Dairy Extension Program

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NM-Manure: A Seasonal Prediction Model of Manure Excretion for Lactating Dairy Cows in New Mexico

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Abstract

Environmental concerns from dairy farms arise primarily because of the potential negative impacts of manure and urine excretions by dairy cattle on air, soil, and water resources. In addition, increasing opportunities are arising for using manure as a source of renewable energy. Consequently, it is important to assess the amounts of manure excreted by dairy herds. Regulatory agencies use only a few animal groups and average herd characteristics to estimate steady manure excretion. However, manure excretion varies seasonally and should be predicted based on dynamic herd group characteristics. Prediction parameters are periodically revised and improved by regulatory agencies. This study describes the creation of a stochastic dynamic herd model to predict seasonal manure excretion with improved predictor parameters.

1 Introduction

- Environmental concerns from dairy farms arise primarily because of the potential negative impacts of manure and urine excretions.
- Objective: To develop a stochastic dynamic model of herd performance to predict seasonal manure excretion by using local herd characteristics and better predictor parameters.

2 Materials and Methods

A Stochastic simulation of milking cow dynamics

- A Markov-chain approach (Cabrera et al., 2006; deVries, 2004; St-Pierre and Thraen, 1999) simulates the dynamics of the dairy herd by calculating the number of cows (MC) in each of more than 1,400 to-be-defined cow production stages, by month.

Milking Cows

$MC_{l,i+1,j} = (MC_{l,i,j})(1-CU_{l,m,i})$ for all l, j, and m [1]

Pregnant Cows

$MC_{l,i+1,j+1} = (MC_{l,i,j})(PG_{l,m,i})$ for all l, i=2-12, and m [2]

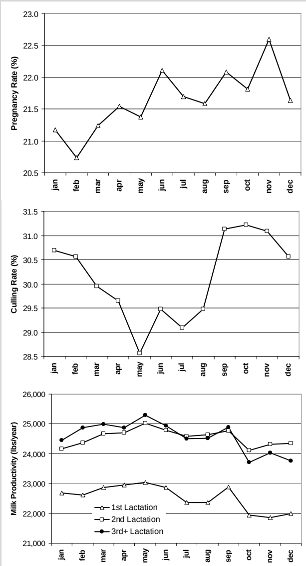
Non-Pregnant Cows

$MC_{l,i+1,0} = (MC_{l,i,0})(1-PG_{l,m,i})$ for all l and m [3]

- To start a simulation, the total number of adult cows in a herd is assigned to the cow state of first lactation, first month of milk, and non-pregnant ($CM_{1,1,0}$). Then, the simulation model distributes these cows and populates all possible cow states.

B New Mexico Indices

- Dairy Herd Improvement Association (DHIA) records for New Mexico, compiled in 2006 by the processing centers of Raleigh, NC (http://www.drms.org/), Provo, UT (http://www.dhiprovo.com/), and Agri-Tech of Visalia, CA (http://www.agritech.com/).
- Monthly data from 23 dairy farms across New Mexico including detailed information of herd size, milk production, pregnancy rates, and culling rates.



Seasonal distribution of Pregnancy rates, culling rates, and milk productivity in New Mexico dairy operations

C Prediction of manure excretion in New Mexico

Me = (MK) (0.72) + (1.45) (i) + 85.37 (lbs) [4]

Nennich et al., 2005

$M_e^m =$

$$\sum_{l=1}^{9}\sum_{i=1}^{18}\sum_{j=0}^{7}(MC_{l,i,j})(i*1.45+0.42*MK_{l,m.i}+85.37)(DY_m) \quad \text{(lbs)} \quad [5]$$

$M_e^d =$

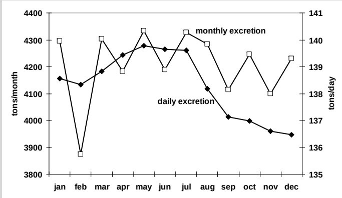
$$\sum_{l=1}^{9}\sum_{i=12}^{20}\sum_{j=7}^{9}(MC_{l,i,j})(83.7)(DY_m) \quad \text{(lbs)} \quad [6]$$

$$M_e^{farm} = M_e^m + M_e^d \quad \text{(lbs)} \quad [7]$$

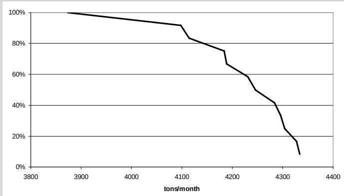
3 Results and Discussion

A Manure Excretion for an Average Dairy in New Mexico

- The model predicted the production of 50,500 tons of wet manure per year for an average dairy farm in New Mexico that has 2,000 adult cows and the average DHIA indices for RHA or milk productivity (23,147 lbs/cow/year), pregnancy rate (21.63%), and culling rate (30.12%). Ninety-three percent of this excretion was accounted to be from the milking cows, while the remaining 7% came from the dry cows.



Manure excretion prediction for a 2,000-cow New Mexico dairy farm

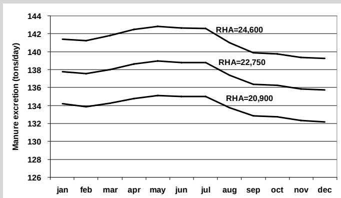


Probability of exceedance of manure excretion in a given month throughout the year

- These manure excretion predictions have strong seasonal variations throughout the year. Excretions are lower during September through December; medium during January through March and in August; and higher between April and July.

B Sensitivity of Manure Excretion to Milk Productivity

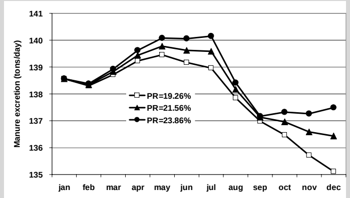
- The excretion of manure varies in direct relation to the RHA, but in lower proportion.



Manure excretion at different milk productivity rates. RHA=Rolling Herd Average

B Sensitivity of Manure to Pregnancy Rate

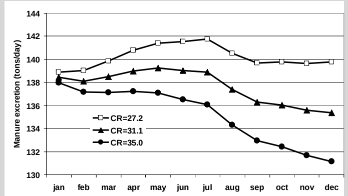
- Higher pregnancy rates leads to more lactating females and therefore greater predicted manure excretion.



Manure excretion at different pregnancy rates

C Sensitivity of Manure to Culling Rate

- Lower culling rates determines more animals remaining in the herd and consequently higher amounts of manure excreted



Manure excretion at different culling rates

4 Conclusions

- Predictions of the seasonal variation of manure excretion creates a better opportunity for calculating manure use and recycling needs, and aids in addressing issues relative to bioenergy production, planning of storage, management, and assessment of environmental impacts.
- This modeling approach is a substantial contribution to current stage of manure prediction in New Mexico.
- This is a "working-in-progress" application, which will be permanently improved and updated.
- This is a "baseline" application, which will serve to integrate other dairy farm components.

5 References

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