FARMING AND TECHNOLOGY: A DAIRYMAN’S PERSPECTIVE

Technological Marvels

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

• 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

1. Changing Dairy Landscape

• Fewer, larger dairy operations

• Narrow profit margins

• Increased feed and labor costs

• Cows are managed by fewer skilled workers
2. Consumer Focus

- Continuous quality assurance
- “Natural” or “organic” foods
- Greenhouse gas reductions
- Zoonotic disease transmission
- Reducing the use of medical treatments
- Increased emphasis on animal well-being

3. Information Era

- Unlimited on-farm data storage
- Faster computers allow for more sophisticated on-farm data mining
- Technologies adopted in larger industries have applications in smaller industries

4. Cow Challenges

1. Finding cows in heat
2. Finding and treating lame cows
3. Finding and treating cows with mastitis
4. Catching sick cows in early lactation
5. Understanding nutritional status of cows
   a. Feed intake
   b. Body condition (fat or thin)
   c. Rumen health (pH/rumination time)

Precision Dairy Management

The use of automated, mechanized technologies toward refinement of dairy management processes, procedures, or information collection
**Precision Dairy Monitoring**

- Using technologies to measure physiological, behavioral, and production indicators
- Focus on preventive health and performance at the cow level
- Make more timely and informed decisions

**Areas to Monitor a Dairy Cow**

- Fatness or Thinness
- Rumination/pH
- Temperature
- Feed intake
- Methane emissions
- Respiration
- Chewing activity
- Lying/standing behavior
- Animal position/location
- Methane emissions

**Precision Dairy Farming Benefits**

- Improved animal health and well-being
- Increased efficiency
- Reduced costs
- Improved product quality
- Minimized adverse environmental impacts
- More objective (less observer bias and influence)
**Electrical Conductivity**

- Ion concentration of milk changes, increasing electrical conductivity
- Inexpensive and simple equipment
- Wide range of sensitivity and specificity reported
- Results improve with quarter level sensors
- Improved results with recent algorithms
- Most useful when combined with other metrics

Brandt et al., 2010; Hogeveen et al., 2011

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**Milk Color**

- Color variation (red, blue, and green) sensors in some automatic milking systems
- Reddish color indicates blood (Ordolff, 2003)
- Clinical mastitis may change color patterns for three colors (red, green and blue)
- Specificity may be limited

www.lely.com

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**Temperature**

- Not all cases of mastitis result in a temperature response
- Best location to collect temperature?
- Noise from other physiological impacts
**Thermography**

- May be limited because not all cases of mastitis result in a temperature response
- Difficulties in collecting images

![Agricam](image)

*Hovinen et al., 2008; Schutz, 2009*

**Automated CMT or WMT**

- CellSense (New Zealand)
- Correlation with Fossomatic SCC 0.76 (Kamphuis et al., 2008)
- Using fuzzy logic, success rates (22 to 32%) and false alerts (1.2 to 2.1 per 1000 milkings), when combined with EC were reasonable (Kamphuis et al., 2008)

**Mastiline**

- Uses ATP luminescence as an indicator of the number of somatic cells
- Consists of 2 components
- In-line sampling and detection system, designed for easy connection to the milk hose below the milking claw
- Cassette containing the reagents for measuring cell counts

**Spectroscopy**

- Visible, near-infrared, mid-infrared, or radio frequency
- Indirect identification through changes in milk composition
- AfiLab uses near infrared
  - Fat, protein, lactose, SCC, and MUN
- May be more useful for detecting high SCC cows than quantifying actual SCC
**Milk measurements**

- Progesterone
  - Heat detection
  - Pregnancy detection
- LDH enzyme
  - Early mastitis detection
- BHBA
  - Indicator of subclinical ketosis
- Urea
  - Protein status

**Estrus Detection**

- Efforts in the US have increased dramatically in the last 2 years
- Producer experiences are positive
- Changing the way we breed cows
- Only catches cows in heat
- Real economic impact

**SCR HR Tag**

- Measures rumination time
- Time between cud boluses
- Monitor metabolic status
Lying Behavior Monitors

- On-farm evaluation of lying time:
  - Identification of cows requiring attention (lameness, illness, estrus)
  - Assessment of facility functionality/cow comfort
  - Potential metric to assess animal well-being

Rumen pH

- Illness
- Feeding/drinking behavior
- Acidosis
Alanya Animal Health

- Behavioral changes
- Temperature
- Lying/Standing Time
- Grazing Time
- Lameness
- Estrus Detection (multiple metrics)
- Locomotion Scoring

Vel’Phone Calving Detection

- Temperature
- Activity
- Rumination
- Feeding Time

CowManager Sensor

ENGS Track a Cow: Feeding Time

Bewley | University of Kentucky
• Greenfeed measures methane (CH₄)
• Select for cows that are more environmentally friendly
• Monitor impacts of farm changes (rations) on greenhouse gas emissions

StepMetrix
• Lameness detection
• BouMatic

Belgian Lameness System

Real Time Location Systems
• Using Real Time Location System (RTLS) to track location of cows (similar to GPS)
• Better understand distribution of animals within barns
• Information used to design better barns and modify existing barns
• Behavior monitoring-implications for estrus detection, time at feedbunk, social interactions

Randi Black et al.
### GEA CowView
- Feeding time
- Waiting time
- Resting time
- Mounting
- Distance Covered

### SmartBow
- Capabilities

<table>
<thead>
<tr>
<th>Technology</th>
<th>Parameter(s) Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>ValPhone</td>
<td>Calving Time, Vaginal Temperature</td>
</tr>
<tr>
<td>Alanya</td>
<td>Temperature, Lying Time, Activity, Locomotion, Behavior</td>
</tr>
<tr>
<td>ALab</td>
<td>Fat, Protein, Lactose</td>
</tr>
<tr>
<td>Pedometer Plus</td>
<td>Lying Time, Steps</td>
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<tr>
<td>HR Tag</td>
<td>Rumination Time, Neck Activity</td>
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<tr>
<td>Track-a-Cow</td>
<td>Lying Time, Time at Feedbunk</td>
</tr>
<tr>
<td>Mastiline</td>
<td>Somatic Cell Count</td>
</tr>
<tr>
<td>CowManager Sensor</td>
<td>Rumination Time, Feeding Time, Ear Skin Temperature, Activity</td>
</tr>
<tr>
<td>IceCube</td>
<td>Lying Time, Steps, Locomotion</td>
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<tr>
<td>Anemon</td>
<td>Vaginal Temperature, Estrus</td>
</tr>
<tr>
<td>TempTrack</td>
<td>Rumen Temperature</td>
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<tr>
<td>FeverTag</td>
<td>Typanic Temperature</td>
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<tr>
<td>AccuBreed</td>
<td>Mounting Activity</td>
</tr>
<tr>
<td>CowScout</td>
<td>Leg Activity</td>
</tr>
</tbody>
</table>

### UK Coldstream Dairy Monitoring Capabilities

Thank You to All our Consortium Sponsors!

### Automated Body Condition Scoring
- Reduced labor requirements
- Less stressful on animal
- More objective, consistent measure
- Increased observation frequency
- Early identification of sick animals
- Tracking BCS trends of individual animals and management cohorts
Body Condition Scoring

- 100% of predicted BCS were within 0.50 points of actual BCS.
- 93% were within 0.25 points of actual BCS.

Bewley et al., 2008

<table>
<thead>
<tr>
<th>BCS</th>
<th>Predicted BCS</th>
<th>Posterior Hook Angle</th>
<th>Hook Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.50</td>
<td>2.63</td>
<td>150.0°</td>
<td>116.6°</td>
</tr>
<tr>
<td>3.50</td>
<td>3.32</td>
<td>172.1°</td>
<td>153.5°</td>
</tr>
</tbody>
</table>

Bewley et al., 2008

Now, Automation

Lau, Shelley, Sterrett, and Bewley, 2013

Feed Intake: 3D Imaging

Lau, Shelley, Sterrett, and Bewley, 2013
Early Test Results

Lau, Shelley, Sterrett, and Bewley, 2013

Cow Sleep Monitoring

• Sleep Quality = Improved Immunity?
• New Way to Measure Cow Comfort?

Donohue, Lhamon, O’Hara, Kiefot, and Bewley, 2013

What Are the Limitations of Precision Dairy Farming?

PDF Reality Check

• 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
• People factors must be considered
Ideal Technology

- Explains an underlying biological process
- Can be translated to a meaningful action
- Cost-effective
- Flexible, robust, reliable
- Simple and solution focused
- Information readily available to farmer
- Commercial demonstrations

Data Handling

- Industry needs to establish guidelines for farmers to follow
- What questions should they be asking?
- What to do with information provided?

How Many Cows With Condition Do We Find?

- 80 Estrus Events Identified by Technology
- 20 Estrus Events Missed by Technology

Example: 100 estrus events

How Many Alerts Coincide with an Actual Event?

- 90 Alerts for Cows Actually in Heat
- 10 Alerts for Cows Not in Heat

Example: 100 estrus events
Sensitivity/Specificity Battle

- ↑ Sensitivity by lowering threshold, BUT...
  - ↓ Specificity (more false positives)
- ↑ Specificity by raising threshold, BUT...
  - ↓ Sensitivity (more missed events)
- Trade off between the two

What’s the Sweet Spot?

- Cost of missed event
  - High for estrus
  - Lower for diseases?
- Cost of false positive
  - Low for estrus
  - High for mastitis
- Farm dependent

Economic Considerations

- Need to do investment analysis
- Not one size fits all
- Economic benefits observed quickest for heat detection/reproduction
- If you don’t do anything with the information, it was useless
- Systems that measure multiple parameters make most sense
- Systems with low fixed costs work best for small farms

Investment Analysis of Heat Detection Technologies

Heat detection is a major concern on many dairy farms today. Technologies used to monitor activity and other cow parameters have been developed to manage heat detection. This not present value tool can be used to compare up to 2 different heat detection technologies in order to determine which might work best economically on a specific dairy. To use, change herd and technology information in the input tabs and then review the outcome in the “Results” and “Before vs. After” tabs.

Developed by Karmella Dolecheck and Jeffrey Bewley Animal & Food Sciences Department University of Kentucky College of Agriculture

www2.ca.uky.edu/afs/dairy/HeatDetectionTechnologies Karmella Dolecheck et al.
Hover buttons explain inputs and results.

Inputs are adjustable in multiple ways.

Compare up to 3 different technologies.

Example Analysis

Technology Example

Investment-Unit Price-EDR
Low-50-90
High-50-90
Low-100-90
High-100-90
Low-50-70
High-50-70
Low-100-70
High-100-70

$104,906
$99,906
$99,300
$94,300
$69,188
$64,188
$63,582
$58,582

Low: $5,000 initial investment
High: $10,000 initial investment
50: $50 unit price
100: $100 unit price
70: 70% estrus detection rate
90: 90% estrus detection rate

Net Present Value

Low: $5,000 initial investment
High: $10,000 initial investment
50: $50 unit price
100: $100 unit price
70: 70% estrus detection rate
90: 90% estrus detection rate

Example:
Low: $5,000 initial investment
High: $10,000 initial investment
50: $50 unit price
100: $100 unit price
70: 70% estrus detection rate
90: 90% estrus detection rate

www2.ca.uky.edu/afsdairy/HeatDetectionTechnologies Karmella Dolecheck et al.
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

Technology Pitfalls

• Too many single measurement systems
• 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

Lessons learned

• Be prepared for little things to go wrong
• Be careful with early stage technologies
• Need a few months to learn how to use data
• Data integration is challenging
From Purdue to Poor Due

Did I get the wrong PhD?

The Book of David: Cow People Benefit Most

Why Have Adoption Rates Been Slow?

Reason #1. Not familiar with technologies that are available (N =101, 55%)
Reason #2. Undesirable cost to benefit ratio 
(N =77, 42%)

Reason #3. Too much information provided without knowing what to do with it 
(N =66, 36%)

Reason #4. Not enough time to spend on technology 
(N =56, 30%)

Reason #5. Lack of perceived economic value 
(N =55, 30%)
Reason #6. Too Difficult or Complex to Use  
(N =53, 29%)

Reason #7. Poor technical support/training  
(N =52, 28%)

Reason #8. Better alternatives/easier to accomplish manually  
(N =43, 23%)

Reason #9. Failure in fitting with farmer patterns of work  
(N =40, 22%)
Reason #10. Fear of technology/computer illiteracy (N = 39, 21%)

Reason #11. Not reliable or flexible enough (N = 33, 18%)

Reason #99. Wrong College Degree (N = 289, 100%)

Customer Service is Key
- More important than the gadget
- Computer literacy
- Not engineers
- Time limits
- Failure of hardware and software
Cautious Optimism

- Critics say it is too technical or challenging
- We are just beginning
- Precision Dairy won’t change cows or people
- Will change how they work together
- Improve farmer and cow well-being

Path to Success

- Continue this rapid innovation
- Maintain realistic expectations
- Respond to farmer questions and feedback
- Never lose sight of the cow
- Educate, communicate, and collaborate

Future Vision

- New era in dairy management
- Exciting technologies
- New ways of monitoring and improving animal health, well-being, and reproduction
- Analytics as competitive advantage
- Economics and human factors are key

Questions?

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