Title: Modeling the Role of Herd Management on the Relationship Between Production and Reproduction of Dairy Cows

Main participants: Robert Tempelman and Nora Bello
Dept. of Animal Science

Objectives of Project
• To investigate the nature of the association between level of milk production and reproductive performance of dairy cows, taking into consideration the within-herd (cow-level) and between-herd (herd-level) effects of this association.
• To evaluate management factors and herd attributes as potential sources of dissimilarity or complexity in the association.

Main Results and Outcomes
We developed and validated cutting edge statistical methods to model the within herd (cow-level) effects jointly with the between-herd (herd-level) relationships between two traits. The methods allowed us to model these relationships as functions of management or herd factors.

Evidence was overwhelming for the complexity in the association between milk production and reproduction applied to data from commercial Michigan dairies. Most notably, inferred relationships were generally quite different and, in some cases, opposite between cow-level versus herd-level components. Intensive management conditions seemed to contribute to a more favorable association in some cases (e.g., estimated herd calving interval decreased by 1.4±0.1 days per 220 lb increase in cumulative milk yield for herds using recombinant bovine somatotropin) or to a partial alleviation of an overall antagonism in others (i.e., improved reproductive performance among herds implementing more frequent milking schemes).

Perhaps the most significant result in our study was the remarkable complexity in the relationship between milk production and reproduction across herds, even after accounting for known management factors as recorded by DHIA. Understanding the multi-dimensional levels of differences in the associations between milk production and reproductive performance are expected to have direct implications for tailoring dairy management programs that optimize overall dairy cow performance in current production systems.

Take-home Messages
Overall, our research shows that the “one-size-fits-all” idea is overly simplistic to describe the nature of the association between milk production and reproductive performance of dairy cows. Instead, this association is not the same at different levels. That is, the relationship between milk production and
reproduction is such that the delicate intricacies of a cow’s physiology do not necessarily mirror the mechanisms of management at the herd-level in which the individual cow resides. Management practices and herd attributes are potential contributors to the dissimilarity in the nature, as well as the magnitude, of the link between milk yield and reproductive performance.

These results have implications for devising management strategies that jointly could optimize milk production and reproduction of dairy cows. Also, subtle differences in the results were apparent when analyzing long-term versus short-term measures of milk production and reproduction. That is, the mechanisms that underlie performance measures spanning a whole lactation (i.e., cumulative milk yield at 305-d or calving interval) may differ from the mechanisms at work for short-term performance indicators corresponding to a specific point in time (i.e., daily milk yield and pregnancy outcome to first postpartum AI service). For example, our results showed that individual cows with greater lactation yields had longer calving intervals, but herd calving intervals were either shorter or unaffected among herds with highest cumulative 305-d yields.

Conversely, herds with greater milk yields at the time of first insemination had impaired reproductive performance, but within such herds, cows with higher daily milk yields were not any more or less likely to become pregnant to first postpartum insemination than lower yielding herdmates. Clearly, the joint consideration of cow and herd components of the association between milk production and reproduction behave differently on a whole-lactation basis compared with a point in time (short-term). Adjusting management recommendations to each short- and long-term scenario undoubtedly add an extra layer of complexity to the challenge of jointly optimizing milk yield and reproductive performance of dairy cows.

A more comprehensive appreciation for complexity of levels and sources of different factors that affect the association between milk production and reproductive performance may make it possible to suggest management practices to jointly optimize milk production and reproductive efficiency. However, we recognize that, by its own nature, this complexity inferred for the milk production-reproduction association complicates the formulation of general management recommendations. Further, more research undoubtedly can help to clarify what these recommendations may be in specific circumstances, particularly given that significant complexity in these associations remains across herds, even after adjusting for known management factors.

2 Title: National Air Emissions Monitoring Study

Main Participant: Wendy Powers
Dept. of Animal Science

The National Air Emissions Monitoring Study (NAEMS) is now complete and the scientists have submitted their data and reports to EPA to interpret. EPA will use a subcontractor for this work and there is considerable interest in ensuring that EPA considers outside input in the process. A unified approach to estimating emissions from livestock operations around the country is needed. EPA is expected to develop emissions estimates based on the results from the NAEMS.

Through funding obtained by the E. Kirkpatrick Endowment Fund, Michigan State University Extension and research staff were engaged in a process to address the topic of collection, measurement and
reporting of data that contribute to emissions estimates. The specific objective of the project was to help move the development of a nationally recognized standard that estimates emissions from livestock operations. Such an air quality emissions standard might parallel the current American Society of Agriculture and Biological Engineers (ASABE) Manure Production Characteristics Standard D384.2 that is widely used to estimate nutrient volumes and excretions based on dietary inputs.

To kick off the project, a meeting was held February 16, 2010 at the EPA location in Research Triangle Park, NC focusing on emission factors from Annual Feeding Operations (AFOs). Air emissions can be expressed in a number of different ways - based on number of animals and units of product produced. In addition, the most appropriate emission factor for different parts of a farm system (housing, storage, land application) may vary. Further consideration of how air emissions are expressed is needed in order to determine what the appropriate emission factors are for the various components of a farm system. An approach to estimating farm emissions may be as simple as a single emission factor multiplied by a farm-specific variable, something more complex that considers multiple emission factors and farm-specific variable combinations, or an approach that provides for use of either of the previous options.

Further discussion of the topic took place locally in Michigan. In addition, the USDA Ag Air Quality Task Force took up the topic and hosted a meeting at EPA in Research Triangle Park, NC September 27, 2010. As was the goal of the project supported by the E. Kirkpatrick Endowment Fund, the topic was discussed and debated by scientists and industry representatives from around the country. Topics at the meeting included reports from groups tasked with considering how to report emissions units, measurement protocol and standardization, and reporting of mitigation effects. One of the recommendations from the organizing group was to continue to develop the reports as an ASABE Technical Reference. More information about this meeting and the presentations can be obtained from http://www.airquality.nrcs.usda.gov/aaqtf/Documents/index.html.

The project funded by the E. Kirkpatrick Endowment Fund has concluded, however; the work to identify the best means of reporting air emissions continues.

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**Title:** Combination of Borax and Condensed Quebracho Tannins to Treat Stored Dairy Manure for Reduction of Hydrogen Sulfide and Ammonia Emissions

**Main Participants:** Principal Investigators: Melvin Yokoyama¹ and Terence Whitehead², Co-Investigators: Kristen Seymour¹, Susan Hengemuehle¹, Cheryl Spence¹, Robert von Bernuth³, Michael Cotta¹ and Robert Kreft¹

**Institutions:** ¹Dept. of Animal Science, MSU; ²National Center for Agricultural Utilization Research, Bioenergy Unit, USDA, ARS, Peoria, IL; ³College of Agriculture and Natural Resources, MSU.

**Objectives of Project**

- To treat stored dairy manure with different combinations of borax-condensed quebracho tannins in laboratory incubations to determine their effectiveness in reducing hydrogen sulfide and ammonia emissions.
- To quantify the total and sulfate reducing bacterial populations in the treated dairy manure by molecular genetic analyses.
Hydrogen sulfide is a toxic gas that is produced by sulfate reducing bacteria during the storage of livestock manure under anaerobic conditions. Hydrogen sulfide emissions have been rising due to intensive livestock production, posing a risk to both farmers and their livestock. The US Environmental Protection Agency (EPA) is considering regulating hydrogen sulfide emissions along with other greenhouse gas emissions from concentrated animal feeding operations.

Previous research we conducted demonstrated that borax is highly effective in reducing hydrogen sulfide emissions from stored swine manure. Other research conducted by the Bioenergy Unit, United States Department of Agriculture,

Table 1: Summary of significant findings in using a combination of borax and condensed quebracho tannins to treat stored dairy manure for reducing hydrogen sulfide emissions.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent Inhibition of Hydrogen Sulfide</th>
<th>Percent Inhibition of Ammonia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
<td>Trial 2</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.1% Borax</td>
<td>95</td>
<td>86</td>
</tr>
<tr>
<td>0.1% Tannins</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>0.1% Borax + 0.1% Tannins</td>
<td>48</td>
<td>40</td>
</tr>
<tr>
<td>0.1% Borax + 0.2% Tannins</td>
<td>32</td>
<td>37</td>
</tr>
<tr>
<td>0.1% Borax + 0.3% Tannins</td>
<td>15</td>
<td>46</td>
</tr>
<tr>
<td>0.2% Borax + 0.1% Tannins</td>
<td>98</td>
<td>95</td>
</tr>
<tr>
<td>0.2% Borax + 0.2% Tannins</td>
<td>84</td>
<td>42</td>
</tr>
</tbody>
</table>
Agricultural Research Service (USDA, ARS) has demonstrated that condensed quebracho tannins will also inhibit hydrogen sulfide emissions from stored swine manure.

Both borax and tannins were effective in inhibiting hydrogen sulfide and ammonia emissions from stored dairy manure. Borax was found to be more effective than tannins in inhibiting hydrogen sulfide emissions at lower treatment concentrations (Table 1). Tannins were found to be more effective than borax in inhibiting ammonia emissions at lower treatment concentrations. The effects of the borax and tannins are not additive, but complementary. Molecular genetic analyses indicate that tannins reduce the total microbial population of dairy manure and that the sulfate-reducing bacteria population of dairy manure differ from that of stored swine manure.

Adding a combination of borax and tannins to stored dairy manure may reduce the hazard of hydrogen sulfide toxicity to farmers and animals and ensure that dairy farms are in compliance with possible future federal regulations on gaseous emissions, while maintaining environmental sustainability. Follow up studies on farms are needed to confirm this treatment benefit, which might also reduce the contribution of greenhouse gas emissions from stored dairy manure to global warming. The data generated is being considered for a patent disclosure submission.

4 Title: The Potential Impact of Chronic Mammary Gland Infections during Pregnancy of Dairy Cows on Fertility of Their Daughters

Main participants: James Ireland, Danielle Scheetz, Joe Folger, George Smith, Richard Pursley, and Lou Neuder

Dept. of Animal Science

Objectives of Project
- To identify Holstein dairy cows with 0 to 5 Somatic Cell Count (SCC) measurements >200,000 shortly before and during pregnancy.
- To determine if the variation in number of SCC measurements >200,000 per cow is inversely associated with their daughter’s circulating anti-Müllerian (AMH) concentrations as adults. AMH is a
biomarker positively associated with ovary size, number of healthy oocytes in ovaries and ovarian function.

**Expected Main Results and Outcomes**
Completion of this project will firmly establish whether dairy cows with a high number of SCC measurements >200,000 shortly before and during pregnancy also have daughters with a relatively low serum AMH concentration and correspondingly smaller ovaries, lower number of high quality oocytes and diminished ovarian function compared with their age-matched herdmates. The expected inverse association between number of SCC > 200,000 in dairy cows with AMH concentrations in their daughters implies that a chronic mammary infection/inflammation during pregnancy of a dairy cow has a negative impact on ovarian function and potentially reproductive performance of their daughters.

**Main Take-home Messages**
The expected inverse association between number of SCC > 200,000 in dairy cows and AMH concentrations in their daughters will impact the dairy industry by showing for the first time that high quality udder health care of animals during pregnancy is critical to prevent not only mastitis and other opportunistic infections, but also to improve the maternal environment during pregnancy to enhance embryo development and subsequent ovarian function and fertility in their daughters. However, because this project will be conducted on a single herd, an expanded study using multiple herds will be necessary before any new culling criteria can be reliably recommended to producers.

Data in this figure depict the inverse relationship between number of SCC measurements > 200,000 per cow with AMH concentrations in their 11-12 mo old daughters. Results imply that a chronic mammary gland infection such as mastitis during pregnancy may decrease ovary size and function and potentially reproductive performance of their daughters. N = number of heifers, numbers in parentheses indicate percent of herd.

*Figure 1: The inverse relationship between number of SCC measurements > 200,000 per cow with AMH concentrations in their 11-12 mo old daughters.*
Title: Improving Milk Fat Production Through the Targeted Feeding of a C16:0-enriched Fat Supplement

Main Participants: Adam Lock and Michael Allen
Dept. of Animal Science

Objectives of Project
• Determine the effect of a C16:0-enriched fat supplement on feed intake, milk yield, milk fat and milk protein production.
• Examine the potential for a C16:0-enriched fat supplement to minimize the response of cows to a dietary-induced milk fat depression challenge using high moisture corn.
• Establish the impact of a C16:0-enriched fat supplement on milk fatty acid composition.

Background and Significance
Milk components and not milk yield, continue to be the principal driver of producer milk prices. The concentration and yield of milk fat is driven by the nutrition of the dairy cow; in particular, low (or reduced) milk fat % and yield is an important economic issue to dairy farms across the U.S. This was highlighted this year with most months in 2010 in the Mideast Federal Order being well below the 10-year average for milk fat %. For example, using September or October 2010 milk pricing information (from Milk Messenger) the change in milk price when milk fat % dropped from 3.8 to 3.4% was equivalent to $0.96/cwt. Therefore, diets that allow for an improvement in milk fat output would potentially be economically advantageous. This study will determine whether a novel fat supplement that is enriched in palmitic acid (C16:0) is a useful tool for maintaining or increasing milk fat production.

Expected Results and Outcomes
This study is examining the impact of a C16:0-enriched fat supplement on feed intake, milk yield, and milk fat and protein production when compared to non-fat supplemented diet. We expect that the C16:0-enriched fat supplement, compared with the control treatment, will increase milk fat output while having no negative effect on milk protein concentration. We anticipate that the supplement will also mitigate a dietary-induced milk fat depression challenge, either by maintaining pre-challenge milk fat yield or lessening the severity of the drop in milk fat content and yield. Results from the proposed study will provide timely information both to farmers and nutritionists for the formulation of diets to maximize milk composition, thereby increasing revenue.