northeastern United States: Part I-Herd description and performance characteristics. J. Dairy Sci. 105:5327-5348.

# University of Wisconsin – River Falls
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
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3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

Kate Creutzinger (PI), Kurt Vogel (Co-PI), Hannah Olsen and Shawna Sigl (Masters students)

## III. Collaborators

Kurt Vogel, Sylvia Kehoe – University of Wisconsin-River Falls (UWRF)

## IV. Progress and Principal Accomplishments within one or more objectives

In the last year, 4 research projects were funded. These projects are in-progress and planned to begin in the 2022-2023 fiscal year. The objectives of these projects as they relate to the NC-2042 objectives are listed below.

1. **Objective 1:**
   a. A novel assessment of hunger in dairy calves using taste aversion (in-progress)

2. **Objective 2:**
   a. Development of a novel calving blind for dairy cows (in-progress)
   b. Dry-off behavior of dairy cows in Automatic Milking Systems (AMS) (predicted start date: August 2023)

3. **Objective 3:**
   a. Assessment of transition cow management (3 weeks before to 3 weeks after calving) on dairy farms in Wisconsin and Minnesota (in-progress)
   b. Characterization of dairy cow-calf pairs on pasture after calving (pilot testing in-progress)

**V. Impact of research to the group's objectives**

The overarching objectives of our research efforts include 1) the improvement of dairy cattle welfare during the transition period and 2) investigate the welfare of surplus dairy calves. Information gained in the on-going and future research is highly applied and will be able to optimize management practices on dairy farms.

**VI. Work planned for next year**

In the next year, in-progress research will continue and projects in the planning stages will begin. Expectations of progress in the next year are listed below

1. The taste aversion in dairy calves will be complete and 1 paper will be submitted for publication
2. Data collection from the calving blind and data analysis will be complete. I expect 1 publication will be in preparation or submitted for publication
3. The survey to assess transition cow management will be disseminated in January 2023 and data collection will be complete by May 2023. Data analysis will be complete, and 1 publication will be in preparation or submitted for publication
4. Data collection of cow-calf pairs will be complete and data analysis will be in-progress
5. The study to assess dairy cow behavior during dry-off in AMS will begin in August 2023

**VII. Publications/products**

Published Peer-Reviewed Journal Articles
(*Italicized are students I directly supervised*)


1. *Olsen, H.*, K. Anderson, **K. Creutzinger**, and K. Vogel. (Accepted). Broken tails in Holstein dairy cattle: a cross-sectional study. J. Dairy Sci.

2. **Creutzinger, K. C.**, K. Broadfoot, H. M. Goetz, K. L. Proudfoot, J. H. C. Costa, R. K. Meagher, and D. L. Renaud. 2022. Assessing dairy calf response to long-distance transportation using conditioned place aversion. J. Dairy Sci. Comm. 3:275-279.

# University of Wisconsin-Madison
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

Matt Akins – Associate Scientist and Extension Specialist
Kate Wells – Graduate Research Assistant
Alyssa Seitz – Graduate Research Assistant
Hidir Gumus – Visiting Scholar (Turkey)
Conor Holohan – Visiting Scholar (Ireland)

## III. Collaborators

## IV. Progress and Principal Accomplishments within one or more objectives

-Evaluated the yield and quality of a cocktail forage mix (sorghum-sudangrass, Italian ryegrass, red clover, berseem clover, hairy vetch) at 6 Wisconsin locations, and also the milk production by cows fed a diet with cocktail forage mix. Yields were 3000-4000 kg DM/acre across 3 harvests with quality variable due to the dominant species changing at each harvest. Milk protein and fat yields were similar between cows fed a diet with or without cocktail forage mix silage with energy corrected milk being about 40 kg/cow/day for both diets.
-Conducted USDA CARE funded research on dairy beef crossbred calf feeding programs (pre-weaning and grower/finisher) to evaluate impact on growth and subsequent carcass yield and quality. Completed pre-weaning phase with data being analyzed for presentation at 2023 meetings. Cattle harvest is underway and will be complete in April 2023.
-Evaluated the use of stockpiled forage for grazing pre-breeding (250 kg) dairy heifers in fall 2020 and 2021. Heifer growth was on par with desired growth (0.8-1.0 kg/day) for Holstein heifers. Presence of legume seemed to be important as heifer growth in 2020 was better with greater red clover presence and forage protein levels. Data were presented at the 2022 ADSA annual meetings.
-Evaluated the use of delactosed whey permeate as a milk replacer ingredient (0, 3, 6, or 9%) for feeding pre-weaning Holstein and dairy beef crossbred calves. Data are being analyzed and will be presented at the 2023 ADSA annual meeting.
-Evaluated virtual fencing technology for grazing pregnant dairy heifers using either normal electric or virtual fencing under different grazing management strategies (rotational or continuous

grazing). Heifers were observed for behavior, virtual fencing electric impulses, and fecal cortisol to determine stress levels. Samples and data are still being analyzed and plan to be presented at the 2023 ADSA annual meeting.

## V. Impact of research to the group's objectives

Our work with cocktail forage mixes has helped dairy producers understand yield and quality potential of these, and how these forages fit into the crop rotation and the dairy cow diet.
The research on dairy beef crossbred feeding will help dairy and beef producers improve crossbred calf growth, carcass value, and profitability. Our work on the use of stockpiled forage for late-fall grazing has helped producers better understand the process of stockpiling, how it may fit into the grazing system, and how to manage grazing stockpiled forage. The work on delactosed whey permeate will help provide a higher value use for a byproduct of whey protein that is in good supply but currently is of low value due to processing issues. There is considerable interest in virtual fencing with several companies developing technologies. Our work has helped producers understand one of the company's technology, how it works, and opportunities for it in either dairy or beef cattle grazing.

## VI. Work planned for next year

-Work will continue for the dairy beef crossbred feeding project with final cattle harvests planned for April 2023. Meat quality analysis and consumer sensory evaluations will be conducted to compare crossbred to Holstein and Angus beef.
-Sorghum forage hybrids developed by Iowa State University for Midwest producers (cold tolerant hybrids) will be evaluated in Wisconsin as a potential forage for dairy heifers.

## VII. Publications/products

Peer-reviewed publications:

Williams, K.T., K.A Weigel, W.K. Coblentz, N.M. Esser, H. Schlesser, P.C. Hoffman, R. Ogden, H. Su, M.S. Akins. 2022. Effect of diet energy level and genomic residual feed intake on bred Holstein dairy heifer growth and feed efficiency. J. Dairy Sci. 105:2201-2214.

Meeting abstracts:

Gumus, H., L.F. Ferraretto, M.S. Akins. 2022. Effect of a cocktail silage mix on lactation performance of Holstein dairy cows. J. Dairy Sci. 105: Suppl 1.

Riesgraf, K., M.S. Akins, J.M.C Van Os, K.A. Weigel. 2022. Preweaning pair and individual housing effects on subsequent heifer feed efficiency. J. Dairy Sci. 105: Suppl 1.

Wells, K.G., M.A. Wattiaux, D.M. Pizarro, J.S. Cavadini, M.S. Akins. 2022. Effect of grazing fall-stockpiled tall fescue, meadow fescue, or orchardgrass on heifer growth and greenhouse gas production. J. Dairy Sci. 105: Suppl 1.

# University of New Hampshire
# Annual Progress Report
# Multistate Research Project NC-2042

**I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

**II. Personnel:** Peter Erickson, Ph.D.

**III. Collaborators:**

1. New Hampshire Agricultural Experiment Station
2. Department of Agriculture, Nutrition and Food Systems
3. Adisseo
4. George Walker Milk Fund
5. School of the Environment, University of Massachusetts, Boston

**IV. Progress and Principal Accomplishments within one or more objectives**

We are conducting two studies under objective one. The first study is evaluating the feeding of two negative dietary cation-anion diets (-40 mEq/kg, -80 mEq/kg) with or without 23 g/d nicotinic acid to prepartum, multiparous Jersey cows in an attempt to evaluate what causes the reduction in colostrum yield in the Jersey breed. It was hypothesized that possibly a prepartum diet could be involved. We are evaluating prepartum cow performance (intake, blood NEFA, glucose, and ketone bodies), colostrum quality, and yield along with the evaluation of IGF-1, insulin, lactoferrin, transforming growth factors, and fatty acids. We followed the respective calves for six weeks and measured initial body weight, 0h IgG, 24 h IgG, feed intake, body weight, and skeletal measures. On day 5 a xylose challenge was done to evaluate intestinal development. This study is completed except for laboratory analyses of urinary purine derivatives, and colostral transforming growth factors β1 and β2. The University of Guelph is providing assays of colostral fatty acid. Feed efficiency is being determined as well. Results so far indicate:

- no effect of treatment on colostrum yield and protein yield.
- Supplementing 23 g/d of nicotinic acid reduced colostrum fat yield. ($P = 0.05$).
- There was no effect of treatment on IgG concentration or yield of IgG.
- However, calves fed colostrum from cows fed 23 g/ nicotinic acid for 28 days tended ($P < 0.12$) to have greater blood xylose concentrations.
- For área under the curve for xylose, calves fed colostrum from dams fed -40 mEq/kg with 23 g/d nicotinic acid tended to have a lesser área under the curve values, while calves fed the -80 mEq/kg with 23 g/d nicotinic acid had greater área under the curve resulting in a tren for an interaction ($P=0.09$).

- Lactoferrin and IGF-1 were elevated in calves fed colostrum from nicotinic acid-fed dams.
- These data suggest that a component within colostrum from cows fed nicotinic acid may have enhanced intestinal development.

The second study is evaluating the use of sodium butyrate in the diets of limit-fed post-weaned heifers. 0.75g/kg of sodium butyrate is being fed to 12 heifers, while the same diet is being fed to 12 control heifers fed the carrier for 12 weeks beginning at week 13. Growth measurements( body weight and skeletal measurements) are taken weekly. A digestibility evaluation at week 7 of the study using acid-insoluble ash as an internal marker was done. This study is completed except for determining urinary purine derivatives. Results indicated that there were no Benefits of feeding 0.75 g/kg BW to heifers in a limit-fed scenario. These data do not concur with our previous studies with sodium butyrate in ad libitum-fed heifers.

Every two weeks during the weekly measurement period, fecal samples are taken and evaluated for coccidian oocysts. Previous research has shown that sodium butyrate is an effective preventative against coccidiosis.

To determine if sodium butyrate is an effective preventative of coccidiosis a cell-culture study is being conducted to determine if butyrate is effective against sporulated oocysts. The study is comparing control, sodium butyrate, butyric acid, and monensin. It appears that butyrate was as effective as monensin in protecting MDBK cells from sporozoite destruction. This paper is in review by the Journal of Animal Science.

A study is underway with 31 Jersey herds from across the US to investigate the lack of colostrum production which sometimes occurs in Jersey herds. Herds are from the New England states, Mid-Atlantic, South, High-plains, midwest, and far-west. Herds range in size from 12 cows to 2300. We plan on using regression techniques and DHI data to develop a colostrum yield and colostrum quality and prediction models similar to the model developed by Cabral et al. (2016).

We are evaluating the use of lobster and crab meal byproducts as protein sources for dairy cattle. These products have the potential to replace soybean meal in the diets of dairy cattle in áreas where crustacean harvest is an important industry such as New England and the Mid-Atlantic regions. We recently completed an in situ study utilizing a 4×4 Latin Square with treatments being crab meal, lobster meal, soybean meal, and blood meal. This study is in conjunction with the School of the Environment at the University of Massachusetts, Boston.

## V. Impact of research on the group’s objectives

These studies have not been completed yet, but data from the Jersey study suggests that by feeding nicotinic acid, colostrum is changed in a way that impacts intestinal development increasing xylose uptake Previous research from our laboratory indicated that Holstein cows fed 32 g/d nicotinic acid for four weeks prepartum resulted in their calves being more feed efficient suggesting that a component in colostrum can impact intestinal development. Feeding sodium butyrate to limit-fed heifers was not effective in stimulating growth in contrast to our ad libitum studies. This result is likely due to longer rumen retention of feed in limit-fed heifers thus resulting in more butyrate being absorbed in the rumen than in the ad libitum fed heifers. Our cell-culture data suggest that butyric acid is effective in controlling coccidiosis supporting our previous in vivo studies (Rice et al., 2019; Stahl et al, 2020)

## VI. Work Planned For Next Year

We plan on finishing the four studies described above. We are planning on further investigating the impact of nicotinic acid on heifer development. The last nicotinic acid work evaluating nicotinic acid in heifers was from the 1950s. Our recent data indicate that adding nicotinic acid to dry cow diets increased urinary purine derivatives compared to cows not supplemented with nicotinic acid. These data suggest that supplementing this vitamin Will enhance microbial protein synthesis thus reducing dietary protein requirements for growing heifers.

**Publications/Products**

**A. Submitted**

K.N. Klobucher, R. Badger, T. Foxall, and P.S. Erickson. 2022. *Short Communication*: Effect of sodium butyrate, monensin, and butyric acid on the viability of *Eimeria bovis* sporozoites and their degree of damage to a bovine epithelial cell line. J. Anim. Sci. (submitted)

**B. In Print**

1. Mendes, A.J., M.R. Murphy, D.P. Casper, and P.S. Erickson. 2022. The female to male calf sex ratio is associated with the number of services to achieve a calf and parity of lactating dairy cows. Trans. Anim. Sci. 6:1-6, txac80. https://doi.org/10.1093/tas/txac080.

2. Erickson, P.S. 2022 Colostrum Management: Keys to optimizing output and uptake of Immunoglobulin G. Front. Anim. Sci. 3:914361. doi: 10.3389/fanim.2022.914361

3. Senevirathne, N.D., J. L. Anderson, P. S. Erickson, and M. Rovai. 2021. Water quality and the drinking preferences of dairy heifers. JDS Comm. 2:393-397.

# Louisiana State University
# NC2042: 2021-2022 Annual Report

**I. Project Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

**Main objective:** To evaluate and develop sustainable management systems for dairy herds that address critical quality and variance control factors with implications to economic efficiencies and environmental impacts.

**Specific objectives:**

1) Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.
2) Improve dairy cow management decisions through nutrient utilization, well-being and profitability.
3) Analyze whole farm system components and integrate information into decision-support tools to improve efficiency, enhance profitability, and environmental sustainability.

II. **Personnel:** Cathleen C. Williams (Project Leader), Steven Blair, Instructor and PhD student

III. **Collaborator**: Mya Orantes, Undergraduate research student

**VII. Progress and Principal Accomplishments within one or more objectives**

**Outputs:**

*Under objective 1.*

The object of this study was to determine if acepromazine affects the mechanism of insulin-induced glucose uptake in dairy calves.

Ten Holstein heifers (12wks of age) were used in a switchback design to determine the effects of acepromazine when used as a chemical restraint on insulin sensitivity. Calves were fasted from grain supplementation overnight and for the duration of the test. One hour prior to the insulin tolerance tests, jugular catheters (16G x3 in) were inserted. A 0.02 mg/kg body dose of acepromazine was administered to 5 randomly assigned calves, while 5 calves assigned to control received an equivalent volume of saline via the jugular catheter. Thirty (30) minutes later, recombinant human insulin in sterile saline (75mU/kg BW) was infused through the jugular catheter at time 0. Blood was collected at -10 and 0 minutes pre-insulin infusion and 10, 20, 30, 40, 50, 60, and 90 minutes post- insulin infusion. Blood was immediately tested in duplicate for glucose concentrations using the commercially available OneTouch Ultra mini handheld glucometer. Catheters were removed upon completion of the test. The percentage decline in glucose concentrations was calculated for all injections and plotted against the natural log (ln) of the insulin dose for each calf. After all effects of sedation waned, calves were returned to their resident pastures. Forty-eight hours later, this procedure was repeated with previous control

animals being placed in the acepromazine treatment group and previously treated animals being placed in the control group.
Insulin stimulated a decrease in blood glucose levels in all calves; however, glucose concentrations did not differ between the two groups at any point during sampling. The administration of acepromazine did not alter the normal glucose response to insulin in dairy calves in this study.

**Impacts:**

In dairy calf research, it is important to understand effects of nutritional management on energy utilization. Insulin is important in the animal's use of glucose as an energy source. The tests often used for measuring energy utilization require animals to be calm during the procedure. Results from this study could provide a safe and effective procedure for chemical restraint during metabolic assessments to be used in dairy calves as well as more fractious ruminant species.

## IV. Work Planned for Next Year:

We further studied the effects of acepromazine on insulin sensitivity and glucose metabolism in a follow up project. In the previous study, we used handheld glucometers to measure glucose response to an insulin infusion. In the follow up study, we conducted include an intravenous glucose tolerance test and an intravenous insulin tolerance test on 12-week-old dairy heifers. Blood samples will be analyzed in the laboratory for insulin and glucose concentrations, and these analyses are currently in progress. Further research is planned to study developmental differences in dairy and beef calves in rumen development and glucose metabolism.

## V. Publications/Products:

Orantes, Mya. 2022. Assessment of the Effect of Acepromazine on Insulin Tolerance tests (ITT) in Dairy Heifers. Undergraduate honors thesis. LSU Roger Hadfield Ogden Honors College.

# University of Idaho
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

## Mireille Chahine (University of Idaho)

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

Mireille Chahine (Professor and Extension Dairy Specialist), Megan Kissel (MS student), Dan Scoresby (MS student), Paul Smith (Ph.D. student).

## III. Collaborators

Gonzalo Ferreira, Mario de Haro Marti, Steve Hines, Rick Norell, Glenn Shewmaker, Hernan Tejeda, Maristela Rovai, Gwinyai Chibisa, Benton Glaze, Noelia Silva-del-Rio, NC 2042 members.

## IV. Progress and Principal Accomplishments within one or more objectives

Collaboration between two NC 2042 stations has continued and has focused on addressing robotics on dairies. Workshops were delivered across Southern Idaho and were posted online (Objective 3). An online clasee is currently being developed and will be posted at the Extension.org website. We continued work on the Idaho Sustainable Agriculture Initiative for Dairy (ISAID) with the objective of optimizing the use of N and P from dairy production to produce useful bioproducts that can be transported and used in other geographical areas for crop production or value-added products such as bioplastics and fertilizers (Objective 3). We have initiated a survey that was sent all Idaho dairies to
examine the use of beef semen on Idaho dairies. We are in the process of summarizing the data in order to publish them.

## V. Impact of research to the group's objectives

The dairy robotics presentations and recording contribute to Objective 3 of NC2042 by improving the profitability of the dairy enterprise. The Beef on Dairy survey also contributes to Objective 3 by understanding the reasons behind the use of beef semen on Idaho dairies.

## VI. Work planned for next year

The following projects are planned for next year:

- Finalize and summarize the the beef on dairy survey
- Create an Online resource area with Extension products targeting the susutainability of the dairy industry

## VII. Publications/products

Valldecabres A, J. Wenz, F. C. Ferreira, M. Chahine, J. Dalton, M. E. de Haro Marti, M. Rovai, and N. Silva-Del-Río. 2022. Perspective of dairy producers from California, Idaho, South Dakota, and Washington: Health and business implications of the COVID-19 pandemic during the second wave. Journal of Dairy Sci. 105 (2): 1788-1796. https://doi.org/10.3168/jds.2021-20924

Ammar, H., , A. E. Kholif, Y. A. Soltan, M. I. Almadani, W. Soufan, , A. S. Morsy, S. Ouerghemmi, M. Chahine**,** M.E. de Haro Martí, S. Hassan, H. Selmi, E.H. Horst, and S. Lopez. 2022. Nutritive Value of Ajuga iva as a Pastoral Plant for Ruminants: Plant Phytochemicals and In Vitro Gas Production and Digestibility. Agriculture, 12(8), 1199. http://dx.doi.org/10.3390/agriculture12081199

Jabri, J., H. Ammar, K. Abid, Y. Beckers, H. Yaich, A. Malek, J. Rekhis, A.S. Morsy, Y.A. Soltan, W. Soufan, M.I. Almadani, M. Chahine, M.E. de Haro Martí, M.K. Okla, and M. Kamoun . 2022. Effect of Exogenous Fibrolytic Enzymes Supplementation or Functional Feed Additives on In Vitro Ruminal Fermentation of Chemically Pre-Treated Sunflower Heads. Agriculture, 12(5), 696. http://dx.doi.org/10.3390/agriculture12050696

Myers, C. A., M. E. de Haro Marti, M. Chahine, and G. E. Chibisa. 2021. *Journal of Animal Science*, Volume 99, Issue Supplement_3, November 2021 (Abs.), Page 287,https://doi.org/10.1093/jas/skab235.527

Ferreira, G. A. Burch, L. L. Martin, S. L. Hines, G. E. Shewmaker, and M. Chahine. 2021. Effect of drought stress on in situ ruminal starch digestion kinetics of corn for silage. Animal Feed Science and Technology. Animal Feed Science and Technology 279 (115027).

Ferreira, G., L. L. Martin, C. L. Teets, B. A. Corl, S. L. Hines, G. E. Shewmaker, M. E. de Haro-Marti, and M. Chahine. 2021. Effect of drought stress on ruminal neutral detergent fiber digestibility of corn for silage. Animal Feed Science and Technology 273 (114803).

# Pennsylvania State University
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

**I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability, and social responsibility.

## II. Personnel

L. A. Holden

## III. Collaborators

## IV. Progress and Principal Accomplishments within one or more objectives

Objective 3

Evaluation of Milk Production and Investment Strategies for Small Scale Dairy Farms the United States and Poland

Investment strategies and re-capitalization are important for long term sustainability of dairy farm businesses. Data from the European Union farms showed that profitable milk production was dependent on being "self-sufficient" with lower cost of production and appropriate re-investment into the dairy farm business. Data from this research has been published in a peer-reviewed journal and has indirect impacts for the US dairy industry.

## V. Impact of research to the group's objectives

Using European financial data, it was determined that funding available through various farm programs, when invested strategically at the farm level, resulted in improvements in net farm income on the studied farms compared to farms not able to access funding for investments. Additionally, without the availability of outside funds, many of the farms in the study would not have made the investment to improve farm profitability.

## VI. Work planned for next year

Work on the long-term agroecosystems project has been completed. A new project proposal is underway that will include evaluation of production efficiency, environmental sustainability and profitability for dairy farms that are incorporating more intensive forage crop management.

Workforce shortages in the dairy industry have led increased interest in developing diverse technical training options, like apprenticeship programs. Research about the effectiveness in animal science apprenticeships is planned to determine the impact of workforce development on employee recruitment and retention.

With the increased interest in biofuels due energy shortages, rising fuel prices and impact of fossil fuels on climate change, new collaborations are planned which focus on the use of renewable fuel sources and competition for crop acres in dairy farming systems.

## VII. Publications/products

Peer-reviewed journal publications.

Zalewski K, Bórawski P, Żuchowski I, Parzonko A, **Holden L**, Rokicki T. The Efficiency of Public Financial Support Investments into Dairy Farms in Poland by the European Union. *Agriculture*. 2022; 12(2):186. https://doi.org/10.3390/agriculture12020186

Bórawski P, **Holden L,** Bórawski MB, Mickiewicz B. Perspectives of Biodiesel Development in Poland against the Background of the European Union. *Energies*. 2022; 15(12):4332. https://doi.org/10.3390/en15124332

Book Chapters

**Holden, Lisa** "Chapter 6: Managing Milk Market Disruptions at the Dairy Farm Level in the USAEconomic and Social Consequences of the COVID-19 Pandemic, Wydawnictwo Ostrołęckiego Towarzystwa Naukowego Im. Adama Chętnika, Ostrołęka, 2022, pp. 100-104.

# University of Minnesota
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

**Objectives (as listed on the Project's webpage)**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

Bradley Heins, University of Minnesota WCROC

## III. Collaborators

Marcia Endres, University of Minnesota
Les Hansen, University of Minnesota
Glenda Pereira, University of Maine
Mike Schutz, University of Minnesota
Dave Zeigler, University of Minnesota SROC
Kirsten Sharpe, University of Minnesota WCROC

## IV. Progress and Principal Accomplishments within one or more objectives

**Growth and health costs of dairy calves raised in individual, pair, or group housing compared with dairy calves raised on cows.** The objective of this study was to determine growth, health treatment costs, and incidence rate for scours, respiratory issues, and other health treatments of dairy calves raised in individual (I), pair (P), group (G), or dam- raised (D) housing systems. The study was conducted at the University of Minnesota West Central Research and Outreach Center, Morris, MN, dairy. Two hundred thirty-nine Holstein and crossbred calves were randomly assigned to housing treatments by birth order during three calving seasons from September to December 2020, March to May 2021, and September to November 2021. The I, P, and G raised calves were introduced to a housing system at 3 d and were fed 10 L of milk per d. Calves raised by their dam were isolated with the dam for 3 d and introduced to a larger group where they suckled ad libitum. All calves were weaned at 63 d. Data were analyzed using PROC MIXED and FREQ of SAS. Independent variables were the fixed effects of breed, pen, birthweight, season, and treatment, and pen within season was a random effect. Hip height was not different ($P > 0.05$) for I, P, G, and D calves. The D calves had higher ($P < 0.05$) weaning weight (113.9 kg vs. 99.3, 101.4, and 102.9 kg, respectively), larger ($P < 0.05$) heart girth (115.2 cm vs. 111, 111.8, and 112.9 cm, respectively), higher ($P < 0.05$) average daily gain (1.15 kg/d vs. 0.98, 0.98, and 0.99 kg/d, respectively), and higher ($P < 0.05$) total gain (75.5 kg vs. 62.1, 62.0, and 64 kg/d, respectively) than I, P, and G calves. The D calves had more ($P < 0.05$) calves triple their birthweight (56.5%) than I, P, and G calves (10.7, 9.3, and 18.3%, respectively). The G calves had higher ($P < 0.05$) health costs ($3.34/calf) than I, P, and D calves ($1.37, $0.27, and $2.20, respectively). Treatments for respiratory and other problems were not different ($P > 0.05$) for I, P, G, and D calves. The G calves had greater ($P < 0.05$) incidence rate for scours (18.3%) than I, P, and D calves (3.57, 1.85, and 10.14, respectively). The results from this study indicate that there are growth advantages to raising dairy calves with their dams during the pre-weaning period.

**Health assessment of calves raised in alternative rearing systems.** The objectives of this study were to investigate the effect of maternal contact on immunoglobulin absorption in the first 24 h of life and the occurrence of diarrhea and respiratory disease in dairy calves raised in alternative systems. Two hundred 41 Holstein (n = 61), ProCross, (n = 118), and GrazeCross (n = 61) calves were evaluated from Fall 2020to Fall 2021. Analysis of passive transfer of immunoglobulins using total serum protein (TSP) was from a MISCO digital refractometer in 2 groups of calves: 1) separated from the dam (n = 170) and bottle-fed 4 L of colostrum in the first 12 h of life, and 2) dam-reared (n = 69) where calves suckled colostrum naturally. At 3 d of age, calves were divided into 4 housing groups: individually housed (n = 56), pair-housed (n = 54), group-housed (6 calves per pen; n = 60), and dam-reared (6 dam-calf pairs per paddock; n = 69). Dam-reared calves suckled milk naturally, while calves from all other treatments received 10L of milk per day until weaning at 63 d of age. Health scores were collected weekly using the Wisconsin Calf Health Scoring Chart until weaning. Statistical analyses for TSP were performed using PROC MIXED of SAS, and fixed effects were season, breed, and housing group. For health scores, analyses included PROC FREQ and PROC GLIMMIX of SAS with housing type, week, calf, breed, and season as fixed effects. There were no significant breed effects on the treatments. The TSP values were higher ($P < 0.05$) in dam-reared calves (TPR: $6.67 \pm 0.32$) than in separated calves (TPR: $6.16 \pm 0.31$). In total, respiratory disease was identified in 1.16% of observations, where 0.61% were from dam-reared calves, 0.29% from pair-housed, 0.20% from group housed, and 0.06% from individually housed calves. Scours occurred in 4.44% of the observations and was higher ($P < 0.05$) in dam-reared calves ($6.9 \pm 1.01$%) than group ($4.1 \pm 0.75$%), pair ($1.1 \pm 0.35$%), and individually ($0.5 \pm 0.23$%) housed calves, but similar in individually and pair-housed calves ($P = 0.15$). The results suggest that dam-reared calves had higher absorption of immunoglobulins and that all rearing systems had a low occurrence of respiratory disease; however, scours were diagnosed more often in dam-reared calves.

**Lying behavior of dairy calves in alternative rearing systems.** The objective of this study was to compare the lying behavior of dairy calves housed in alternative rearing systems before and during weaning. One hundred fifty-nine Holstein, ProCross (Montbéliarde, Viking Red, and Holstein,) and GrazeCross (Normande, Jersey, and Viking Red) calves were evaluated during Fall 2020 and spring 2021. At 3 d of age, calves were fit with IceTag (IceRobotics, Scotland) sensors on the right hind leg and divided into 4 housing groups: individually housed (n = 36), pair housed (n = 34), group-housed (6 calves per pen; n = 40), and dam-reared (6 cow-calf pairs per paddock; n = 49). Lying time and number of lying bouts were recorded daily until 3 d after weaning (d 63). Statistical analysis of lying time and lying bouts were with PROC MIXED of SAS with housing group, breed, and season as fixed effects. Random and repeated effects of calf and date were included in the model. Before weaning and across breeds, dam-reared calves (16.24 ± 0.17 h/d) spent fewer hours lying ($P < 0.0001$) compared with individually raised (17.91 ± 0.19), pair-housed (17.37 ± 0.19), and group-housed (17.24 ± 0.18) calves. Individually housed calves had more lying hours ($P < 0.05$) than all other housing systems. Group and pair-housed calves had similar lying times ($P = 0.57$). During weaning, group-housed (15.11 ± 0.33) had more lying hours per day ($P < 0.05$) compared with dam-reared calves (13.84 ± 0.28) and individual calves (14.22 ± 0.19). Pair-housed (14.51 ± 0.4) did not differ from any other housing group. There was no difference in the number of lying bouts before weaning; however, after weaning, dam-reared calves (24.17 ± 0.73) had a higher number of lying bouts than group calves (21.6 ± 0.8), but no differences between other housing systems were observed. The results suggest that pre-weaned calves individually housed spent more time resting, while dam-reared calves spent more time performing other activities. During weaning, group-housed calves spent more time resting than dam-reared and individually housed calves.

**Comparison of three-breed rotational crossbreds of Montbéliarde, Viking Red, and Holstein with Holstein cows fed two alternative diets for dry matter intake, production and residual feed intake.** The objective of this study was to compare 3-breed rotational crossbred (CB) cows of the Montbéliarde, Viking Red, and Holstein (HO) breeds with HO cows fed two alternative diets for dry matter intake (DMI), fat plus protein production (CFP), body weight (BW), body condition score (BCS), feed efficiency and residual feed intake (RFI) from 46 to 150 DIM during first lactation. The CB cows (n = 17) and HO cows (n = 19) calved from September 2019 to March 2020. Cows were fed either a traditional TMR diet (TRAD) or a higher fiber, lower starch TMR diet (HFLS). The HFLS had 21% more corn silage, 47% more alfalfa hay, 44% less corn grain, and 43% less corn gluten feed than the TRAD. The two diets were analyzed for dry matter content, crude protein, forage digestibility, starch, and net energy for lactation. Daily milk, fat, and protein production were estimated from twice monthly milk recording with random regression. The RFI from 46 to 150 DIM was the residual error from regression of DMI on milk energy, metabolic BW, and the energy required for change in BW. Statistical analysis of all variables included the fixed effects of diet, breed group, and the interaction of diet and breed group. The CB cows fed HFLS had less ($P < 0.05$) DMI, and lower ($P < 0.05$) DMI/BW compared with the HO cows fed TRAD. For CFP, CB and HO cows were not different ($P > 0.05$) when fed TRAD or HFLS. Furthermore, the CB cows fed HFLS had higher ($P < 0.05$) BW compared with HO cows fed HFLS. The CB cows fed TRAD had higher ($P < 0.05$) BCS than HO cows fed TRAD and HO cows fed HFLS. The HO cows fed TRAD had more ($P < 0.05$) DMI and lower fat plus protein production per kg of DMI compared with the HO cows fed HFLS. Furthermore, mean RFI from 46 to 150 DIM was lower and more desirable for CB cows fed HFLS compared with HO cows fed TRAD. Dairy producers may feed either TRAD or HFLS to CB cows without loss of CFP.

**Effects of multimodal pain relief on stress in disbudded dairy calves under organic management.** Disbudding is a standard procedure on most dairy farms, but organic options to alleviate pain are limited. White willow bark (WB) is commonly used to reduce pain in dairy calves under organic management. Dull It (DU) is a tincture of organic alcohol, apple cider vinegar, WB, St. John's Wort, chamomile, arnica, and fennel. The objective of this study was to assess the analgesic effects of oral WB and DU on the heart rates, salivary cortisol concentration, and lying behavior of disbudded Holstein and crossbred dairy calves. Calves were disbudded with a hot iron between 5 to 7 weeks of age (Mean = 44 d) and randomly assigned to 1 of 3 treatments: Lidocaine only (LID; n = 18), Lidocaine and DU (n= 18), or Lidocaine and WB (n = 17). Polar H10 monitors recorded heart rates continuously during the 5-h study period; readings were averaged in 5-min intervals. HOBO loggers recorded lying behavior during the study and the following 3 d in 1-min intervals. Saliva samples were collected from 30 randomly selected "minimally-invasive" (MIN) calves 1 h before disbudding, at the time of disbudding, 5 min, 10 min, and every 30 min until 240 min after disbudding; the remaining 23 calves served as a "non-invasive" (NI) group to control for stress from repeated sampling. Results were analyzed with the fixed effects of treatment, group (NI or MIN), time, and the interactions of treatment, group, and time, with calf as a random effect. There was no main effect of treatment on heart rate or cortisol concentrations. The heart rates of MIN WB calves were above baseline in 30 (of 48) 5-min intervals post-disbudding ($P < 0.05$); by comparison, heart rates of NI WB calves were above baseline in only 2 intervals post-disbudding ($P < 0.01$), MIN LID calves were above baseline in 3 intervals ($P < 0.05$) and MIN DU calves were above baseline in 1 interval ($P < 0.05$). Cortisol concentrations of DU calves (100.40 pg/mL) were higher ($P < 0.05$) than WB calves (88.37 pg/mL); neither DU nor WB differed from LID. There was no difference in lying behavior between treatments. These findings indicate that DU and WB offer little to no analgesic effect.

**Effects of willow bark (Salix) on pain and stress in recently disbudded organic dairy calves.** White Willow Bark (Salix) is commonly used to alleviate pain in disbudded calves under organic management, but there is no scientific evidence that willow bark (WB) has an analgesic effect in cattle. The objective of this study was to evaluate the effect of an oral WB bolus on heart rate, salivary cortisol, ocular temperature, and lying behavior of 42 Holstein and crossbred heifer calves disbudded between 4 to 7 weeks of age (Mean = 42 d). Calves (n = 14 calves per treatment) were randomly assigned to 1 of 3 treatments: hot-iron disbudding with lidocaine (5 mL per horn bud), hot-iron disbudding with oral WB (200 mg/kg), or a cold iron "sham" disbudding. Thermal images of the eye and saliva samples were collected 1 h before disbudding, at the time of disbudding, 5 min, 10 min, and every 30 min until 240 min after disbudding. Polar H10 heart rate monitors recorded heartrates continuously throughout the 5-h study period; readings were analyzed in 5-min intervals. HOBO loggers recorded lying behavior during the study period and the following 2 d in 1-min intervals. Results were analyzed with the fixed effects of treatment, time within the study, and the interactions of treatment and time, with calf as a random effect. The mean heart rate of sham calves was lower than both lidocaine ($P < 0.05$) and WB calves ($P < 0.001$) by $11.44 \pm 4.13$ bpm and $14.71 \pm 4.21$ bpm, respectively. The WB calves' heart rates were $11.64 \pm 5.78$ bpm higher than lidocaine calves during the 5 min immediately following disbudding ($P < 0.05$) and $17.00 \pm 5.72$ bpm higher during the next 5 min ($P < 0.05$). Salivary cortisol concentrations were higher in lidocaine calves (98.93 pg/mL, $P < 0.001$) and WB calves (108.03 pg/mL, $P < 0.001$) than sham calves (87.44 pg/ mL). Cortisol peaked 90 min after disbudding in WB calves (146.161 pg/mL; $P < 0.001$) and 120 min after disbudding in lidocaine calves (121.98 pg/mL; $P < 0.05$). No differences were observed for ocular temperature or lying time or bouts. These results indicate that neither WB nor lidocaine alone are sufficient for relieving disbudding-related pain in dairy calves.

**Precision technologies to improve dairy grazing systems.** Pasture-based dairy herds continue to grow around the world as the demand for sustainable farming practices increases. Grazing dairy producers may benefit from the utilization of precision dairy technologies. The application of precision dairy technologies on grazing dairy farms has the potential to improve animal welfare, increase farm efficiency, and reduce costs. However, the adoption of precision technologies on grazing farms is still a challenge because of the lack of research-based information that addresses the accuracy of wearable cow technologies in grazing-based systems. Precision dairy technologies have provided novel information about activity, rumination and grazing behavior of various breeds in pasture-based systems. Previous research with wearable technologies of cows has indicated that rumination, eating, and no activity has high correlations ($r = 0.65$ to $0.88$) with visual observation; however, activity may be difficult to record in grazing herds. Grazing is a complex behavior to define because cows may walk to an area and stop to eat or continuously walk and take bites of grass from the pasture. However, grazing behavior data collected with wearable technologies was highly correlated ($r = 0.92$ to $0.95$) with visual observations. Grazing is a behavior that should continue to be explored especially with precision dairy technologies. Accurate pasture biomass measurements can improve efficiency and production of pastured dairy cows; however, few farms use technology to determine forage availability. Therefore, using dairy technologies to monitor pasture forage may provide a potential benefit for grazing-based dairy farms. Current satellite technology with normalized difference vegetation index (NDVI) and electronic rising plate meters may provide new technologies for farms to monitor pasture forage biomass and fine-tune grazing within pastures. In the future, pasture-based dairy farms may rely on virtual fencing, drones to detect animal health issues and forage availability, and autonomous vehicles to move cattle and to detect weeds on pasture.

**Evaluation of pasture biomass from cool-season and Kernza pastures with satellite imagery compared to an electronic plate meter.** Evaluation of pasture biomass measurements aids producers in knowing the availability of cool season grass in in pasture for cattle grazing. The objective of this study was to compare pasture forage biomass from satellite imagery and an electronic plate meter. The study was conducted at the University of Minnesota West Central Research and Outreach Center, Morris, MN grazing dairy from May 2021 to October 2021. The pasture system was composed of cool-season perennials and included mixtures of meadow bromegrass (Bromus riparius Rehmann), meadow fescue (Schedonorus pratensis (Huds.) P. Beauv.), orchardgrass (Dactylis glomerata L.), alfalfa (Medicago sativa L.), red clover (Trifolium pratense L.), white clover (T. repens L.), and intermediate wheatgrass (Thinopyrum intermedium). Grazing height and forage availability were measured weekly in 9 pastures with a Jenquip pasture plate meter (Jenquip, Feilding, New Zealand). Pastures ranged in size from 2.55 ha to 9.7 ha. Satellite images were from Planet Labs PBC (San Francisco, CA) and average normalized difference vegetation index (NDVI) values were calculated weekly for the area inside each pasture. Pearson correlations were from PROC CORR of SAS 9.4 and determined associations of forage biomass from the plate meter and satellite imagery. Forage biomass was analyzed with PROC MIXED and included the fixed effects of pasture (9 pastures) and week with repeated effects. Across the summer grazing season, mean forage biomass was 3,267 kg DM/ ha (range was 2,864 to 3,622 kg DM/ha; $P < 0.05$) from the plate meter and 2,325 kg DM/ha (range was 985 to 3,321 kg DM/ha; $P < 0.05$) from NDVI satellite images. The correlations for specific pastures of the rising plated meter and the satellite image NDVI ranged from 0.074 to 0.91 ($P < 0.05$) and the average correlation was 0.58. Correlations were greater with greater forage availability in the pastures. Alternative methods to calculate the biomass of pastures may provide more advantages for farmers to determine grazing management of pastures.

**Alternative Practices in Organic Dairy Production and Effects on Animal Behavior, Health, and Welfare**. The number of organic dairy farms has increased because of the increased growth of the organic market, higher organic milk price, and because some consumers prefer to purchase products from less intensive production systems. Best management practices are expected from organic dairy farms to ensure animal health and milk production. Organic dairy producers typically transition from conventional systems to avoid chemicals and pesticides, enhance economic viability, improve the environment, and increase soil fertility. Organic dairy producers respect and promote a natural environment for their animals, is also an important component of animal welfare. Organic producers have few options to mitigate pain in dairy calves. In the United States, therapies to mitigate pain for disbudded organic dairy calves are regulated by the US National Organic Program. Organic producers regularly use naturally derived alternatives for the treatment of health disorders of dairy calves, heifers, and cows. Alternative natural products may provide an option to mitigate pain in organic dairy calves. Despite the reluctance to implement pain alleviation methods, some organic farmers have expressed interest in or currently implement plant-based alternatives. Efficacy studies of alternative remedies for organic livestock are needed to verify that their use improves animal welfare. Non-effective practices represent a major challenge for organic dairy animal welfare. The relationship between humans and animals may be jeopardized during milking because first-lactation cows may exhibit adverse behaviors during the milking process, such as kicking and stomping. The periparturient period is particularly challenging for first-lactation cows. Adverse behaviors may jeopardize animal welfare and reduce safety for humans because stressed heifers may kick off the milking unit, kick at milkers, and display other unwanted behaviors in the milking parlor. This may reduce milking efficiency, overall production, and ultimately reduce the profitability of the dairy farm. Positive animal welfare is a challenging balancing act between the three overlapping ethic concerns. Identifying animal welfare deficits in organic livestock production is the first step in capitalizing on these opportunities to improve welfare.

## V. Impact of research to the group's objectives

Group calf rearing offers opportunities to reduce labor and to aid in socializing calves, but performance of group-managed calves in enlarged hutches is not well documented in dairy production systems. Consumers of dairy products are interested in management practices related to raising dairy calves on cows, but research-based studies on this topic are lacking. The maintenance of health and growth of dairy calves is very important in their first few months of life. Successful group feeding of dairy calves is enhanced with aggressive suckling during infancy and early consumption of high-quality calf starter. An on-going research study at the University of Minnesota West Central Research and Outreach Center, Morris, MN dairy will evaluate the growth, health and, most importantly, the economic performance of dairy calves in individual housing, group housing, pair housing, and raising calves with cows on pasture in the context of calf health, behavior, and welfare. Future studies will evaluate the economic impacts, as well as production effects of these calves when they come into milk. The results will help improve the long-term profitability and social sustainability of the dairy industry by improving its public image.

## VI. Work planned for next year

Evaluation of calf rearing and housing systems in organic dairy herds
Evaluation of horned cattle in the milking parlor
Evaluation of The SmaXtec rumen bolus systems for grazing dairy herds.
Evaluation of pasture biomass with satellite imagery
Evulate forage quality of grass and legume species with AgriVoltaics
Improve perennial legume abundance and persistence in mixed forage swards utilized for grazing and conserved feed
Conduct winter feeding trials to determine the alfalfa:red clover ratio that maximize milk

production, quality, and N and energy utilization

## VII. Publications/products


1. Dean, C. J., F. Pena Mosca, T. Ray, B. J. Heins, V. S. Machado, P. J. Pinedo, L. S. Caixeta, N. R. Noyes. Evaluation of contamination in composite milk samples pooled from independently collected quarters within a laboratory setting. Front. Vet. Sci. 9:818778. doi: 10.3389/fvets.2022.818778

2. Haagen, I.W., L.C. Hardie, B.J. Heins, and C.D. Dechow. 2021. Genetic parameters of passive transfer of immunity for US organic Holstein calves. J. Dairy Sci. 104:2018–2026. https://doi.org/10.3168/jds.2020-19080

3. Haagen, I.W. L.C. Hardie, B.J. Heins, C.D. Dechow. 2021. Genetic parameters of calf morbidity and stayability for US organic Holstein calves J. Dairy Sci. 104: 11770-11778. https://doi.org/10.3168/jds.2021-20432

4. Hardie, L., B. Heins, and C. Dechow. 2021. Genetic parameters for stayability of Holsteins in US organic herds. J. Dairy Sci. Volume 104, Issue 4, 4507 – 4515 https://doi.org/10.3168/jds.2020-19399

5. Hardie, L. C., I. W. Haagen, B. J. Heins, and C. D. Dechow. 2022. Genetic parameters and association of national evaluations with breeding values for health traits in US organic Holstein cows J. Dairy Sci. 105:495-508. https://doi.org/10.3168/jds.2021-20588

6. Pearsons, K.A.; Omondi, E.C.; Heins, B.J.; Zinati, G.; Smith, A.; Rui, Y. Reducing Tillage Affects Long-Term Yields but Not Grain Quality of Maize, Soybeans, Oats, and Wheat Produced in Three Contrasting Farming Systems. Sustainability 2022, 14, 631. https://doi.org/10.3390/su14020631

7. Pereira, G.M., B.J. Heins, B. Visser, and L.B. Hansen. 2022. Comparison of 3-breed rotational crossbreds of Montbéliarde, Viking Red, and Holstein with Holstein cows fed 2 alternative diets for dry matter intake, production, and residual feed intake, J. Dairy Sci. https://doi.org/10.3168/jds.2022-21783.

8. Phillips, H.N.; Heins, B.J. Alternative Practices in Organic Dairy Production and Effects on Animal Behavior, Health, and Welfare. *Animals* 2022, *12*, 1785. https://doi.org/10.3390/ani12141785

9. Phillips, H. N., K. T. Sharpe, M. I. Endres, B. J. Heins. 2022. Effects of oral white willow bark (Salix alba) and intravenous flunixin meglumine on prostaglandin $E_2$ in healthy dairy calves. JDS Communications. 3:49-54. https://doi.org/10.3168/jdsc.2021-0138

10. Sharpe, K.T. and B. J. Heins. 2021. Growth, health, and economics of dairy calves fed organic milk replacer or organic whole milk in an automated feeding system. JDS Communications. 2:319-323. https://doi.org/10.3168/jdsc.2021-0084

# Purdue University
# Annual Progress Report –
# Multistate Research Project NC-2042
# 2021-2022

## I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.

### Objectives

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

## II. Personnel

Dr. Jacquelyn Boerman
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## III. Collaborators

Dr. Theresa Casey, Animal Sciences Department, Purdue University

Dr. Rafael Neves, Department of Veterinary Clinical Sciences, Purdue University

Dr. Luiz Brito, Animal Sciences Department, Purdue University

Dr. Amy Reibman, College of Electrical & Computer Engineering, Purdue University

Dr. Mohit Verma, Agriculture and Biological Engineering, Purdue University

Dr. Timothy Johnson, Animal Sciences Department, Purdue University

Dr. Jay Johnson, USDA-ARS

## IV. Progress and Principal Accomplishments within one or more objectives

We have focused on all three objectives of this Multistate project, below are the progress and accomplishments within each objective.

1. We have collected nasal samples from four commercial dairy farms and are working on comparing the nasal microbiome between healthy and sick animals across geographical regions. Several publications are in progress related to these projects. We have collected data from a commercial dairy farm and are evaluating the impact of early life on future performance and factors that impact feeding behavior. Two publications have been published with several more forthcoming.
2. We have completed an animal study evaluating the effect of high oleic soybean oil on production and body weight measurements. We have completed an essential oil study in mid-lactation dairy cows. Both of these will result in publications.

3. We have spent the last 2.5 years developing the Purdue Animal Sciences Data Ecosystem collaborating with Hewlett Packard Enterprises, Agriculture Data Services (Purdue University) to automate data collection and integration from disparate data sources. This has required a considerable amount of data mapping, programming, and troubleshooting to achieve searchable databases using Jupyter notebooks. This has allowed for additional collaboration and we anticipate a considerable amount of research output from this effort.

   We have worked on a collaborative project to develop a paper-based sensor to determine the causative agent of bovine respiratory disease in cattle. The goal is for this to be used cow side and supply veterinarians and farmers with information about what is causing the respiratory disease and if and which antibiotic are recommended.

   We have worked on developing a video analytics system in a pen setting to identify, track and detect attributes of an animal's appearance and behavior. We have been able to predict bodyweight with a video-based system however, we continue to expand the complexity of where we are evaluating animals to try to make it more applicable for dairy farmers. We have begun working on projects related to utilizing video to measure intake of dairy cows in group settings.

## V. Impact of research to the group's objectives

We have published a number of pieces on the physiological changes caused by disrupting the circadian rhythm of dairy cattle. We believe this can be applied to management of dairy cattle to optimize production and minimize health disorders. We have focused on reducing antibiotic usage in animals by evaluating nutraceuticals as a way to improve growth and immune function in dairy calves. Additionally, we have contributed to the development of a paper-based sensor that detects the causative agent for Bovine Respiratory Disease in dairy cattle. This paper-based sensor can be applied to other diseases and has the potential to aid in decision making on farm and reduce the use of antibiotics. We have developed an automated process to collect and integrate data from disparate data sources on farm which will ultimately allow us to answer more complex questions and provide producers with a more complete picture of their problem or question.

## VI. Work planned for next year

1. We will finalize work related to environmental and biological factors that impact early life feeding behavior in dairy calves. We will evaluate the use of autofeeders to provide information that can be used for social network analysis in groups of animals.
2. We will finalize work on supplementing a branch-chain volatile fatty acids to non-lactation, pregnant cows and evaluating its impact on tissue mobilization, milk production in subsequent lactation and efficiency. We will conduct proteomic analysis from muscle biopsies taken during this research project. We will finalize research related to feeding essential oil products as well as feeding high oleic soybean oil to mid-lactation dairy cows.
3. We plan to continue to develop the Purdue Animal Science Data Ecosystem to integrate data from our research facility and commercial dairy farms. This project will allow for automated integration of data and speed up the ability to analyze information for research purposes. We will continue to work on identifying, tracking and obtaining behavior and appearance data from cattle in a group setting using video analytics. We will continue to develop video systems in order to evaluate feed consistency and feed intake of group housed dairy cattle.

## VII. Publications/products

Klopp, R. N., Hernandez Franco, J. F., Dennis, T. M., Cowles, K. E., HogenEsch, H., and Boerman, J. P. 2022. Effects of medium-chain fatty acids on growth, health, and immune response of dairy calves. J. Dairy Sci. 105:7738-7749.

Ceja, G., Boerman, J.P., Neves, R.C., Johnson, N.S., Schoonmaker, J.P., Jorgensen, M.W., and Johnson, J.S. 2022. Technical Note: A procedure to place urinary catheters in 1-week and 6-week-old preweaned Holstein heifer calves for the in vivo evaluation of intestinal permeability. J. Anim. Sci. 100:1-8.

Klopp, R. N., Centeno-Martinez, R. E., Yoon, I., Johnson, T. A., and Boerman, J. P. 2021. Effects of feeding *Saccharomyces cerevisiae* fermentation products on the health and growth performance of Holstein dairy calves through four months of age. J. Dairy Sci. Comm. 3:174-179.

Casey, T., Suarez-Trujillo, A.M., McCabe, C., Beckett, L., Klopp, R., Brito, L., Rocha Malacco, V.R., Hilger, S. Donkin, S.S., Boerman, J.P. and Plaut, K. 2022. Transcriptome analysis reveals disruption of circadian rhythms in late gestation dairy cows may increase risk for fatty liver and reduced mammary remodeling. Physiological Genomics. 53:441-455.

Hurst, T. S., Neves, R. C., and Boerman, J. P. 2022. The effect of early life indicators on future Holstein heifer survivability and first lactation milk production. The Veterinary Journal. 282:105826.

Centeno-Martinez, R. E., Glidden, N., Mohan, S., Davidson, J. L., Fernandez-Juricic, E., Boerman, J. P., Schoonmaker, J., Pillai, D., Koziol, J., Ault, A., Verma, M. S., and Johnson, T. A., 2022. Identifying bovine respiratory disease through the nasal microbiome. Animal Microbiome. 4:15.

Klopp, R. N., Ferreira, C. R., Casey, T. M., and Boerman, J. P. 2022. Relationship of cow and calf circulating lipidomes with colostrum lipid composition and metabolic status of the cow. J. Dairy Sci. 105:1768-1787.

Suarez-Trujillo, A., Hoang, N., Robinson, L., McCabe, C., Conklin, D., Minor, R., Townsend, J., Plaut, K., George, U., Boerman, J., and Casey, T. 2022. Effect of circadian system disruption on the concentration and daily oscillations of cortisol, progesterone, melatonin, serotonin, growth hormone, and body temperature in periparturient dairy cattle. J. Dairy Sci. 105:2651-2668.

Casey, T. M., Plaut, K., and Boerman, J. 2022. Circadian clocks and their role in lactation competence. Domestic Animal Endocrinology. 78:106680.

Klopp, R. N.[G], Yoon, I., Eicher, S. and Boerman, J. P. 2022. Effects of feeding *Saccharomyces cerevisiae* fermentation products on the health of Holstein dairy calves following a lipopolysaccharide challenge. J. Dairy Sci. 105:1469-1479.

# University of Kentucky
# NC2042: 2021-2022 Annual Report

**I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

**Objectives**

1. Optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.
3. Evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility.

II. **Personnel** Joao HC Costa (PIs), Josh Jackson, Morgan Heyes (Co-PIs), Anna Bradtmueller, Melissa Cantor (Completed), Gustavo Mazon, Emily Rice, Megan Sester (PhD students), Brad Kelly, Joao Lovatti, and Emily Michalski (MS students).

III. **Collaborators:** Eric Vanzant, University of Kentucky.

IV. **Progress and Principal Accomplishments within one or more objectives**

Dr Costa's Project:

Objective of the Project:

1- The long-term goal of this research program is to create new management strategies based on the use of precision dairy technologies, especially related to the early detection of diseases, the use of multi-teared algorithms, and the development, application and validation of new technologies.

2- Also, to identify support, concerns, and trust relative to PDTs among producers, other industry stakeholders (e.g. processors, veterinarians, nutritionists, consultants, and extension specialists) and the public, as well as disseminate project findings to dairy producers using extension efforts. We predict that increased familiarity and use of data collected by PDTs will improve producer and other industry stakeholder trust in PDTs as a component of management and animal welfare assessments. Public acceptance is predicted to associate with the extent to which PDTs are perceived to confer welfare improvements to animals.

This research done in the last period provides new insight into the use of precision dairy technologies, the examination of feeding behavior and activity development of calves, and the potential for compost bedded pack barns. Including the new project: "Sustainable precision dairy farming: Bridging animal welfare and stakeholder concerns about the use of precision dairy technologies (USDA-NIFA IDEAS 2020)"

## IV. Impact of research to the group's objectives

Our research station research in the last year provided new insight into the utility of precision technology utilized on dairy farm, investigated the economics of dairy calf raising and benchmarking tools at the farm level. Decision support tools will help dairy farmers understand decision economics and make more informed decisions toward improved profitability. Also, a major objective of our research is the development of new housing systems and nutritional management to dairy calves. Technology research provides new insight into the utility of automated temperature monitoring. Decision support tools will help dairy farmers understand decision economics and make more informed decisions toward improved profitability.
Finally, good animal welfare is paramount to the dairy industry, including producers, processors, distributors, and cooperatives. The development of a new, accurate, and remote welfare assessment benchmark using validated multi-variable precision dairy technologies (PDTs) has the potential to increase the sustainability of the dairy industry. We have been developing a plethora of studies in this area. Also, Four graduate students (1 PhD and 3 MSc) and more than 20 undergraduate students were trained during the execution of this project. These students were able to get experience with livestock precision tools and animal welfare science. During the last few years, Dr Costa was an active speaker in many scientific and extension meetings where many of the findings of this project were reported. Also, Dr Costa in conjunction with the graduate students in this project published several scientific reviews on the topic in leading journals.

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## V. PUBLICATIONS (in the last 12 mo related to this project; 11 shown out of 20 total):


1. Cantor, M. C.[‡], Casella, E., Silvestri, S., Renaud, D. L. and **Costa, J. H. C.**[†]. 2022. Using machine learning and precision livestock farming technology for early indication of Bovine Respiratory Disease status in preweaned dairy calves. Front. Vet. Sci. https://doi.org/10.3389/fanim.2022.852359
2. Truman, C. R., Campler, M. R., **Costa, J. H. C.** 2022. Body Condition Score Change throughout Lactation Utilizing an Automated BCS System: A Descriptive Study. Animals. https://doi.org/10.3390/ani12050601
3. Woodrum Setser, M. M. [‡], Neave, H. W, Vanzant, E., and **Costa, J. H. C.**[†]**.** 2022. Development and utilization of an isolation box test to characterize personality traits of dairy calves. 2022. Frontiers in Animal Sci. https://doi.org/10.3389/fanim.2022.770755
4. Cantor, M. C. [‡], and **Costa, J. H. C.**[†]**.** 2022. Daily feeding and activity behavioral patterns collected by precision technology are associated with Bovine Respiratory Disease in preweaned dairy calves. J. Dairy Sci. https://doi.org/10.3168/jds.2021-20798
5. Cantor, M. C. [‡], Renaud, D. L., Neave, H.W., and **Costa, J. H. C.**[†]**.** 2022. Feeding behavior and activity levels are associated with recovery status in dairy calves treated with antimicrobials for Bovine Respiratory Disease. Sci. Rep. https://doi.org/10.1038/s41598-022-08131-1

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10. Robles, I., Nolan, D., Fendley, A., Stokley, H., France, T., Ferrell, J., and Costa, J H. C†. 2021. Technical note: Evaluation of a commercial on-farm milk leukocyte differential tester to identify subclinical mastitis cases in dairy cows. J. Dairy Sci.
11. Costa, J.H.C. †, Cantor, M.C.‡, and H.W. Neave. 2021. Symposium review: Precision technologies for dairy calves and management applications. J. Dairy Sci.

## UNIVERSITY OF ILLINOIS
## Annual Progress Report
## Multistate Research Project NC-2042
## 2021-2022

**I. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

**Objectives (as listed on the Project's webpage)**
1. Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.
2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.

**II. Personnel**
Felipe (Phil) Cardoso (Project Leader), Laura Fehlberg (PhD student), Anne Rosi (PhD student), Britney Thomas (MS student), Fabiana Cardoso (PhD student), Lizet Garcia (MS student), and Emily O'Meara (MS student).

**III. Collaborators**
James K. Drackley, J. Loor, and D. W. Shike, University of Illinois; Leo Timms, Iowa State University; Lance Baumgard, Iowa State University; M. Akins, University of Wisconsin-Madison; Ken Kauscher, USDA Forage Center; Rodrigo Almeida, UFPR, Brazil; and M. Neves, UFLA, Brazil.

**IV. Progress and Principal Accomplishments within one or more objectives**

**Under objective 1:** Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.

**Effects of feeding rumen-protected lysine prepartum on placental immunometabolic gene expression of Holstein cows**
Our previous studies reported that a prepartum supply of rumen-protected Lys (RPL) alters uteroplacental metabolism and glucose transport. This was demonstrated through increased expression of transcripts involved in energy metabolism (GLUT3, glucose transporter 3; PCK1, phosphoenolpyruvate carboxykinase 1), placental metabolism (FGF2, fibroblast growth factor 2; FGF2R, fibroblast growth factor 2 receptor; and PGF, placental growth factor). Continuing, we aimed to determine the effects of feeding rumen-protected lysine (RPL, AjiPro-L Generation 3, Ajinomoto Heartland Inc., Chicago, IL) prepartum (0.54% DM of TMR) on protein abundance in placental tissue. Sixty-six (n=66) multiparous Holstein cows were randomly assigned to 1 of 2 dietary treatments, consisting of TMR top-dressed

with RPL (PRE-L) or without (control, CON), fed from 27±5d prepartum until calving. After natural delivery (6.87±3.32h), placental samples were collected and flash-frozen in liquid nitrogen to assess protein abundance through Western blot analysis. Data were analyzed using the MIXED procedure in SAS. Placental FGF2 protein abundance (7.47±0.73) was greater (P=0.03) for cows in PRE-L than for cows in CON (5.27±0.73), reiterating the indication of more significant cell differentiation and, consequently, greater metabolic activity in the placenta of cows consuming RPL during late gestation. Additionally, LRP1 (low-density lipoprotein receptor-related protein 1) protein abundance was greater (P=0.03) for cows in PRE-L (0.43±0.06) than cows in CON (0.25±0.06), which could be involved with translocation of glucose transporters to the plasma membrane or could be serving as a sensor of the placental nutritional status, particularly regarding lipid composition. In conclusion, late gestation supplementation with RPL increases the placental protein abundance of FGF2 and LRP1, indicating possible enhanced placental metabolic activity, probably linked to trophoblast proliferation and migration processes.

**Under objective 2:** Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.

**Association of dry matter intake, milk production at early lactation, and endometrial cytology during the transition period in Holstein cows**
A prompt and robust inflammatory response with a substantial influx of PMN (polymorphonuclear cells) in the uterus early postpartum is associated with a reduced incidence of reproductive disorders. However, when excessive, this inflammatory response can lead to cytological endometritis. Endometrial cytology is usually performed at 5 wk postpartum to diagnose cytological endometritis, but uterine immunity has been dynamically active since the calving date. Thus, we aimed to determine the association among peripartal dry matter intake (DMI), milk production, and endometrial cytology at 15 days in milk (DIM; CYT15) and at 30DIM (CYT30). We conducted a pooled statistical analysis of 5 studies, including data from 205 multiparous Holstein cows. Cutoff values for the PMN percentage were determined by taking the median value of the data set for PMN percentage at 15 DIM (24%) and 30DIM (7%). Based on the cutoffs for PMN %, cows were categorized as follows: L_O_W_1_5_ _(_P_M_N_ _%_ _a_t_ _1_5_ _D_I_M_ _≤2_4_%_)_,_ _H_I_G_H_1_5_ _(_P_M_N_ _%_ _a_t_ _1_5_ _D_I_M_ _>_2_4_%_)_,_ _LOW30 (PMN % a_t_ _3_0_D_I_M_ _≤7_%_)_;_ _a_n_d_ _H_I_G_H_3_0_ _(_P_M_N_ _%_ _a_t_ _3_0_D_I_M_ _>_7_%_)_._ _D_a_i_l_y_ _D_M_I_ _a_n_d_ _w_e_e_k_l_y_ _m_i_l_k_ _production by cow were used in the database. Statistical analyses were performed using SAS's MIXED, GLIMMIX, and LOGISTIC procedures, considering cow as the experimental unit and experiment as a random effect. Cows in HIGH15 consumed on average 1.97±0.5 kg of DM/d less than cows in LOW15 during prepartum, and 3.01±0.5 kg of DM/d less during postpartum (P<0.01). Additionally, the milk yield of cows in HIGH15 tended to be lower than cows in LOW15 on wk 3 through 5 postpartum (P=0.08). Furthermore, for every 0.90kg of daily DMI decrease prepartum, the odds of cows being classified as HIGH15 increased by 4.72 (P<0.01, 95%CI 2.59-8.62). There was no association between CYT30 and DMI nor m_i_l_k_ _p_r_o_d_u_c_t_i_o_n_ _(_P_>_0_._1_8_)_._ _I_n_ _c_o_n_c_l_u_s_i_o_n_,_ _t_h_e_ _a_s_s_o_c_i_a_t_i_o_n_ _o_f_ _D_M_I_ _a_n_d_ _m_i_l_k_ _p_r_o_d_u_c_t_i_o_n_ _w_i_t_h_ _CYT15, but not with CYT30, suggests that uterine health diagnostics at an earlier stage may demand nutritional adjustments to help prevent the negative impact of cytological endometritis on cows' performance.

**Effects of feeding non-toxigenic clostridia and Bacillus on performance during the prepartum period in Holstein cows**

There is scarce evidence on the effects of non-toxigenic clostridia (Clostridium beijerinckii) and the combination of non-toxigenic clostridia and Bacillus (Certillus, Arm and Hammer Animal Nutrition, Waukesha, WI) on animal performance. This experiment was conducted to determine the effects of feeding non-toxigenic clostridia (0.001%DM of TMR) and Bacillus (20g/cow/d) from -25±5 d prepartum to calving on performance of Holstein cows. Seventy-one multiparous Holstein cows, blocked by parity, previous 305-d mature-equivalent milk production, expected calving date, and BCS during the far-off dry period were assigned to 1 of 4 dietary treatments in a randomized, complete block design. Treatments consisted of TMR top-dressed prepartum with Bacillus (CER), C. beijerinckii (BJE), C. beijerinckii plus Bacillus (CBJ), and neither C. beijerinckii or Bacillus (CON). During the first week on experiment, cows were fed a basal diet and observations for the variables were used as a covariate. Dry matter intake (DMI) was obtained daily; and BW and BCS weekly. Colostrum was obtained from each cow at the first milking following calving and IgG concentration were recorded immediately following collection using a refractometer (BRIX, MISCO PA202x-400, Solon, OH). Statistical analysis was performed using the MIXED procedure of SAS. There were no treatment effects for cows in CON, BJE, CER, and CBJ for DMI (12.9, 13.6, 12.4 and 13.0±0.4 kg/d, respectively), DMI as a percentage of BW (1.62, 1.72, 1.64 and 1.56±0.1 %, respectively), BW (819, 828, 830 and 83±7.5 kg, respectively), BCS (3.2, 3.3, 3.2 and 3.2±0.04, respectively) BW change (week -3 to -1) (34.3, 4.72, 42.9 and 7.6±0.4 Kg, respectively), colostrum yield (6.0, 6.0, 7.7 and 7.2±1.0 Kg, respectively) or colostrum IgG concentration (7670, 7080, 7631 and 6930±4.2 mg/dL, respectively). There was a tendency ($P = 0.09$) for a treatment by week interaction for DMI. In week -1 cows in BJE tended to have greater DMI of (13.01±0.5 kg/d) than cows in CER (10.72±0.5 kg/d). In conclusion, C. beijerinckii or Bacillus supplementation did not seem to neither harm or improve dairy cow`s performance prepartum even though, on week -1, cows receiving Bacillus had lower DMI than cows receiving C. beijerinckii.

**Effects of total mixed ration moisture content on its temperature stability**

Total mixed rations (TMR) with high moisture content are known to spoil more frequently during increased environmental temperatures. High temperatures are indicative of spoilage and decreased nutritional value of feeds. The objective of this study was to investigate the effects of water inclusion on feed temperature of a dry cow diet with inclusion of wheat straw (37% of total dietary DM). A total of six (n= 6) gallon size buckets were randomly allocated into 2 treatment groups: NW (with no water added; 49% DM) and WW (with 7.3 kg of water added to the mixture; 43 % DM). Feed temperature recording began once buckets were filled with their corresponding treatments using data loggers (n = 3 per bucket; Thermochron iButtons, iButtonLink, Whitewater, WI), that were placed in the bottom, middle and top of each bucket. The average temperature for all locations was used. Data loggers were set to 5-minute increments and the hourly average for 24 h (24 time points). In addition, data loggers (n = 3) were placed outside of the buckets to register ambient temperature. Following the 24-h period, data were collected and analyzed using the MIXED procedure in SAS. There was no treatment effect ($P = 0.21$); for feed temperature (NW = 29.11 ±0.76 oC and WW = 30.55 ±0.76 oC). A main effect of time point (h) was observed ($P < 0.0001$). There was a tendency for a treatment by time interaction ($P = 0.10$) where feed temperature tended to be higher for WW (34±1.57, 34±1.49, 34±1.41, 34±1.39, 34±1.43, 34±1.50, 34±1.56oC) than NW (30±1.57, 30±1.49, 30±1.41, 31±1.39, 31±1.43, 32±1.50, 33±1.56 oC) at 18, 19, 20, 21, 22, 23 and 24 h, respectively. In conclusion, water added to a dry cow TMR seem to impact feed temperature after 18 h of its preparation. During warmers days, two-times a day feeding should be beneficial.

## V. Impact of research to the group's objectives

**Under objective 1:** Optimize calf and heifer performance through increased understanding of feeding strategies, management systems, well-being, productivity and environmental impact for productivity and profitability.

- Neonatal growth and development should be one of the main focus in dairy production systems. It is well established that methionine and lysine are the most limiting amino acids in diets fed to dairy cattle. In this experiment, calves from cows fed rumen-protected lysine (RPL) prepartum had increased body weight during the first 56 days of life when compared to calves from cows that did not consume RPL. Furthermore, calves from dams that were fed RPL had improved overall health (i.e., days medicated) compared to those without. Providing cows with adequate metabolizable lysine prepartum is important to ensure offspring growth and health for improved early life performance.

**Under objective 2:** Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.

- Dietary formulation and feeding management during the dry period, peripartal period, and early postpartum (fresh) period may facilitate or interrupt many of the steps for metabolic adaptation before pregnancy is established and maintained. Allowing cows to have adequate nutritional status is paramount for improved health, milk production, and fertility. Feeding dairy cows controlled-energy diets with negative DCAD and rumen-protected methionine and rumen-protected lysine during the prepartum period may improve their performance. These nutritional strategies may have a maximum effect when used together.
- Overall, when cows consumed RPL during the transition period, there were improved biomarkers related to liver function and a decreased inflammatory status, with minimal changes to liver composition. A tendency for increased concentrations of albumin in conjunction with decreased concentrations of haptoglobin in the blood and downregulation of hepatic mRNA expression of SAA3 postpartum when RPL is consumed prepartum indicates a lesser acute phase response, and therefore, increased liver function and decreased inflammation. A tendency for downregulation of hepatic m_R_N_A_ _e_x_p_r_e_s_s_i_o_n_ _o_f_ _I_L_1_β _p_r_e_p_a_r_t_u_m_,_ _I_L_8_ _p_o_s_t_p_a_r_t_u_m_,_ _and downregulation of SOD1 postpartum with RPL is consumed prepartum indicates a lesser immune response during the transition period. Combined with a tendency for increased oxidative burst capacity of monocytes, cows that consumed RPL likely were able to control immune activation while maintaining liver function.

## VI. Work planned for next year

- Continue to work on aspects of amino acid nutrition and better understanding of the connection between nutrition and reproduction.

## VII. Publications/products

### Articles in Journals (in print or accepted)

1) Pate, R.T., D. Luchini, J.P. Cant, L.H. Baumgard, and F.C. Cardoso. (2021). Immune and metabolic effects of rumen-protected methionine during a heat stress challenge in lactating Holstein cows. Journal of Animal Science. 99:skab323.

2) Liang Y., N. Ma, D.N. Coleman, F. Liu, Y. Li, H. Ding, F.F. Cardoso, C. Parys, F.C. Cardoso, and J.J. Loor. (2021). Methionine and Arginine Supply Alters Abundance of Amino Acid, Insulin Signaling, and Glutathione Metabolism-Related Proteins in Bovine Subcutaneous Adipose Explants Challenged with N-Acetyl-d-sphingosine. Animals. 11:2114.
3) Liang Y., F.F. Cardoso, C. Parys, F.C. Cardoso, and J.J. Loor. (2021). Branched-Chain Amino Acid Supplementation Alters the Abundance of Mechanistic Target of Rapamycin and Insulin Signaling Proteins in Subcutaneous Adipose Explants from Lactating Holstein Cows. Animals. 11:2714.
4) Thomas, B.L., L.K. Fehlberg, A.R. Guadagnin, Y. Sugimoto, I. Shinzato, and F.C. Cardoso. (2021). Feeding rumen-protected lysine to dairy cows prepartum improves performance and health of their calves. Journal of Dairy Science. S0022-0302(21)01052-3. doi: 10.3168/jds.2021-20545.
5) Underwood, J., J. Clark, F.C. Cardoso, P. Chandler, J.K. Drackley. (2021). Production, metabolism, and follicular dynamics in multiparous dairy cows fed diets providing different amounts of metabolizable protein prepartum and postpartum. Journal of Dairy Science.105:4032-4047.
6) Ma, N., Y. Liang, D.N. Coleman, Y. Li, H. Ding, F. Liu, F.F. Cardoso, C. Parys, F.C. Cardoso, X. Shen, and J.J. Loor. (2022). Methionine supplementation during a hydrogen peroxide challenge alters components of insulin signaling and antioxidant proteins in subcutaneous adipose explants from dairy cows. Journal of Dairy Science. 105:856-865.
7) Ma, N., Y. Liang, F.F. Cardoso, C. Parys, F.C. Cardoso, X. Shen, and J.J. Loor. (2022). Insulin signaling and antioxidant proteins in adipose tissue explants from dairy cows challenged with hydrogen peroxide are altered by supplementation of arginine or arginine plus methionine. Journal of Animal Science. In Press.

**Conferences (national and international)**

1. Rumen-Protected Amino Acids by Kemin EMENA. Title: “Transition Cow Management and its Impact on Cow’s Health, Production, and Reproduction.” (on-line due to COVID-19). Approximately 100 participants. March 17, 2021, Europe.
2. Eurotec Nutrition Argentina Technical Seminar. Title: “Practical considerations and the effects of feeding dairy cattle with rumen-protected amino acids.” (on-line due to COVID-19). Approximately 40 participants. April 14, 2021, Argentina.
3. Feedinfo Webinar – Tackling Sustainability Challenges in Ruminants Production. Title: “Dairy Industry and the Environment.” (on-line). Approximately 280 participants. April 22, 2021, England.
4. Mole Valley Farmer Feed Solutions Webinar. Title: “Low Protein Diets – The Ultimate Answer?” (on-line due to COVID-19). Approximately 80 participants. July 28, 2021, Devon, England.
5. The Amino Acid Summit by Kemin Animal Nutrition. Title: “Transition Cow Management and the Impact of Rumen-Protected Amino Acids on Cow’s Health, Production, and Reproduction.” (on-line due to COVID-19). Approximately 300 participants. September 8, 2021, Singapore.
6. U.K. Progressive Dairy Nutrition Roundtable. Title: “What’s New in Transition Cow Feeding?” (on-line due to COVID-19). Approximately 20 participants. October 14, 2021, England.
7. Animal Feed Manufactures Association Symposium. Title: “Transition Cow Management and its Impact on Cow’s Health, Production, and Reproduction.”

(on-line due to COVID-19). Approximately 400 participants. October 19, 2021, Pretoria, South Africa. 8. LATEC – Dairy Nutritionists Webinar. Title: "Balancing Diets for Amino Acids and its Impact on Health, Production, and Reproduction." (on-line due to COVID-19). Approximately 60 participants. October 21, 2021, Puerto Vallarta, Mexico.
9. Biotrigo Dia de Cocho Symposium. Title: "Dietary Recommendations for Cows During the Transition Period." (on-line due to COVID-19). Approximately 200 participants. October 28, 2021, Passo Fundo, Brazil.
10. Galaxis E-Learning Platform Webinar. Title: "A View Behind the Scenes of Transition Cow Success." (on-line). Approximately 860 participants. December 14, 2021, Osnabrück, Germany.
11. United Kingdom webinar "Unravelling the secrets of transition success" by Kemin Animal Nutrition. Title: "Optimising transition with an anionic ration for a power start." (on-line). Approximately 400 participants. February 24, 2022, Southport, UK.

**On-line**
1. PaperCast (podcast and videos). https://dairyfocus.illinois.edu/media-library/videos/

# U.S. Dairy Forage Research Center
# Annual Progress Report
# Multistate Research Project NC-2042
# 2021-2022

**II. Project: Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises.**

**Objectives (as listed on the Project's webpage)**

2. Optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management.

**II. Personnel:** Kenneth Kalscheur, USDA-ARS, U.S. Dairy Forage Research Center

**III. Collaborators**

**IV. Progress and Principal Accomplishments within one or more objectives**

Four projects were conducted under Objective 2, investigating dairy cow performance by improving nutrition, forage utilization, technology and management. The objective of the first study was to evaluate the effect of rearing dairy heifers on pasture or in confinement on first lactation performance. Thirty-six Holstein heifers (5 ± 0.8 mo old) were raised under two different practices. Eighteen heifers (BW = 167 ± 26.2 kg) were rotationally grazed on cool-season grass pastures for 5 mo in the first year, and 6 mo in the second-year grazing season (3 paddocks of 6). In parallel, 18 heifers (BW = 167 ± 26.4 kg) were reared in a free-stall barn (3 pens of 6). Heifers in confinement were fed a TMR for growing dairy heifers, and heifers on pasture were fed a commercial calf-starter as supplement (0.5% BW/d) to ensure to support adequate ADG. In the winter (6 mo), all heifers were housed in confinement and fed the same diet. After calving at 24.4 mo (±1.2) of age, animals were managed identically during the first lactation. Milk yield and composition, DMI, and BW were recorded at 50, 100, 150, and 200 DIM, and treatments compared using repeated-measures ANOVA. Total milk production, fat, and protein were recorded for the first lactation (305 d), and least square means compared by T-test statistics. Heifers reared on pasture resulted in greater milk yield (+3.54, +4.05, +4.31, +6.40 kg; P=0.007), greater DMI (+1.80, +1.04, +0.64, +1.80 kg; P=0.0143), and greater MUN (+1.27%, +0.72%, +0.90%, +0.97%; P=0.0436) across DIM compared to heifers raised on confinement. Milk fat, protein, and lactose, body weight, and feed efficiency were not different between the groups (P>0.10). Total milk production (12,337 vs 11,107 kg; P=0.02) and total protein yield (437 vs 358 kg; P=0.04) for the first lactation (305 d) was greater for heifers raised on pasture compared to heifers raised in confinement, whereas total fat yield was similar (P>0.10). In conclusion, raising heifers on pasture can be a strategy to support greater milk production through increased DMI throughout the first lactation.

The objective of the second study was to determine the production effects of feeding isonitrogenous diets formulated with SBM or CM as the primary protein source to mid-lactation dairy cows determined to have low or high residual feed intake (RFI). Holstein cows (115 total – 40 primiparous, 75 multiparous) were screened for 4 wk during early lactation to assess RFI and used in the experiment if RFI was less or greater than 0.5 standard deviations from expected intake. Cows (72 total - 24 primiparous and 48 multiparous) were blocked into groups of 4 by parity and days in milk (DIM). Each block contained 2 low and 2 high RFI cows, with one of each assigned to the SBM or CM diet. Cows remained on diet for 10 wk beginning at 86.5 ± 6.7 DIM. SBM and CM were included in diets at 11.7% and 15.5% [dry matter (DM) basis]. Milk yield, components, DM intake (DMI), feed efficiency (FE), and body weight (BW) were determined weekly. Low RFI cows decreased DMI (25.2 vs. 27.2 ± 0.3 kg/d; $P < 0.01$), increased FE (1.83 vs. 1.76 ± 0.02; $P = 0.03$), and tended to decrease energy-corrected milk (ECM; 45.8 vs. 47.6 ± 0.8 kg/d; $P = 0.10$) and milk protein yield (1.34 vs. 1.40 ± 0.02 kg/d; $P = 0.06$) compared to high RFI cows. Cows fed CM increased total solids yield (5.79 vs. 5.45 ± 0.10 kg/d; $P = 0.02$) and tended to increase BW (642.7 vs. 633.2 ± 3.8 kg/d; $P = 0.08$), ECM (47.8 vs. 45.6 ± 0.8 kg/d; $P = 0.054$), and fat-corrected milk (44.5 vs. 42.7 ± 0.8 kg/d; $P = 0.10$) compared to cows fed SBM. The diet and wk interaction was significant ($P < 0.05$) for DMI, milk yield, milk fat percent, milk protein percent and yield, total solids percent, and milk lactose yield. These interactions were largely due to increased persistency for cows fed the CM diet versus SBM. Altogether, our data demonstrated that dairy cows increased production when fed a diet with CM as the primary protein source versus SBM. However, responses for cows fed the CM diet were unaffected by RFI status.

The objective of the third study was to evaluate the inclusion of forages with varying fiber digestibility on lactation performance and methane ($CH_4$) emissions of dairy cows. Sixty-four lactating Holstein cows (109±25 DIM) were assigned to 1 of 4 diets using a randomized complete block design with a 2-wk covariate period followed by a 6-wk experimental period. Cow was the experimental unit. Following the production study, cows were allocated to 1 of 4 environmental chambers (2 cows/chamber) for wk 7. Performance and emissions data from wk 7 were used for analysis. Chamber was the experimental unit. Experimental diets were arranged as a 2×2 factorial evaluating two types of corn silages [conventional corn silage (CS) and brown midrib corn silage (BMR)] and two types of alfalfa haylages [conventional (AH) alfalfa haylage and reduced-lignin (RL) alfalfa haylage]. Dry matter intake (DMI) averaged 27.3 kg/d and was not affected by the type of corn silage nor by the type of alfalfa haylage included in the 6-wk production study; however, a trend was observed for corn silage × alfalfa haylage during wk 7 ($P=0.08$). Milk production averaged 45.5 kg/d and was not affected by treatment. No treatment effect was observed for ECM (46.8 kg/d) nor feed efficiency (ECM/DMI=1.72). Milk fat and protein % (3.89 and 2.97%, respectively) were also not affected by treatment. Milk urea nitrogen was greater for cows fed RL compared to cows fed AH (13.9 vs 12.9 mg/dL; $P=0.001$). There were no interactions between the varieties of corn and alfalfa on lactation performance during the 6-wk production study. During the emissions study, an interaction of corn silage × alfalfa haylage was observed for $CH_4$/ECM ($P=0.01$), whereas there was tendency for $CH_4$ emissions (g/d; $P=0.07$). These results indicate that varieties of corn silage and alfalfa haylage with greater digestibility did not improve production measures but did affect methane emissions in the present study.

The objective of the fourth study was to evaluate the effect of different seaweed species on in vitro methane production in a lactating dairy cow diet. Six species of macroalgae collected along the California coast were evaluated for their potential to mitigate in vitro methane emission when supplemented to a lactating dairy cow diet. *Asparagopsis taxiformis*, collected near Santa Catalina Island, and *Gracilaria parvispora*, *Gracilaria andersonii*, *Codium fragile*, *Acrosiphonia coalita*, and *Devaleraea mollis* collected from the central coast, were freeze-dried, ground to pass a 2-mm screen, and added to a lactating dairy cow total mixed ration (TMR) at 2% of the dry matter. The TMR was composed of 30.8% corn silage, 30% alfalfa silage, and 29.2% concentrate feedstuffs. The TMR (control) and the 6 treatment combinations were placed in a bottle with a solution of 3.44:1 of artificial saliva and ruminal fluid in an in vitro gas production system to measure enteric methane production in a randomized complete block design (2 rep/block and 4 blocks). Methane production (G) was measured for 48 hours, logging the time of each 2-mL aliquot produced and then data was fit to a nonlinear equation. Equations developed for each treatment combination were then used to predict total enteric methane emission for a 722-kg dairy cow consuming 27.8 kg/day of TMR. When the cow consumed only TMR, it produced 635 g of methane/day ($A_0$=25.9 g, k=0.148 g/hour, and $T_{Lag}$=4.02 hours). However, when the cow consumed the TMR with 2% *A. taxiformis*, it produced 48.3% less ($P < 0.05$) methane (328 g/day) compared to the TMR. The diets containing *G. parvispora* and *G. andersonii* produced 10.9% (566 g/day) and 9.8% (573 g/day) less ($P<0.05$) methane compared to the TMR. For TMR containing *C. fragile*, *A. coalita*, and *D. mollis,* methane production did not differ ($P>0.05$) from the TMR. In this experiment, *A. taxiformis* was the most effective at mitigating enteric methane production, whereas *G. parvispora* and *G. andersonii* showed moderate reductions in enteric methane production.

## V. Impact of research to the group's objectives

- Heifers raised on pasture supported greater milk production through increased DMI throughout the first lactation compared to heifers raised in confinement.
- Dairy cows increased production when fed a diet with canola meal as the primary protein source compared to cows fed soybean meal as the primary protein source, however, responses for cows fed the canola meal diet were unaffected by RFI status.
- Varieties of corn silage and alfalfa haylage with greater digestibility did not improve production measures, but did affect methane emissions in the present study.
- *Asparagopsis taxiformis* was the most effective at mitigating enteric methane production, whereas *Gracilaria parvispora* and *Gracilaria andersonii* resulted in moderate reductions in enteric methane production in vitro.

## VI. Work planned for next year

- Begin a larger study evaluating heifer raising regimens on growth, methane emissions, and productivity in subsequent lactations.
- Evaluate the inclusion of reduced-lignin alfalfa and maturity on lactation performance and nutrient digestibility of lactating dairy cows.
- Evaluate the inclusion of seaweed on lactation performance and methane emissions of lactating dairy cows.

## VII. Publications/products

***Refereed journal articles***

Fischer, A., X. Dai, and K. F. Kalscheur. 2022. Feed efficiency of lactating Holstein cows is repeatable within diet but less reproducible when changing dietary starch and forage concentrations. Animal. 16:100599.

Pintens, D. A., K. J. Shinners, J. C. Friede, K. F. Kalscheur, M. F. Digman, and D. K. Combs. 2022. Intensive mechanical processing of forage crops to improve fiber digestion. Grass Forage Sci. 77:55-65.

Sikora, M. C., R. D. Hatfield, and K. F. Kalscheur. 2021. Impact of long-term storage on alfalfa leaf and stem silage characteristics. Agronomy. 11:2505.

***Abstracts***

Camisa Nova, C. H. P., K. F. Kalscheur, and G. E. Brink. 2022. First-lactation performance of dairy heifers reared on pasture versus in confinement. J. Dairy Sci. 105 (Suppl. 1):57-58.

Kalscheur, K., S. Gunter, D. Gossard, C. Moffet, M. Schuppenhoaur, M. Graham, S. Hamilton, M. Bukowski, J. Roemmich, T. Thelen, and L. Gardner. 2022. Effect of macroalgal species on in vitro methane production in a lactating dairy cow diet. 8th International Greenhouse Gas & Animal Agriculture Conference; Orlando, FL. p. 165.

Kuehnl, J. M., and K. F. Kalscheur. 2022. Production effects of feeding soybean meal versus canola meal to dairy cows with low versus high residual feed intake. J. Dairy Sci. 105 (Suppl. 1):71.

Nelson, D. J., and K. F. Kalscheur. 2022. Effect of forages with varying fiber digestibility on lactation performance and methane emissions of dairy cows. J. Dairy Sci. 105 (Suppl. 1):373.

# NC-2042 Accomplishments Report

**Project/Activity Number:** NC-2042

**Project/Activity Title:** Management Systems to Improve the Economic and Environmental Sustainability of Dairy Enterprises

**Period Covered:** 10/01/2021 – 11/30/2022

**Date of This Report:** 11/30/2021

**Annual Meeting Dates:** 10/13 – 10/15/2022

**Participants:** Boerman, Jackie (jboerma@purdue.edu) - Purdue University; Schutz, Michael (mschutz@umn.edu) - University of Minnesota and NCRA Administrative Advisor; Heins, Brad (hein0106@umn.edu) - University of Minnesota; Aguerre, Matias (maguerr@clemson.edu) - Clemson University; Chahine, Mireille (mchahine@uidaho.edu) - University of Idaho; Endres, Marcia (miendres@umn.edu) - University of Minnesota; Ferreira, Gonzalo (gonf@vt.edu) - Virginia Tech; De Vries, Albert (devries@ufl.edu) - University of Florida; Erickson, Peter (Peter.Erickson@unh.edu) - University of New Hampshire; Costa, Joao (costa@uky.edu) - University of Kentucky.
Noelia Silva Del Rio (UC - ANR)
Ken Kalscheur (ARS -WI)
Kate Creutzinger (UW-RF)

**Guests:**

Dr Terry W Lehenbauer (UC Davis – VMTRC)
Dr Sharif Aly (UC Davis – VMTRC)
Dr Heidi Rossow (UC Davis – VMTRC)

**Brief Summary of Minutes of Annual Meeting:**

Mike Schutz – NCRA administrative advisor gave an overview of the role of the administrative advisor. The group discussed the dates and the process to have the re-writing done.
Dr Ward volunteered to host in 2023 at North Carolina State by email, a motion was passed to Raleigh, NC to be the location for the 2023 NC2042 meeting.
It was moved and seconded to nominate Dr Albert DeVries as the next secretary
Discussion about new members to be invited to the new project. A list was made of potential experts to be invited to join the group.
First the group reviewed the comments received after last submission. Dr Gonzalo Ferreira lead the discussion.
The objectives of the new project were set after a discussion with the full group.
Station presentations: All stations represented presented their work related to the Multi-State objectives.

**Accomplishments:** Sustainable dairy production remains the focus of your research group. We are focused around three objectives: 1. optimize calf and heifer growth and development by improving feeding strategies, management systems, well-being, new technologies, and environmental impacts for productivity and profitability; 2. optimize dairy cow performance and well-being by improving nutrition, forage utilization, technology, and management; and 3. evaluate whole farm system components and integrate information and technology to improve efficiency, profitability, environmental sustainability and social responsibility. The NC-2042 group has focused research and Extension activities around meeting the objectives listed to improve the sustainable production of milk.

**Short-term Outcomes:** None to report at this time.

**Outputs:** 82 reported peer-reviewed publications from members within the NC-2042 group for 2021 – 2022. We would like to emphasize several review articles that were written through collaborations between NC-2042 members.

**Activities in collaboration:**

1- Virginia Tech in collaboration with University of Idaho delivered educational workshops to farmers about automatic milking systems.
2- Dairy calves nutritional and behavioral research done in collaboration between the University of Kentucky and University of Wisconsin –River Falls
3- Development and demonstration of dairy decision support tools by many members of the group

**Milestones:** In the last year 5 of this 5-year project, we are focused on building collaborations within our group to conduct complementary research and to successfully continue this important research project. We have discussed and were able to frame the re-write of this project.

**Impacts:**

Objective 1: This group in the last year have investigated many aspects of dairy calves' housing, nutrition, and welfare. As example, we have conducted research and published results on the role of supplementing rumen protected AA to the dry cow on performance of their offspring. We have evaluated the growth, health and, most importantly, the economic performance of dairy calves in individual housing, group housing, pair housing, and raising calves with cows on pasture in the context of calf health, behavior, and welfare. We have evaluated the AA requirements of growing animals, and we have evaluated the role of nutraceuticals to reduce the use of antibiotics in dairy calves. The impacts of this work are a more comprehensive understanding of dairy calf growth, health, and economic performance to share with dairy stakeholders.

Objective 2: We have evaluated the feeding value of by-products and co-products. We have conducted research to develop the best management practices for forages including alternative forages in Southeastern conditions. We have evaluated the effect of drought stress on the digestibility of forages. We have evaluated combinations of nutritional strategies fed to dry cows on their subsequent performance in lactation. Finally, we have evaluated the effect of circadian rhythms on dairy cattle health and productivity. The impacts of this research are improvements in nutritional and management of dairy cattle to continue to have sustainable dairy production.

Objective 3: This group has developed new insight into the utility of precision technology utilized on dairy farm, investigated the economics of dairy calf raising and benchmarking tools at the farm level, we  have developed equations to predict associations between dry period length and milk production, culling, and reproduction in subsequent lactations for economic studies. We have developed infographics describing the different revenue programs available to dairy farmers in the United States. .  We have developed decision support tools will help dairy farmers understand decision economics and make more informed decisions toward improved profitability. We have utilized multi-year modeling of dairy farms to maximize the use of manure and harvesting of high-quality forages. We have analyzed the economic value of using beef semen in dairy herds. Finally, we have developed multiple systems to collect and integrate data generated on dairy farms. The impacts of this work are to assist dairy farmers and other stakeholders with decision making on the dairy industry by identifying the complex relationships that exist and giving them tools to utilize the data to aid in decision making.

Across all three objectives, the impact of the NC-2042 group is seen through the research and dissemination of that research to dairy stakeholders to improve the sustainability of dairy production.

**Publications:** Below are an example of the collaborative publications from NC-2042 with a comprehensive list of publications from 2020 – 2021 found at the link below:

https://github.com/jhcardosocosta/NC2042/blob/d7c767eccb152d5c275ded9534348fd85fc7130c/NC-2042%20Publication%20Report%20%E2%80%93%202021-2022_Final.pdf


1. Creutzinger, K. C., K. Broadfoot, H. M. Goetz, K. L. Proudfoot, J. H. C. Costa, R. K. Meagher, and D. L. Renaud. 2022. Assessing dairy calf response to long-distance transportation using conditioned place aversion. J. Dairy Sci. Comm. 3:275-279.
2. Ferreira, G., H. Galyon, A. I. Silva-Reis, A. A. Pereyra, E. S. Richardson, C. L. Teets, P. Blevins, R. Cockrum, and M. J. Aguerre. 2022. Ruminal fiber digestion kinetics within and among summer annual species as affected by the brown midrib (BMR) genotype. Animals 12(19) 2536; https://doi.org/10.3390/ani12192536.
3. Valldecabres A, J. Wenz, F. C. Ferreira, M. Chahine, J. Dalton, M. E. de Haro Marti, M. Rovai, and N. Silva-Del-Río. 2022. Perspective of dairy producers from California, Idaho, South Dakota, and Washington: Health and business implications of the COVID-19 pandemic during the second wave. Journal of Dairy Sci. 105 (2): 1788-1796. https://doi.org/10.3168/jds.2021-20924
4. Ferreira, G., L. L. Martin, C. L. Teets, B. A. Corl, S. L. Hines, G. E. Shewmaker, M. E. de Haro-Marti, and M. Chahine. 2021. Effect of drought stress on ruminal neutral detergent fiber digestibility of corn for silage. Animal Feed Science and Technology 273 (114803).