Precision Dairy Farming: The Next Dairy Marvel?

Jeffrey Bewley, PhD, PAS

University of Kentucky

seeblue: in the College of Ag

15ème Carrefour des Productions Animales
What is Kentucky Famous For?
Kentucky Dairy Industry

90,000 dairy cows across 958 dairy farms
However You Say It!

Thank you very much
Merci beaucoup
Vielen Dank
Dank u zeer
Technological Marvels

- Tremendous technological progress in dairy farming (i.e. genetics, nutrition, reproduction, disease control)

- Modern dairy farms have been described as “technological marvels” (Philpot, 2003)

- The next “technological marvel” in the dairy industry may be in Precision Dairy Farming
• Fewer, larger dairy operations
• Narrow profit margins
• Increased feed and labor costs
• Cows are managed by fewer skilled workers
Consumer-Centric Approach

- Continuous quality assurance
- “Natural” or “organic” foods
- Pathogen-free food
- Zoonotic disease transmission
- Reducing the use of medical treatments
- Increased emphasis on animal well-being
• Unlimited on-farm data storage

• Faster computers allow for more sophisticated on-farm data mining

• Technologies adopted in larger industries (i.e. automobile or personal computing industries) reduce costs for applications in smaller industries
• Using technologies to measure physiological, behavioral, and production indicators

• Supplement the observational activities of skilled herdspersons

• Focus on health and performance at the cow level

• Optimize economic, social, and environmental farm performance
• Make more timely and informed decisions

• Minimize medication (namely antibiotics) through preventive health

• Precision Dairy Farming is inherently an interdisciplinary field incorporating concepts of informatics, biostatistics, ethology, economics, animal breeding, animal husbandry, animal nutrition and process engineering
Precision Dairy Practice
Management Levels

Operational

- Management by exception (i.e. low milk yield, activity)
- Risk management (i.e. alerts on withhold cows)
- Record keeping (i.e. breeding details, quality assurance)

Tactical

- Proactive management strategies (i.e. predicted calving, predicted heat)
- Intra-herd comparison (i.e. breaking herd into virtual groups)

Strategic

- Long-term decision making and benchmarking (i.e. response to grain, achievement of cow performance targets, labor efficiency)

Adapted from Eastwood, 2008
PDF Benefits

- Increased efficiency
- Reduced costs
- Improved product quality
- Minimized adverse environmental impacts
- Improved animal health and well-being
- Risk analysis and risk management
- More objective (less observer bias and influence)
• Explains an underlying biological process
• Can be translated to a meaningful action
• Low-cost
• Flexible, robust, reliable
• Information readily available to farmer
• Farmer involved as a co-developer at all stages of development, not just beta-testing (Eastwood, 2008)
• Commercial demonstrations
• Continuous improvement and feedback loops
• Precision (individual) feeding
• Regular milk recording (yield and components)
• Pedometers
• Milk conductivity indicators
• Automatic estrus detection
• Body weight
• Temperature
Recent or Future Technologies

- Lying behavior
- Ruminal pH
- Heart rate
- Global positioning systems
- Feeding behavior
- Blood analyses
- Respiration rates
- Rumination time
- Locomotion scoring using image analysis
AfiMilk

- Afilab-milk analyzer
  - Fat, protein, lactose, SCC, blood
- Pedometer + (lying behavior)
- Fat protein ratios-ketosis and SARA ID
- Heat detection
- Mastitis detection
- Calving time prediction
Milk measurements

- Progesterone
  - Heat detection
  - Pregnancy detection
- LDH enzyme
  - Early mastitis detection
- BHBA
  - Indicator of subclinical ketosis
- Urea
  - Protein status
<table>
<thead>
<tr>
<th>Monitor</th>
<th>Parameter Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-D acceleration/movement</td>
<td>Behavior</td>
</tr>
<tr>
<td>Electromyogram</td>
<td>Muscle activity</td>
</tr>
<tr>
<td>Skin potential</td>
<td>Vegetative-nervous reaction</td>
</tr>
<tr>
<td>Skin resistance</td>
<td>Vegetative-emotional reaction</td>
</tr>
<tr>
<td>Skin temperature/Environmental temperature</td>
<td>Thermoregulation</td>
</tr>
</tbody>
</table>
• 100% of predicted BCS were within 0.50 points of actual BCS.
• 93% were within 0.25 points of actual BCS.
<table>
<thead>
<tr>
<th></th>
<th>BCS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BCS</td>
<td>2.50</td>
<td></td>
</tr>
<tr>
<td>Predicted BCS</td>
<td>2.63</td>
<td></td>
</tr>
<tr>
<td>Posterior Hook Angle</td>
<td>150.0°</td>
<td></td>
</tr>
<tr>
<td>Hook Angle</td>
<td>116.6°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BCS</td>
<td></td>
</tr>
<tr>
<td>BCS</td>
<td>3.50</td>
<td></td>
</tr>
<tr>
<td>Predicted BCS</td>
<td>3.32</td>
<td></td>
</tr>
<tr>
<td>Posterior Hook Angle</td>
<td>172.1°</td>
<td></td>
</tr>
<tr>
<td>Hook Angle</td>
<td>153.5°</td>
<td></td>
</tr>
</tbody>
</table>
On-farm evaluation of lying time:

- Identification of cows requiring attention (lameness, illness, estrus)
- Assessment of facility functionality/cow comfort
- Research exploring lying time × milk yield interaction
- Potential metric to assess animal well-being
Possible PDF Technologies

- Stress levels (direct or indirect)
- Pregnancy
- Environment gas levels (i.e. methane)
- Air born pathogen levels
- Pollutants
- Zoonoses
- Image analysis for anatomical measurements
Genetic Evaluations

- Precision Dairy Farming technologies may provide information previously unavailable for genetic evaluations
- New or improved traits (i.e. feed intake, lameness, BCS, heat tolerance, fertility)
- Improved data accuracy (i.e. yield, fat, protein, SCC, health traits)
- Image analysis for conformation traits?
Genetic Evaluations

- Could bull studs supplement technology costs in large progeny test herds in exchange for data?

- Reduction in data collection costs

- May be a new form of product differentiation

- More data, fewer erroneous measurements
• Precision Dairy Farming/genomic synergies may lead to improvement in health traits

• For some traits, not yet able to account for genetic variation

• But, need enough phenotypic data to match the SNP (single nucleotide polymorphisms) data first
Potential Limitations

- Slow adoption rates
- Who pays for what?
- Animal ID read errors
- Animal ID transfers
- Equipment failure
- Data transfer errors/bottlenecks
- Manufacturer differences
- Sensor drift?
- Quality control
- Trait heritability limits
• Maybe not be #1 priority for commercial dairy producers (yet)

• Many technologies are in infancy stage

• Not all technologies are good investments

• Economics must be examined

• Sociological factors must be considered
• Investment decisions for PDF technologies

• Flexible, partial-budget, farm-specific

• Simulates dairy for 10 years

• Includes hundreds of random values

• Measures benefits from improvements in productivity, animal health, and reproduction

• Models both biology and economics
Inputs
- Farm Specific or Industry Averages
- Underlying System Behavior
- Historical Prices
- Technology Costs and Impact

Intermediate Calculations (Modules)
- Herd Behavior
- Random Variables
- Improvements from Technology Adoption

Technology Impact
- Revenues
- Expenses

Project Analysis
- Net Present Value
- Financial Feasibility
- Sensitivity Analysis
Model Modules

- Revenues and Expenses
- BCS Module
- Other Disease Costs
- Disease Milk Loss
- Culling
- Retention Pay-Off
- Disease Incidence
- Reproduction
- Average Cow Simulation
- Herd Demographics
- Stochastic Prices
- Stochastic Variables
- Project Analysis
Automatic BCS Investment

• **Benefits**
  – Reduced ketosis, milk fever, and metritis
  – Improved conception rate at first service
  – Improved efficiency from minimizing BCS loss

• **Costs**
  – Investment
  – Variable costs

• **Management level**

• **1000 simulations**
Net Present Value (NPV)

Simulation Results

- Positive NPV: 86.60%
- Negative NPV: 13.40%

• Results from 1000 simulations
• Positive NPV = “go” decision/make investment
NPV establishes what the value of future earnings from a project is in today's money.
<table>
<thead>
<tr>
<th>Reason</th>
<th>%</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not familiar with technologies that are available</td>
<td>54.89%</td>
<td>101</td>
</tr>
<tr>
<td>Undesirable cost to benefit ratio</td>
<td>41.85%</td>
<td>77</td>
</tr>
<tr>
<td>Too much information provided without knowing what to do with it</td>
<td>35.87%</td>
<td>66</td>
</tr>
<tr>
<td>Not enough time to spend on technology</td>
<td>30.43%</td>
<td>56</td>
</tr>
<tr>
<td>Lack of perceived economic value</td>
<td>29.89%</td>
<td>55</td>
</tr>
<tr>
<td>Too difficult or complex to use</td>
<td>28.80%</td>
<td>53</td>
</tr>
<tr>
<td>Poor technical support/training</td>
<td>28.26%</td>
<td>52</td>
</tr>
<tr>
<td>Better alternatives/easier to accomplish manually</td>
<td>23.37%</td>
<td>43</td>
</tr>
<tr>
<td>Failure in fitting with farmer patterns of work</td>
<td>21.74%</td>
<td>40</td>
</tr>
<tr>
<td>Fear of technology/computer illiteracy</td>
<td>21.20%</td>
<td>39</td>
</tr>
<tr>
<td>Not reliable or flexible enough</td>
<td>17.93%</td>
<td>33</td>
</tr>
</tbody>
</table>

Russell and Bewley, 2009
Sociological Factors

- Labor savings and potential quality of life improvements affect investment decisions (Cantin, 2008)
- Insufficient market research
- Farmers overwhelmed by too many options (Banhazi and Black, 2009)
  - Which technology should I adopt?
  - End up adopting those that are interesting or where they have an expertise
  - Not necessarily the most profitable ones
Technology Pitfalls

• “Plug and play,” “Plug and pray,” or “Plug and pay”

• Technologies go to market too quickly
  – not fully-developed
  – software not user-friendly

• Developed independently without consideration of integration with other technologies and farmer work patterns

• Too many single measurement systems
Technology Pitfalls

- Inappropriate process models
- Lack of large-scale commercial field trials and demonstrations
- Technology marketed without adequate interpretation of biological significance of data
- Information provided with no clear action plan
Australian Case Study

• R&D tends to focus on the device rather than the management system within which the device will be used

• “Return on investment is only achieved through subsequent improvement in the farming system and it is here that people are key”

• Not enough focus on farmer adaptation and learning

• Need more formal and informal user networks

Eastwood, 2008
Conclusions

- New era in dairy management
- Exciting technologies available and in development
- Technologies may have considerable impact on genetic evaluations
- Investment profitability depends heavily on management after purchase
- Adoption rates affected by sociological factors and technology development strategies
Any Questions?

Jeffrey Bewley, PhD, PAS
407 W.P. Garrigus Building
Lexington, KY  40546-0215
Phone: 859-257-7543
Fax: 859-257-7537
jbewley@uky.edu