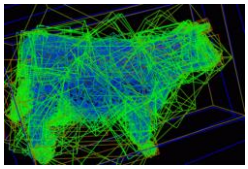
Precision Dairy Farming: The Next Dairy Marvel?



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see blue. in the College of Ag

2009 European Association of Animal Production Meeting

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

Changing Dairy Landscape

- 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

Information Era

- 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

PDF: Key Elements

- 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

PDF: Key Elements

- 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)

Ideal PDF Technology

- 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

PDF Examples

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

DeLaval Herd Navigator™

Milk measurements

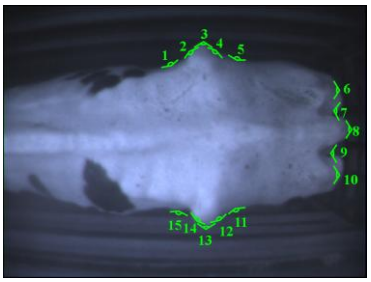
- Progesterone
  - Heat detection
  - Pregnancy detection
- LDH enzyme
  - Early mastitis detection
- BHBA
  - Indicator of subclinical ketosis
- Urea
  - Protein status

smardwatch

Your key to animal health.

Monitor	Parameter Measured
3-D acceleration/movement	Behavior
Electromyogram	Muscle activity
Skin potential	Vegetative-nervous reaction
Skin resistance	Vegetative-emotional reaction
Skin temperature/Environmental temperature	Thermoregulation

Body Condition Scoring



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

Body Condition Scoring

BCS	2.50
Predicted BCS	2.63
Posterior Hook Angle	150.0°
Hook Angle	116.6°

BCS	3.50
Predicted BCS	3.32
Posterior Hook Angle	172.1°
Hook Angle	153.5°

IceTag Activity Monitor

- 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. CO^2, NH^3)
- 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

Genomics

- 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

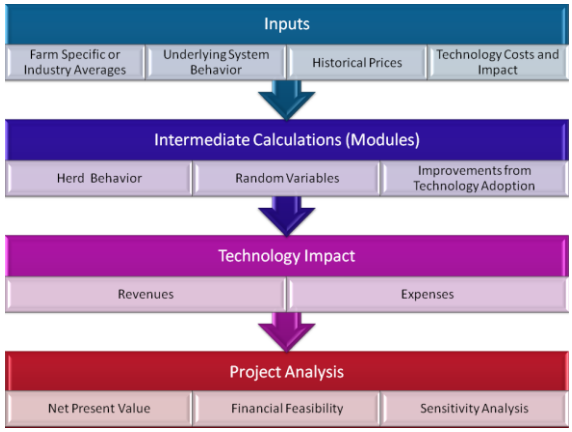
- Slow adoption rates
- Who pays for what?
- Animal ID read errors
- Animal ID transfers
- Equipment failure
- Data transfer errors/bottlenecks
- Manufacturer differences
- Sensor drift?
- Quality control
- Trait heritability limits

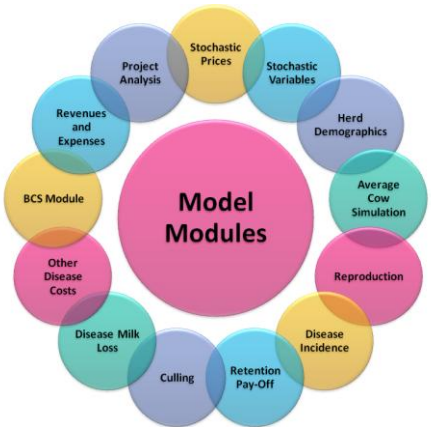
PDF Reality Check

- 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
- Sociological factors must be considered

Purdue/Kentucky Investment Model

- 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

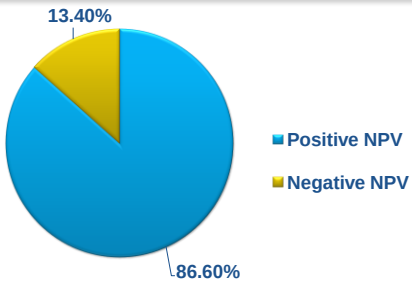




Automatic BCS Investment

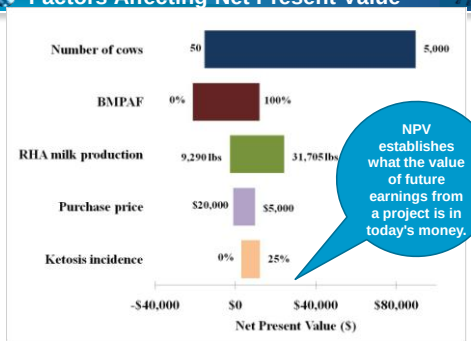
- Benefits
  - Reduced ketosis, milk fever, and metritis
  - Improved conception rate at first service
  - Improved efficiency from minimizing BCS loss
- Costs
  - Investment
  - Variable costs
- Management level
- 1000 simulations

Net Present Value (NPV) Simulation Results



- Results from 1000 simulations
- Positive NPV="go" decision/make investment

Tornado Diagram for Factors Affecting Net Present Value



BMPAF-Best Management Practice Adherence Factor

Reasons for Slow PDF Adoption

Reason	%	#
Not familiar with technologies that are available	54.89%	101
Undesirable cost to benefit ratio	41.85%	77
Too much information provided without knowing what to do with it	35.87%	66
Not enough time to spend on technology	30.43%	56
Lack of perceived economic value	29.89%	55
Too difficult or complex to use	28.80%	53
Poor technical support/training	28.26%	52
Better alternatives/easier to accomplish manually	23.37%	43
Failure in fitting with farmer patterns of work	21.74%	40
Fear of technology/computer illiteracy	21.20%	39
Not reliable or flexible enough	17.93%	33

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

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