Feed efficiency: unravelling the opportunities

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Outline and goals

Outline

1. Defining feed efficiency.
2. Breeding for optimal production and body size.
3. Using residual feed intake to further improve efficiency.

Goal: to spur the discussion about what kind of cow we want in the future
The modern dairy cow is a different beast!

- We have been altering cattle genetics for 9000 years.
- Most selection was made based on animal’s own phenotype.
- Population genetics (>1937) accelerated the progress.
- We made a lot of progress based on looks and a few numbers.
- Modern dairy cows are taller, thinner, and less muscular, and they have bigger udders.
- Today we have data. Lots of it.
Increased productivity in the past has resulted in increased efficiency

Our focus to increase milk yield has increased feed efficiency indirectly through the dilution of maintenance.

Gross feed efficiency < 10%

Gross feed efficiency ~ 20%

CO2/milk = 3.7

CO2/milk = 1.4
Feed efficiency is a complex trait.

Foods consumable by humans

- Climate impacts
- Farm profitability
- Ecosystem services
- Soil erosion and conservation
- Imported oil
- Rural aesthetics
- Rural sociology
- Food quality and healthfulness
- Food security
- Animal behavior and well-being
- Efficiency of the beef industry

Foods not consumable by humans

- Non-food usable energy sources, fertilizers, and other chemicals
- Environmental pollutants

Land

- Wastes
- Heat energy

Water

- Products that are not consumable by humans

Human-consumable milk and beef

This is too complicated to use!
Feed efficiency on the farm

Feed

Lactating cows

Dry cows

Heifers

Wasted feed

Milk

Calves

Body tissue

Feces

Urine

Gas

Heat
**The basics of feed efficiency**

Gross Energy of Feed → Net Energy of Feed → Energy captured as milk or body tissue

- Energy lost as feces, gas, urine, and heat for metabolizing feed
- Energy lost as heat for maintenance

**Gross feed efficiency** is the percentage of feed energy captured in milk and body tissues.

To improve gross feed efficiency:
1. Increase the conversion of GE to NE
2. Increase milk production relative to maintenance.
Is there an optimal milk production and body size?

Feb 15, 2010: Wisconsin cow Ever-Green-View My 1326-ET became the national milk production record holder, at 4 yr 5 mo. of age. She produced a 365-day record of 72,200 lbs of milk, with 2,790 lbs of fat and 2,140 lbs of protein.

If a cow produces this much, I don’t care if she weighs 2000 lb!
Efficiency increases from the “Dilution of Maintenance”

As cows eat more and produce more per day, a smaller percentage of the food they eat is used for maintenance and a greater percentage is converted to product.

\[ \text{NEL maint} \approx 10 \text{ Mcal} \quad (0.08 \times \text{BW}^{0.75}) \]
High producing cows per unit BW are more efficient. The returns in efficiency from more milk are diminishing, but not as much as current NRC suggests!
The dilution of maintenance: milk vs cow size

Whether we get more milk with the same BW or the same milk with a smaller BW, the cow is operating at a higher level and efficiency increases (but maybe not much).
**Maintenance requirement – what is it?**

- **NRC 2001:** $0.08 \times \text{Metabolic BW}$
- **Birnie et al., 2000:** $0.084$ to $0.113 \times \text{MBW}$ depending on BCS
- **Moraes et al., 2015:** $0.086$ to $0.115 \times \text{MBW}$ depending on decade
- **Tempelman et al., 2015:** $0.11$ to $0.17 \times \text{MBW}$ depending on research farm

A higher maintenance requirement means cows needs to make more milk relative to BW to dilute it out.

*If maintenance = 0.08 \times \text{MBW},*

optimal milk for 1700 lb cow is $\sim$100 lb milk/day.

*If maintenance = 0.12 \times \text{MBW},*

optimal milk for 1700 lb cow might be $\sim$150 lb milk/day
**Holsteins are getting larger!**

- Of current proven AI bulls, 62% are >1SD for stature and 3% are <1SD. (Anderson, 2007)
- Current AI bulls are average for stature, but “average” for Holsteins jumped 0.8 stature points because of the 2014 base change!

- Larger, more angular cows have more health problems. *Hansen, 2000, JDS*

Why select for cows that look they can milk more, when we can select for cows that really do milk more?
Genetic (upper right) and non-genetic (lower left) correlations and heritabilities (diagonal) for efficiency traits on 5700 Holsteins. Lu et al., unpublished.

<table>
<thead>
<tr>
<th></th>
<th>MilkE</th>
<th>MBW</th>
<th>DMI</th>
<th>Gross Eff.</th>
<th>IOFC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MilkE</strong></td>
<td>0.37</td>
<td>0.06</td>
<td>0.66</td>
<td>0.66</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>±0.03</td>
<td>±0.06</td>
<td>±0.04</td>
<td>±0.08</td>
<td>±0.01</td>
</tr>
<tr>
<td><strong>MBW</strong></td>
<td>0.22</td>
<td>0.51</td>
<td>0.45</td>
<td>-0.28</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>±0.04</td>
<td>±0.03</td>
<td>±0.05</td>
<td>±0.06</td>
<td>±0.07</td>
</tr>
<tr>
<td><strong>DMI</strong></td>
<td>0.56</td>
<td>0.37</td>
<td>0.38</td>
<td>-0.11</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>±0.02</td>
<td>±0.03</td>
<td>±0.03</td>
<td>±0.04</td>
<td>±0.06</td>
</tr>
<tr>
<td><strong>Gross Eff.</strong></td>
<td>0.39</td>
<td>-0.03</td>
<td>-0.19</td>
<td>0.13</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>±0.02</td>
<td>±0.01</td>
<td>±0.02</td>
<td>±0.00</td>
<td>±0.05</td>
</tr>
<tr>
<td><strong>IOFC</strong></td>
<td>0.85</td>
<td>0.17</td>
<td>0.34</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td></td>
<td>±0.01</td>
<td>±0.04</td>
<td>±0.03</td>
<td>±0.01</td>
<td></td>
</tr>
</tbody>
</table>

Selection against body size will enhance feed efficiency but not milk income per cow. Selection for milk increases both.
Other considerations in the size debate

- Milk component yield is more important for profitability than body size when selecting for increased feed efficiency.
- Feed efficiency and profitability must be considered on a whole-farm basis.
- Smaller cows need less space so could have more cows per farm.
- Smaller cows take about as much time to manage on a per head basis.
- Smaller cows and their bull calves have less salvage value.
- Smaller cows might have fewer health problems.
- Smaller cows might handle heat stress better.
- Smaller cows might be better in a grazing system.
- Smaller cows might need more digestible diets (large herbivores can digest fiber better than small ones).
Summary for body size and efficiency

Liu et al., 2015. Body weight.
- For 5700 Holsteins, body weight was not genetically correlated with milk energy per day. The genetic correlation of body weight with gross feed efficiency was -0.3.

Manzanilla-Pech et al., 2015. Stature.
- For 1900 US Holsteins, stature was not genetically correlated with milk energy/day. The genetic correlation of stature with gross feed efficiency was -0.7 and with residual feed intake was +0.4.

- Selecting for bigger, taller cows does not increase milk.
- Selecting for bigger, taller cows decreases feed efficiency.
The basics of feed efficiency

Residual feed intake (RFI) → Net Energy of Feed → Energy captured as milk or body tissue

Gross Energy of Feed → Energy lost as feces, gas, urine, and heat for metabolizing feed

Net Energy of Feed → Energy lost as heat for maintenance

To improve efficiency:

1. Increase the conversion of GE to NE
2. Increase milk production relative to maintenance.
Residual feed intake (RFI) = “unjustified” feed intake

\[
\text{Observed DMI} = \mu + b_1 \cdot \text{MilkEnergy} + b_2 \cdot \text{BW}^{0.75} + b_3 \cdot \Delta\text{BodyEnergy} + \text{cohort} + \text{RFI}
\]

The heritability of RFI is 0.17, based on 4900 Holsteins from North America and Europe. (Tempelman et al., 2015)
Residual Feed Intake (RFI) is a heritable trait

<table>
<thead>
<tr>
<th>Study</th>
<th>Number cows</th>
<th>Heritability (s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Arendonk et al., 1991</td>
<td>360</td>
<td>0.19 (0.12)</td>
</tr>
<tr>
<td>Ngwerume and Mao, 1992</td>
<td>247</td>
<td>0.02</td>
</tr>
<tr>
<td>Veerkamp et al., 1995</td>
<td>204</td>
<td>0.32</td>
</tr>
<tr>
<td>Tempelman et al., 2015</td>
<td>4893</td>
<td>0.15 to 0.18 (0.02)</td>
</tr>
</tbody>
</table>

**Tempelman et al** (4893 cows: 1966 NL, 1052 UK, 1875 USA)
- each with >28 daily records between 50 and 200 DIM
- 50% had multiple lactations.
- Weekly DMI was fitted as a function of MilkE, BW^{.75}, BCS, change in BW (dBW), parity, and dBWxparity with a 5th order polynomial on DIM ranging from 50 to 200 d. **The residuals from this analysis = RFI.**
- Heritabilities for country-specific RFI were based on fitting random regression models and was reasonably repeatable across DIM; residual variances were particularly heterogeneous across research stations, perhaps due to differences in data recording protocols.
RFI is a repeatable trait

- Diet: high starch vs high fiber
- Climate conditions
- Lactation number
- Lactation stage
- Heifer vs cow

Selecting genotypes today that are more efficient should provide more efficient cows in the future, even if they are on higher fiber diets in a hotter climate.
Biological basis for RFI – the variation in expected intake

- Digestion: 10%
- Tissue Metabolism & Protein Turnover: 27%
- Heat Increment of Feeding: 37%
- Activity: 5%
- Feeding Patterns: 9%
- Body Composition: 10%
- Other: 2%

(Richardson and Herd, 2004)
Traditional breeding values are based on daughter performance, but feed efficiency data are not available. Perhaps genomics can help.
Selection for RFI based on Single Nucleotide Polymorphisms (SNP)

• Genomics enables us to select for new traits and make decisions earlier on old ones.

• The SNP itself may have no biological effect, but it is linked to the DNA around it. If allele T is associated with a desirable trait, we can select for T and against C.

• Each single SNP may not have much effect, but additive effects of 1000s of SNP might.

SNP: 1 2 3 4 5 6 7...78000
Genotype: 1 1 2 0 0 1 0... 2
Value: 0 2 3-3 0 0 8... -1
gPTA: 0 2 6 0 0 0 0 . . . -2    Sum = 650

from David Hall, 2007/en.wikipedia.org/wiki/File:Dna-SNP.svg
Preliminary genomic analysis for traits related to feed efficiency (2900 cows)

The mean and estimates of genetic variance (VarG), proportion of phenotypic variance accounted for by SNP (Mh$^2$), and Pi, such that 1-Pi represents the proportion of SNP fitted in the genome wide association analyses.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Mean</th>
<th>VarG</th>
<th>Mh$^2$</th>
<th>Pi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter intake, kg/d</td>
<td>22</td>
<td>1.5</td>
<td>0.26</td>
<td>0.93</td>
</tr>
<tr>
<td>Milk energy output, Mcal/d</td>
<td>27</td>
<td>3.3</td>
<td>0.22</td>
<td>0.91</td>
</tr>
<tr>
<td>Metabolic BW</td>
<td>119</td>
<td>23</td>
<td>0.38</td>
<td>0.92</td>
</tr>
<tr>
<td>BW change, kg/d</td>
<td>0.39</td>
<td>0.17</td>
<td>0.02</td>
<td>0.98</td>
</tr>
<tr>
<td>Residual feed intake, kg DM/d</td>
<td>0</td>
<td>0.27</td>
<td>0.14</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Spurlock et al., 2014
Initial findings on genomic analysis for RFI (2900 cows) – Spurlock et al., 2014

- 61,000 SNP markers accounted for 14% of the variance in RFI.
- Top ten SNP accounted for 7% of the genetic variance.
- Six of the 8 chromosomes harboring QTL influencing RFI did not contain QTL influencing dry matter intake (DMI), net energy for lactation, or metabolic body weight.
Animals could be selected for specific SNP or for the summation of 1000s of SNP.

**SNP:** 1 2 3 4 5 6 7 ... 78000

**Genotype:** 1 1 2 0 0 1 0 ... 2

**Value:** 0 2 3 -3 0 0 8 ... -1

**gPTA:** 0 2 6 0 0 0 0 ... -2

**Sum = 650**
Genomic selection for RFI can work

- Genomic Breeding Values for RFI were developed in growing heifers.
- Cows that were identified as being more efficient based on these GEBV did in fact need less feed to make milk. (Davis et al., 2014)

- AU is using genomic breeding values for RFI in combination with breeding values for smaller BW per unit milk in a “Feed Saved” index (Pryce et al., 2015).

- NL is using GBV for DMI
Preliminary genomic results of efficiency traits for North American bulls. (Yao et al., 2016)

- Breeding values for 16,000 Holstein AI bulls in North America were predicted from a reference population of 3,500 cows.
- 57,000 SNP markers per animal were analyzed.
- Heritabilities were similar to what we previously reported.
- A “Feed_Saved” trait was calculated based on RFI and BW. Selection for this trait looks promising.
- Feed saved/yr
  \[ = -RFI + 2.1 \text{ lb per extra lb BW} \]
- Reliability of EBV for RFI = 0.29

BV ranged from -2200 to +2200 lb DMI / lactation.
<table>
<thead>
<tr>
<th></th>
<th>1971</th>
<th>2010</th>
<th>2014</th>
<th>2019?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk Yield</td>
<td>52</td>
<td>0</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>Fat Yield</td>
<td>48</td>
<td>19</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Protein Yield</td>
<td>16</td>
<td>20</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Productive Life</td>
<td>22</td>
<td>19</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td><strong>Somatic Cell Score</strong></td>
<td>-10</td>
<td>-7</td>
<td>-8</td>
<td></td>
</tr>
<tr>
<td>Udder Composite</td>
<td>7</td>
<td>8</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Feet/legs Composite</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Body Size Composite</strong></td>
<td>-6</td>
<td>-5</td>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>Daughter Pregnancy Rate</td>
<td>11</td>
<td>7</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Cow Conception Rate</td>
<td>-</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heifer Conception Rate</td>
<td>-</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calving Ability</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Unjustified Feed Intake</strong></td>
<td>-</td>
<td>-18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New TPI formula (April, 2015)

- Feed Efficiency:
  (Dollar Value of milk produced) – (Feed costs of extra milk) – (Extra maintenance costs)

- Fertility Index:
  18% HCR + 18% CCR + 64% DPR

From Tom Lawlor, Holstein Association
New TPI slows the rate of increase in stature of our cows.

New TPI has less relationship with stature than Old TPI.
Summary on selection for efficiency

- To increase total feed efficiency and profitability, we want cows that eat and produce at a higher multiple of maintenance.

- We need to stop breeding for large cows just because they look nice. Instead we should breed for cows that produce more milk solids per unit of BW.

- In the near future, we may select directly for feed efficiency, using genomic breeding values for RFI in combination with breeding values for smaller BW per unit milk in a “Feed Saved” index.
Managing for greater feed efficiency

Ad lib TMR feeding has helped increase milk production but decreased the focus on individual cow needs and sometimes increases feed wastage.

How can we feed cows to promote production and efficiency of feed use?
### Impact of selected management changes on energy and protein efficiency for a farm with 10,000 kg milk/cow/year

<table>
<thead>
<tr>
<th>Change</th>
<th>Energy</th>
<th>Protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base feed efficiency for whole farm</td>
<td>21%</td>
<td>28%</td>
</tr>
<tr>
<td>Increase milk production 10%</td>
<td>+0.7%</td>
<td>+0.4%</td>
</tr>
<tr>
<td>Increase longevity from 3 to 4 lactations</td>
<td>+0.6%</td>
<td>+0.5%</td>
</tr>
<tr>
<td>Reduce age at first calving 2 months</td>
<td>+0.3%</td>
<td>+0.3%</td>
</tr>
<tr>
<td>Reduce calving interval 1 month</td>
<td>+0.4%</td>
<td>+0.4%</td>
</tr>
<tr>
<td>Feed cows optimally for energy</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Feed cows &gt;150 DIM a diet with 2% less CP</td>
<td>+0.0%</td>
<td>+1.3%</td>
</tr>
<tr>
<td>Reduce feed wastage 10%</td>
<td>+2.3%</td>
<td>+3.1%</td>
</tr>
</tbody>
</table>

*based on the model used in VandeHaar, 1998, JDS.*

**Grouping cows for better management and feeding can help with all of these!**
**Nutritional Grouping**

- **Optimal health**
  - Maximal milk
  - Successful breeding
  - Optimal condition

**GOALS**

- Intake limited mostly by fill
- Intake limited by liver

**Body weight (lb)**

- Milk yield
- DM intake

**Milk or feed (lb/day)**

- Minimum fiber/
  - high starch
  - Digestible fiber
  - high CP and RUP
  - low

- Expensive supplements
- Cheap feeds

**Days in milk**
How can we better promote nutritional grouping?

Reasons given not to group cows and feed according to needs

• “Makes things too complicated”
  ➢ Make rules for moving cows
  ➢ Design systems to track cows
  ➢ Develop protocols for feeding an extra diet
  ➢ Consider computer feeders for high cows within a group

• “Low diets decrease milk yield”
  ➢ Calculate the returns for a “maintenance diet”
  ➢ Develop maintenance diets that favor milk instead of body fat
  ➢ Move cows to the maintenance diet at BCS 3.0
1. Fresh group: Day 0 til thriving
2. High group: Day 30? til pregnant and BCS 3.5
3. Low (Maintenance) group: BCS 3 til calving

The switch to maintenance could be based partly on production

Add a 2-year-old group ??
Maintenance diets

• Several studies show this works! (Oba and Allen, 1998; Ipharraguerre et al., 2002; Voelker and Allen, 2003; Bradford and Allen, 2004; Boerman et al., 2015a; Boerman et al., 2015b)

• Use high quality forages (digestible fiber) as the base.
• Drop the starch to 10-20%.
• Use slowly fermenting starch sources (ground dry corn).
• Include high fiber byproduct feeds at 20-30%.
• Consider fat if the price is right
• Drop %CP 2 units to increase N efficiency and save money.
• Drop out expensive ingredients that are most effective for the high group.
• Pay attention to prices! The goal is to increase income over feed costs in the short run and health in the long run!
Should milk/feed be a goal in feeding?

- Each nutrient class also alters feed intake and partitioning between body stores and milk, and thus efficiency.
- These effects cannot easily be modeled.
- We must assess what is happening on the farm!

<table>
<thead>
<tr>
<th></th>
<th>Fiber</th>
<th>Starch</th>
<th>Protein</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE kcal/g</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>NE</td>
<td>1-2</td>
<td>~2</td>
<td>~2</td>
<td>4-7</td>
</tr>
</tbody>
</table>
Choose feeds based on actual $ return, not efficiency.

- Feed efficiency is not an end in itself for most farms.
- The financial return to dietary change for the farm is what matters! Profit might increase with a cheaper ration even though milk per feed decreases. Profit might decrease with expensive rations even though milk per feed increases.
- Treatment responses can be misleading for mixed groups.
- Grouping cows by production level allows allocation of feeds to cows that will benefit the most.
- Computer models cannot accurately predict responses. Feed intake and cow responses (including body condition changes) must be measured to determine if diet changes are returning a profit!
Summary on management for efficiency

• Feeding animals to meet their genetic potential without overfeeding is a key to efficiency. Nutrition models can help but monitoring the cows is essential!

• Most producers recognize that grouping cows according to feed needs improves feed efficiency and profitability. But grouping requires more work for management.

• The farm team must work together and strategize about how to implement effective grouping strategies.
Summary

Point 1: Efficient cows produce a lot of milk!
Point 2: Efficient cows efficiently convert feed to net energy.

What can we do?

• Breed for milk and moderate reductions in cow size.

• Select for low RFI or DMI or “Feed Saved” someday.

• Group and feed according to nutritional needs.

• Feed and manage for high production.

• Feed to increase profits, which is not always most efficient.
Discussion?

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We want more than just efficiency

Our goal is a cow that efficiently converts feed to milk
– has high GE to NE (low RFI) because of greater digestibility, greater % of DE to NE, or lower maintenance
– efficiently captures (partitions) lifetime NE to product because she operates at a high multiple of maintenance
– is profitable (high production dilutes out farm fixed costs)
– has minimal negative environmental impacts

AND
• is healthy and thrives through the transition period
• yields products of high quality and salability
• is fertile and produces high-value offspring
• is adaptable to different climates and diets
• can use human-inedible foods, pasture, and cheap feeds
• can digest feeds better
• requires less protein and phosphorus per unit of milk
• has a good disposition and looks happy to the general public
Refocusing farm goals towards efficiency

Factors altering efficiency
- nutritional grouping
- feeding management
- environment
- diet composition
- nutrient over or under supply
- rumen activity
- RFI (unjustified feed)

- mature body wt
- milk solids production
- BCS and BW gain or loss
- % of life spent lactating

Gross Energy of Feed

Energy losses
- wasted feed
- feces
- gasses
- urine
- heat from nutrient processing

Net Energy of Feed

- heat from maintenance work
- heat for activity and thermoregulation

Energy captured as milk or body tissue
Partial Correlation of RFI & DM Digestibility

*Both terms adjusted for effects of parity, cohort, and experiment

Corn grain Diet:
\[ y = 0.01x - 0.01 \]
\[ R^2 = 0.00 \]

Soyhulls Diet:
\[ y = -0.18x - 0.31 \]
\[ R^2 = 0.09 \]
\[ r = -0.30 \]
\[ P < 0.01 \]

Negative RFI = more efficient than average

⇒ Digestibility may account for up to 33% of the variation in the ability of cows to extract feed NE. But what is causal?

Potts et al., 2016
The microbiome and feed efficiency

Data is inconclusive. (Freetly et al., 2015 vs. Myer et al., 2015)

Weimer et al., 2010.

- Selected 2 pairs of cows with very different bacterial community composition and exchanged >95% of ruminal contents one time.
- Host cows quickly reestablished original ruminal pH and VFA concentrations.
- Ruminal communities displayed substantial host specificity.
Should we focus on smaller cows or more milk?

Effect of increasing multiple of maintenance from 2.8 to 3.0

<table>
<thead>
<tr>
<th></th>
<th>BW at maturity lb</th>
<th>Lifetime multiple of maintenance</th>
<th>Milk yield at maturity lb/year</th>
<th>Lifetime income over feed cost $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current cows</td>
<td>1760</td>
<td>2.8</td>
<td>28,750</td>
<td>$8460</td>
</tr>
<tr>
<td>Select for size</td>
<td>1500</td>
<td>3.0</td>
<td>28,750</td>
<td>$8770</td>
</tr>
<tr>
<td>Select for milk</td>
<td>1760</td>
<td>3.0</td>
<td>31,970</td>
<td>$9690</td>
</tr>
</tbody>
</table>

Moving production from 2.8 to 3.0 multiples of maintenance
- increases biological efficiency by either option
- by decreasing BW, profit increases $300.
- by increasing milk, profit increases $1200.
- Selecting against RFI is similar to selecting against BW.

Feed at 15¢/Mcal NEL (~12¢/lb) for lactating cows and 12¢/Mcal NEL for heifers and dry cows. Milk price at $0.18/lb. Cull cow price at $0.80/lb. This assumes NEm = 0.08*MBW.
Capper and Cady did not measure feed intake and assumed Jerseys were operating at a higher multiple of maintenance (3.3 vs 3.0). Published data is lacking to decide if feed efficiency is actually different between the breeds. But the perception is out there that Holsteins are big and less efficient!
The big heifer: #114

• The year was 1974
• She made >100 lb milk/day for first 150 DIM
• She ate a lot of grain at the magnet feeder.
• She was bigger than most mature cows.
• Was she efficient?