# Grouping Strategies to Improve Feed Efficiency

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# Feeding all lactating cows equally

## A larger number of cows are overfed

**Same ration (TMR) to all cows (groups)**

All lactating cows receive same nutrient density diet

**Preferred “high” rations**

Low producing animals receive more nutrients than required

**One diet for all**

Would never optimize production and efficiency

VandeHaar, 2011

# Improve feed efficiency

+ feeding groups (precision feeding)

**Improved nutrient use efficiency**

Diet closer to cow requirements

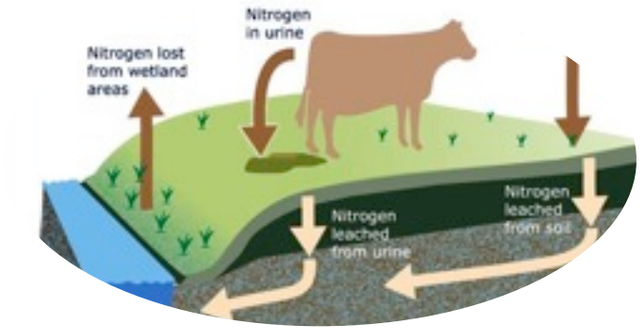
**Less overfed animals**

Decreased over conditioned cows

**Less nutrient excretion**

Decreased environmental concerns

Wang et al., 2000



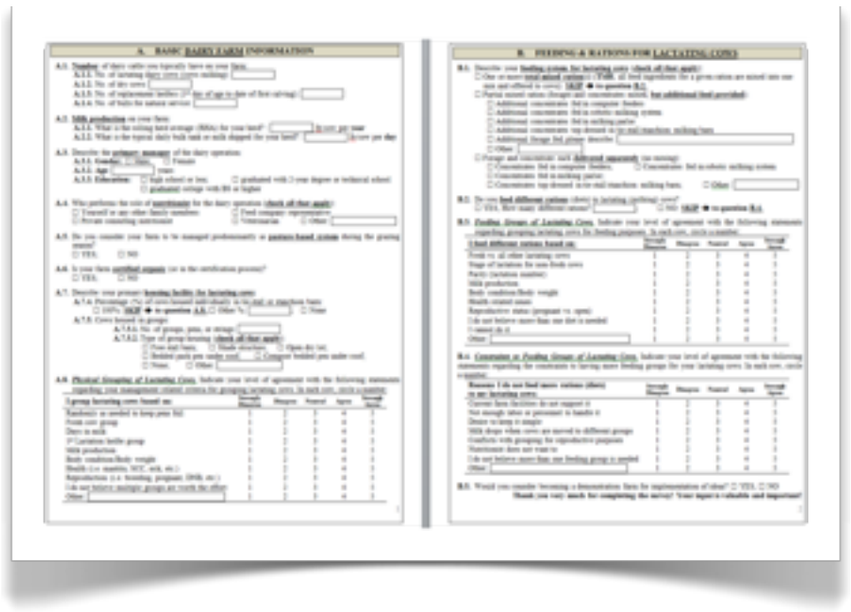

**Lower feeding costs**

Higher milk income over feed cost

# Why farmers do not group more?

## Trying to find most important constraints

### 2-page mailed survey



**Results (responses)**

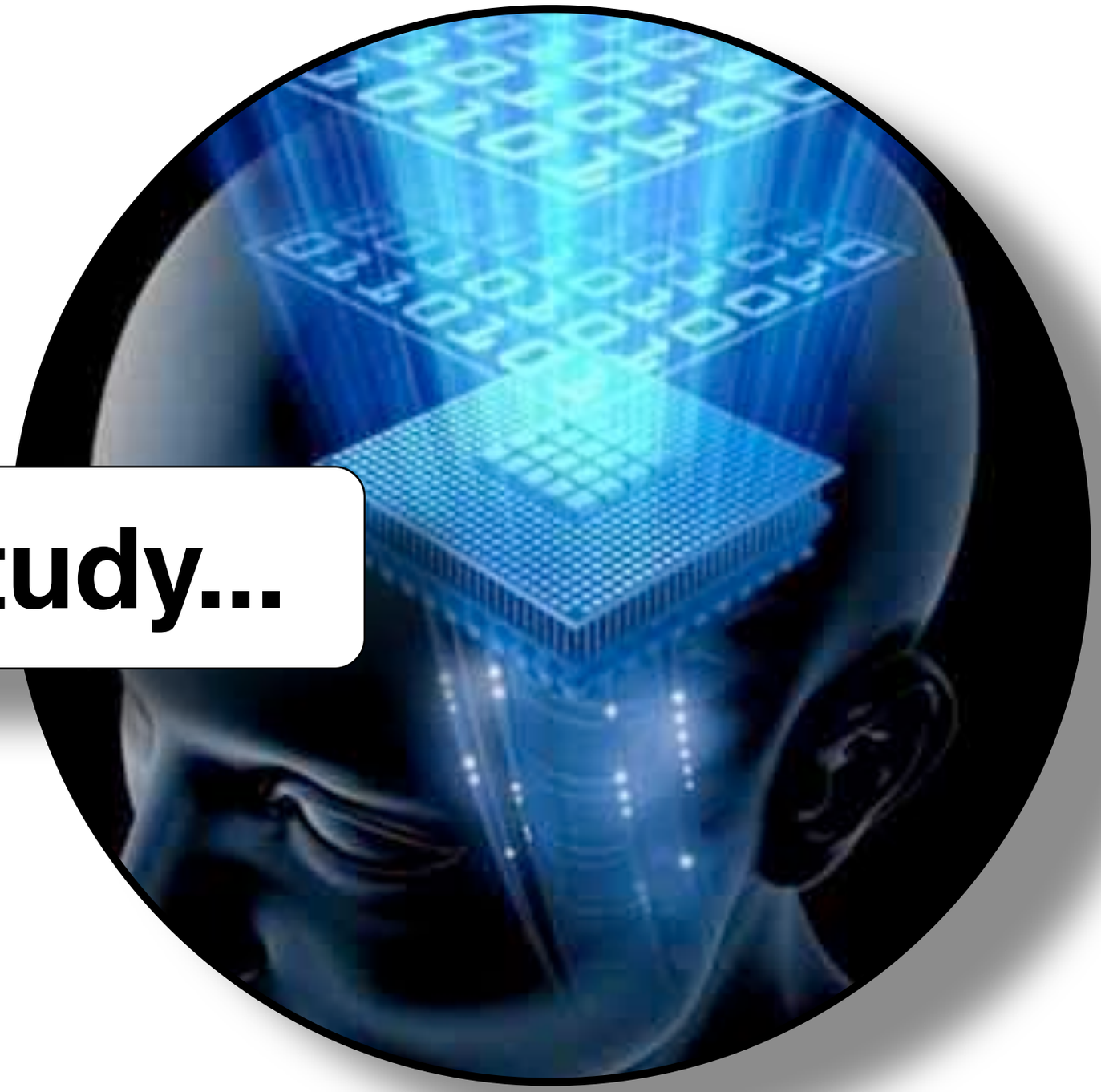
~200 Wisconsin farms

### 25% feeding same ration to all lactating

| | Reported constraints |
|---|---|
| 1 | Perception milk drops |
| 2 | Keep mgt. simple |
| 3 | Conflicts w/reproduction |
| 4 | Facilities do not allow |
| | |
| 5 | Don’t believe are needed |
| 6 | Nutritionist don’t want |
| 7 | Labor or personnel |

Contreras-Govea et al., 2013

# A simulation study...



# Strategies for grouping cows

## Depend on farm and herd characteristics

**Individual cow nutrient requirements**

- Energy
- Protein

**Number of lactating cows on the herd**

**Farm characteristics**

Capacity to handle lactating feeding groups

Adapted from McGilliard et al., 1983;
St-Pierre and Thraen, 1999

# Cow nutrient requirement

## Energy

**Daily total net energy ($NE_{total}$)**

$$NE_{total}\ (Mcal) = NE_{maintenance} + NE_{milk} + NE_{BW\ change}$$

$$NE_{maintenance} = 0.079 \times BW^{0.75}$$

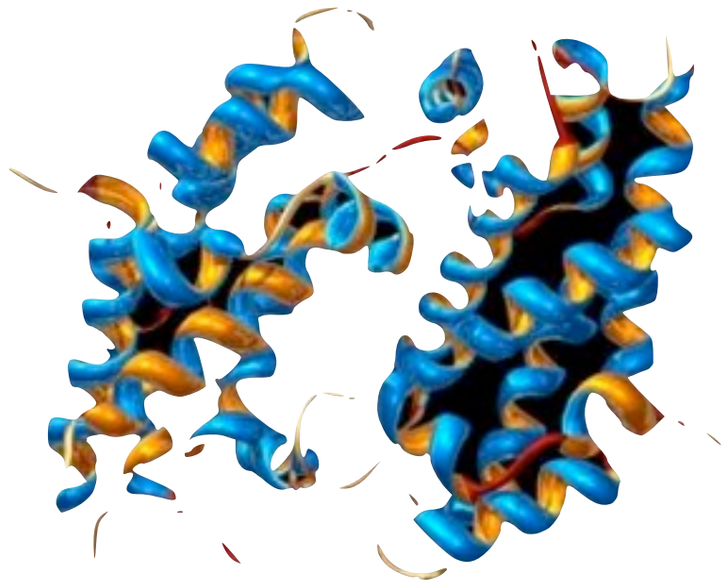
$$NE_{milk} = DailyMilk \times (0.0929 \times Fat\% + 0.0547 \times Protein\% + 0.192)$$

$$NE_{BW\ change} = Table\ from\ NRC,\ 2001$$

NRC, 2001

# Cow nutrient requirement

## Protein



### Daily total crude protein ($CP_{total}$)

$$CP_{total}\ (g) = CP_{maintenance} + CP_{milk}$$

$$CP_{maintenance} = 104.78 + 0.73 \times BW - 0.00015432 \times BW^2$$

$$CP_{milk} = DailyMilk \times (4{,}586 + 1{,}036 \times Fat\%)/100$$

McGilliard et al., 1983

# Cow feed requirement

## Dry matter intake

**Daily total dry matter intake (DMI)**

$$DMI\ (kg) = (0.372 \times 4\%\ FCM + 0.0968 \times BW^{0.75}) \times (1 - e^{(-0.192 \times ((DIM/7) + 3.67))})$$

$$4\%\ FCM = 0.4 \times Milk + 15 \times (Fat\%/100) \times Milk$$

NRC, 2001

$$NE\ (Mcal/kg\ DMI) = NE_{total}(Mcal)/\ DMI\ (kg)$$

$$CP\ (\%/kg\ DMI) = (CP_{total}(g)/1{,}000)\ /\ DMI\ (kg)$$

# Milk (and components)

## Cow-specific lactation curves

**Milk based on**

- Herd ME305
- Cow PPA or ME305
- Stochasticity

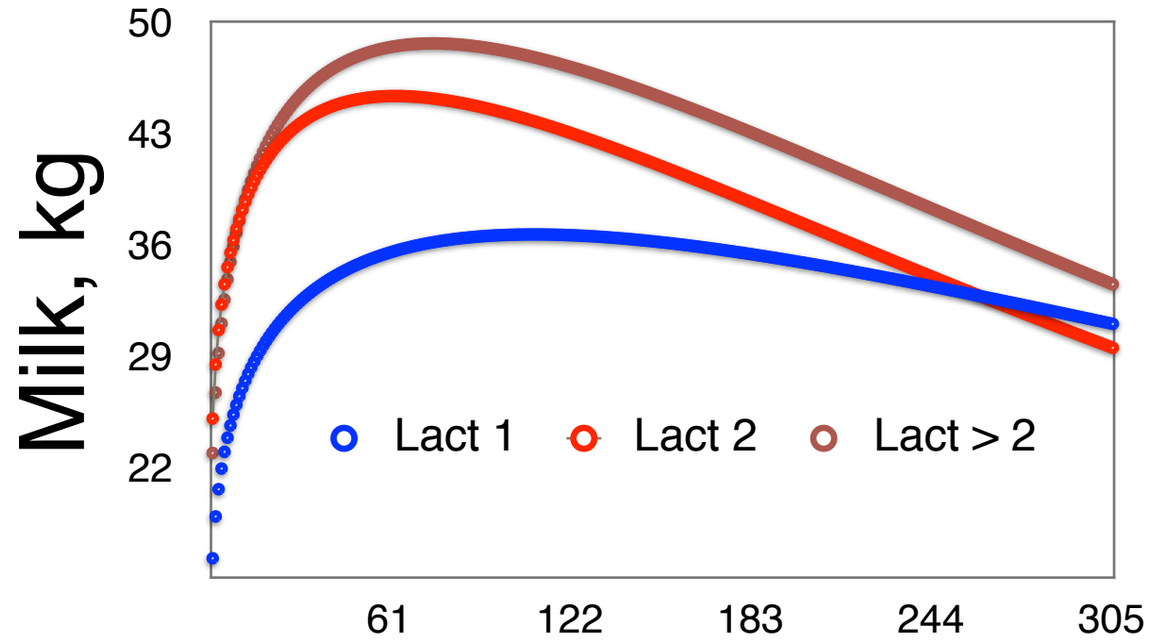
**Components**

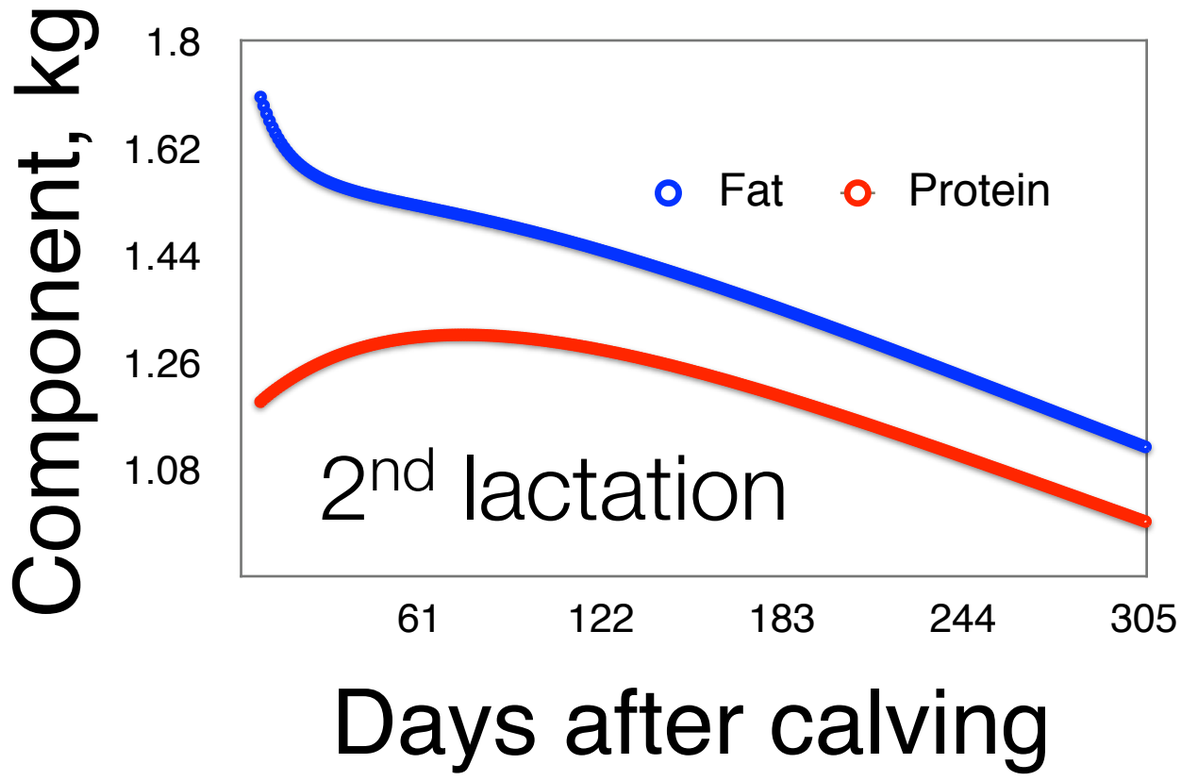
- Herd
- Stochasticity

**Base function**

- Woods
- Adjusted Woods

De Vries, 2001



# Initial individual cow BW

## Seed BW

**1. Available from farm records**

**2. Not available from farm records:**

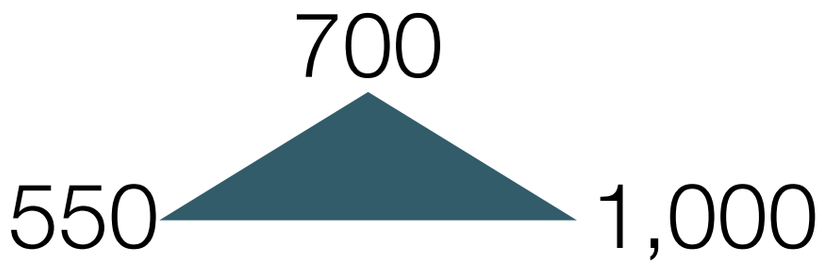
Triangular distribution

+

Lactation

+

State of lactation



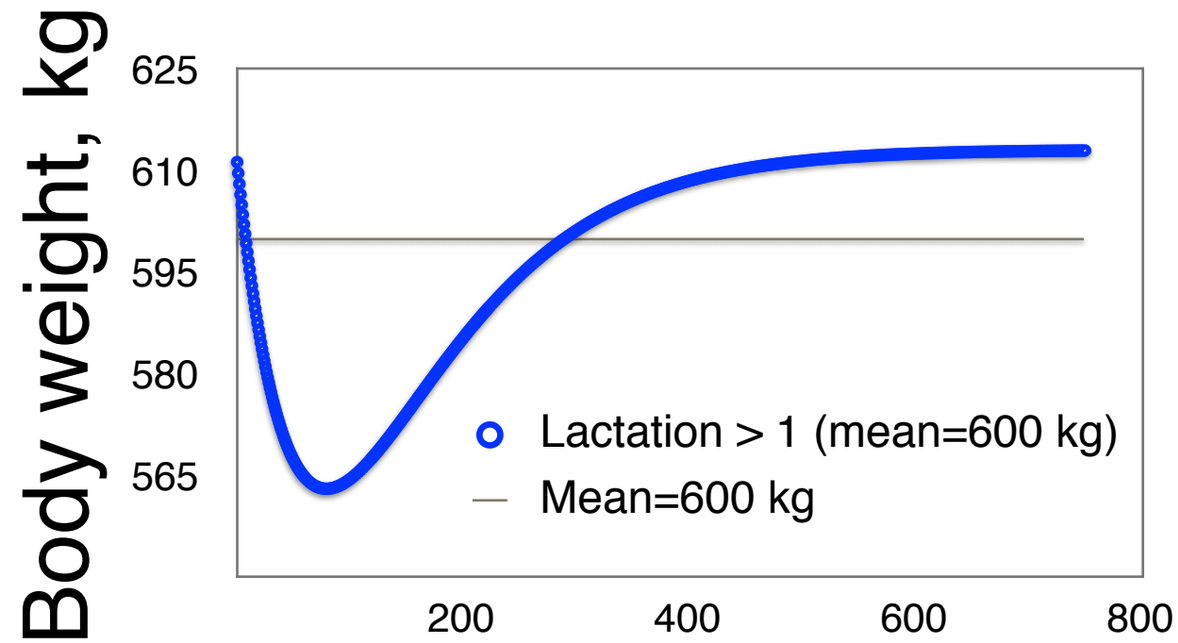

794 Holstein BW records from 2 Wisconsin farms

# Daily BW changes

## Important for maintenance requirements

**Based on**

- Lactation
- DIM
- Stochasticity




Korver et al., 1985 function
Described by van Arendonk , 1985
fitted to NRC, 2001

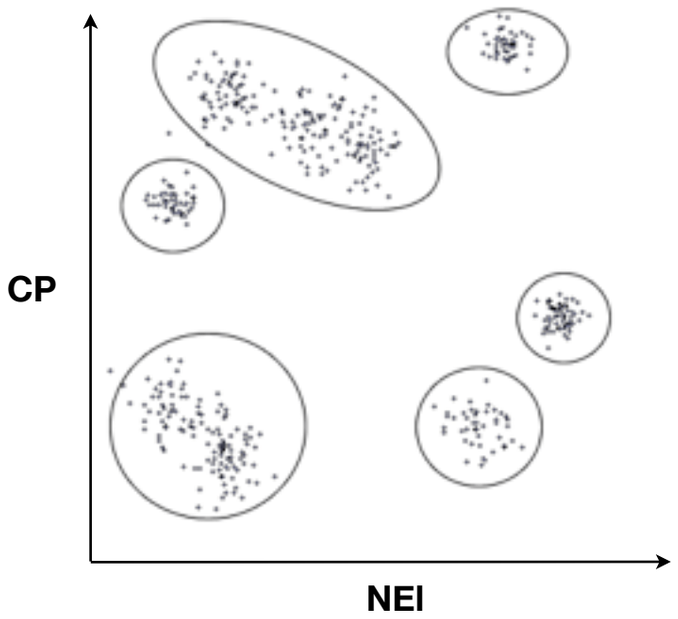
# Nutrient requirement for a group

## Energy and protein

$$NE_{group}\ (Mcal) = 83^{rd}\ Percentile\ of\ (NE_{group\_cows})$$

$$CP_{group}\ (\%) = 83^{rd}\ Percentile\ (CP_{group\_cows})$$

Stallings and McGilliard, 1984
St-Pierre and Thraen, 1999




McGilliard et al., 1983
St-Pierre and Thraen, 1999

**Cluster**

Seems to be MOST efficient criterion for grouping

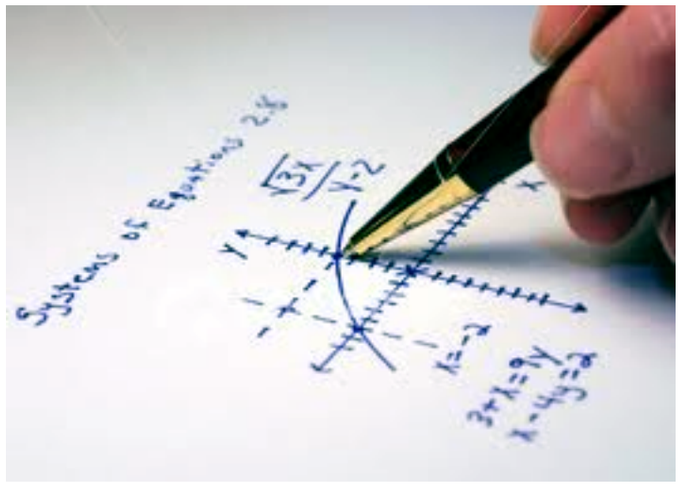
# Value of NE, CP, and milk

## Determine diets' cost (August 2013)

### Using referee feeds

Petersen method

St-Pierre and Giamocic, 2000



***Corn:  9% CP + 2 Mcal/kg  = $0.267/kg***

***SBM: 54% CP + 2.2 Mcal/kg = $0.587/kg***

### Price NE and CP

NE ($/Mcal) = 0.116

CP ($/kg)  = 0.747

http://dairymgt.info/tools/feedval_12/index.php

### Price of milk

$0.412/kg

http://future.aae.wisc.edu/

# Nutritional grouping

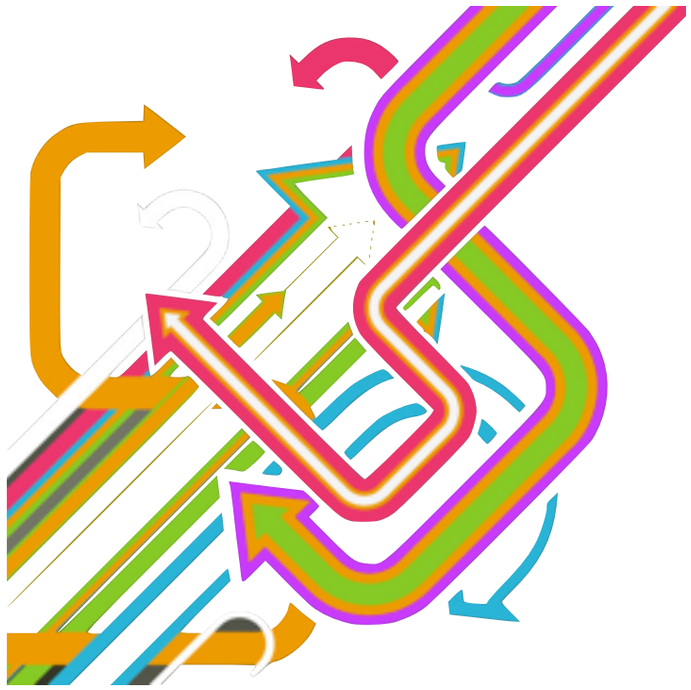
## Two main types of groups

**Obligated groups**

- Fresh (< 22 DIM)
- Dry (~> 220 DCC)
- Daily assigned

**Optional groups**

- 1 to 6 additional groups
- Daily assigned
- Monthly re-grouped

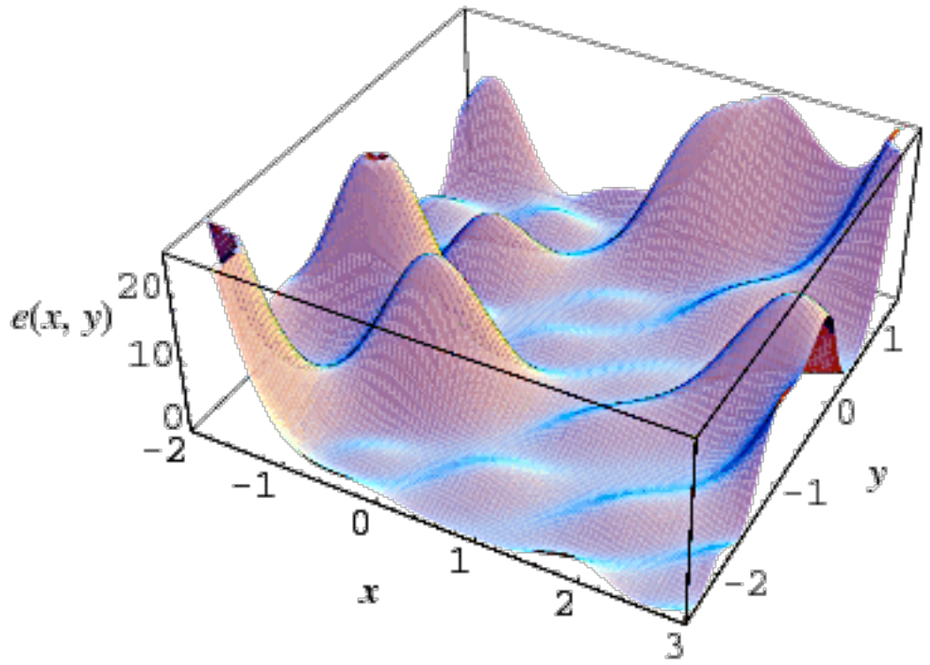


# Optimize cows to a feeding group

## Maximize the income over feed cost

**Non-linear optimization**

- Iterative process (all permutations)
- Search for global maxima IOFC




$$Max(IOFC) = SUM(IOFC_{group})$$

$$IOFC_{group} = Milk\ Value_{group} - Feed\ Cost_{group}$$

Cabrera, 2012

# Cow and herd simulation

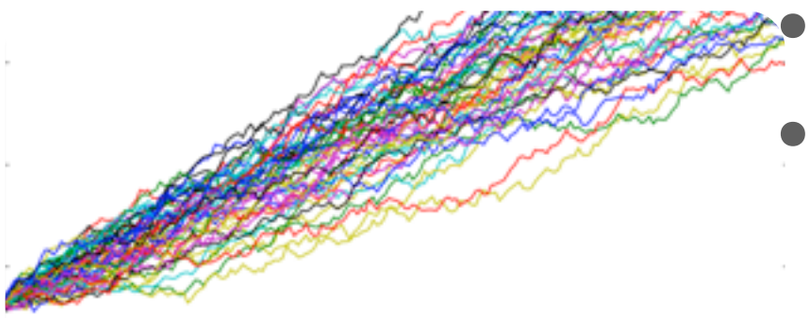
## Monte Carlo approach

**Next event scheduling**

- Pregnancy
- Abortion
- Dry-off
- Parturition
- Involuntary culling
- Death

**Two-step**

- 1. Binary outcome of event:
  - Happens or not
  - E.g., uniform distribution
- 2. DIM of the occurrence
  - When it happens
  - E.g., Weibull distribution



**Immediate replacement**

- After a cow leaves the herd

**Replicates**

- 1,000 replicates for each cow within specific herd

# Cow simulation

## Follows actual COW card

| Variable | Unit | Description |
|---|---|---|
| Cow ID | # | Cow identification |
| Parity | # | Lactation |
| DIM | d | Days in milk, days after calving |
| DCC | d | Days in pregnancy (DIP) |
| Fat | % | Fat component on milk |
| Protein | % | Protein component on milk (%) |
| PPA* | % | Predicted producing ability |
| ME 305* | kg/305 d | Mature equivalent milk production |
| BW | kg | Live body weight |

*Either PPA or ME305 used to assess cow's milk class. PPA preferred if available

# Herd simulation

## Nutritional grouping baseline information

| Parameter | Description |
|---|---|
| Herd ME 305 | Herd production level |
| Diet formulation 1 group | 83$^{rd}$ percentile |
| Diet formulation + groups | 83$^{rd}$ percentile |
| Size for optional groups | Same size groups |
| Groups size flexibility | Adjust herd dynamics (i.e., dry-off freshening) |
| Milk depression when new group-pen | 1.82 kg/d for 5 d |

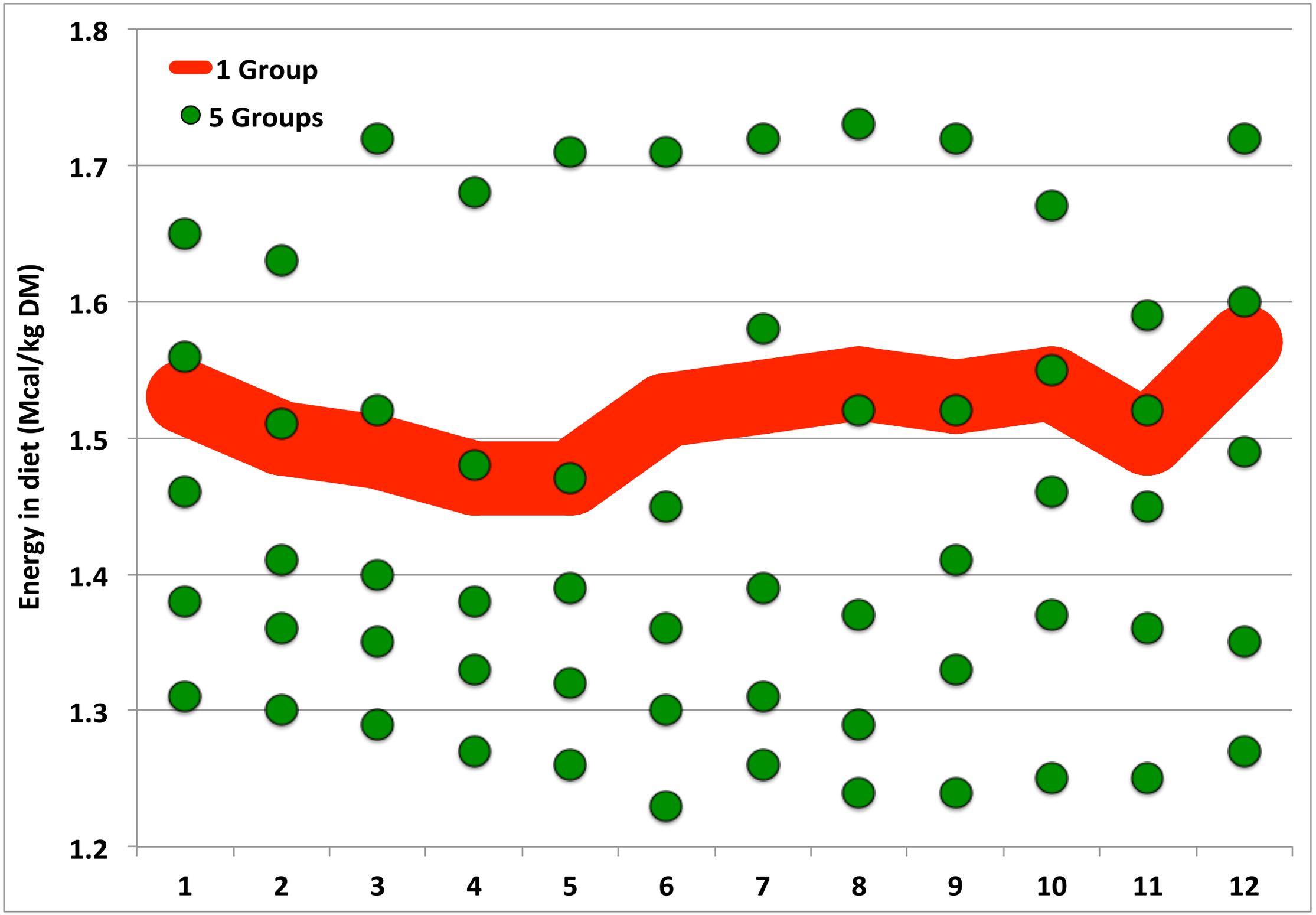
# Studied herds

## All data collected at the **cow-level**

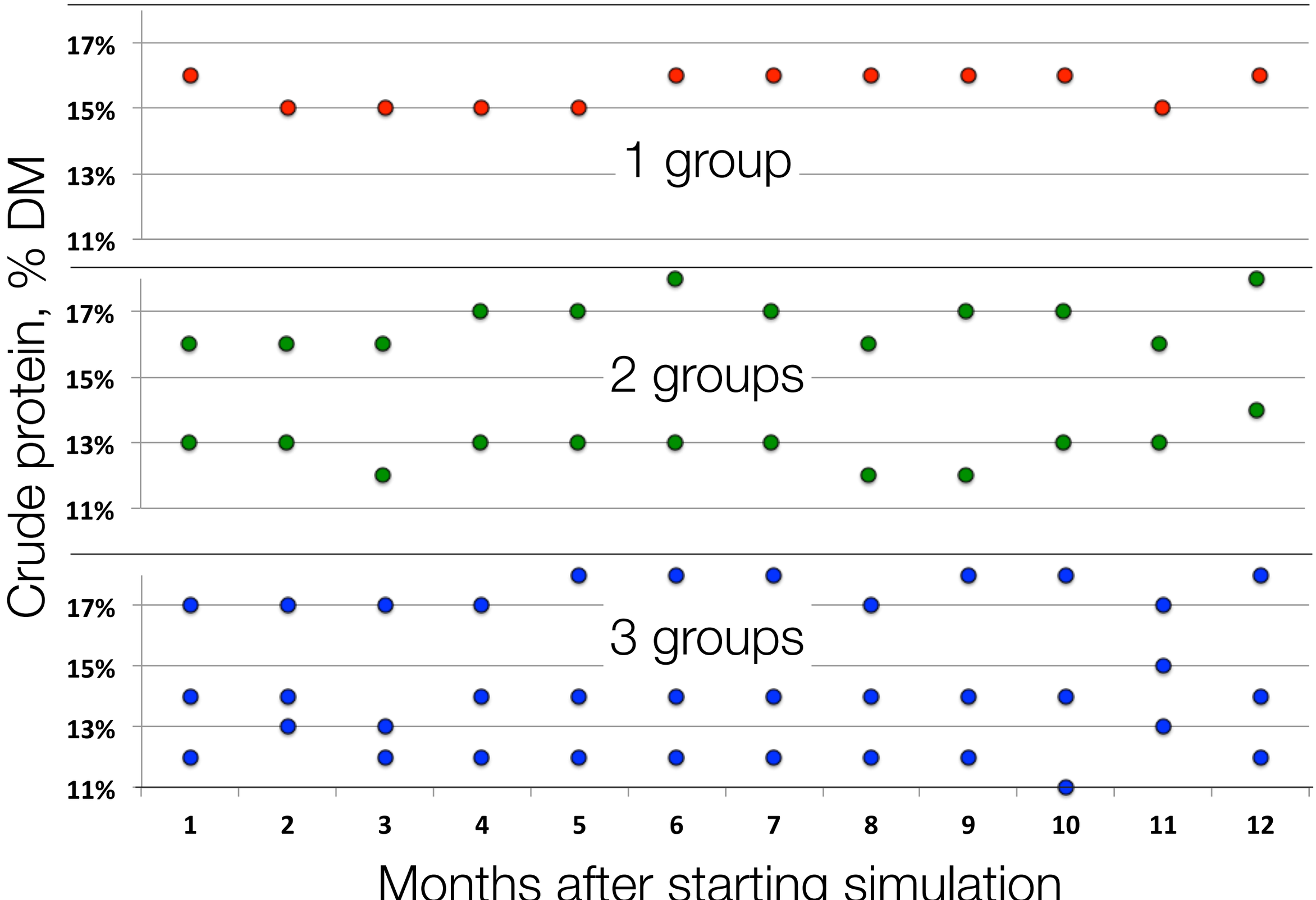
| Herd (size) | 570 | 787 | 727 | 331 | 1460 |
|---|---|---|---|---|---|
| **Herd ME 305, kg** | 16,140 | 12,884 | 13,897 | 13,348 | 14,188 |
| **1st lactation, %** | 43 | 39 | 39 | 38 | 45 |
| **Average DIM** | 187 | 178 | 201 | 208 | 189 |
| **21-d PR, %** | 18 | 19 | 19 | 17 | 18 |
| **Culling risk, %** | 32 | 37 | 36 | 35 | 40 |
| **Abortion, %** | 7 | 11 | 11 | 16 | 7 |
| **BW available** | ✗ | ✗ | ✓ | ✓ | ✗ |

...And we are finding

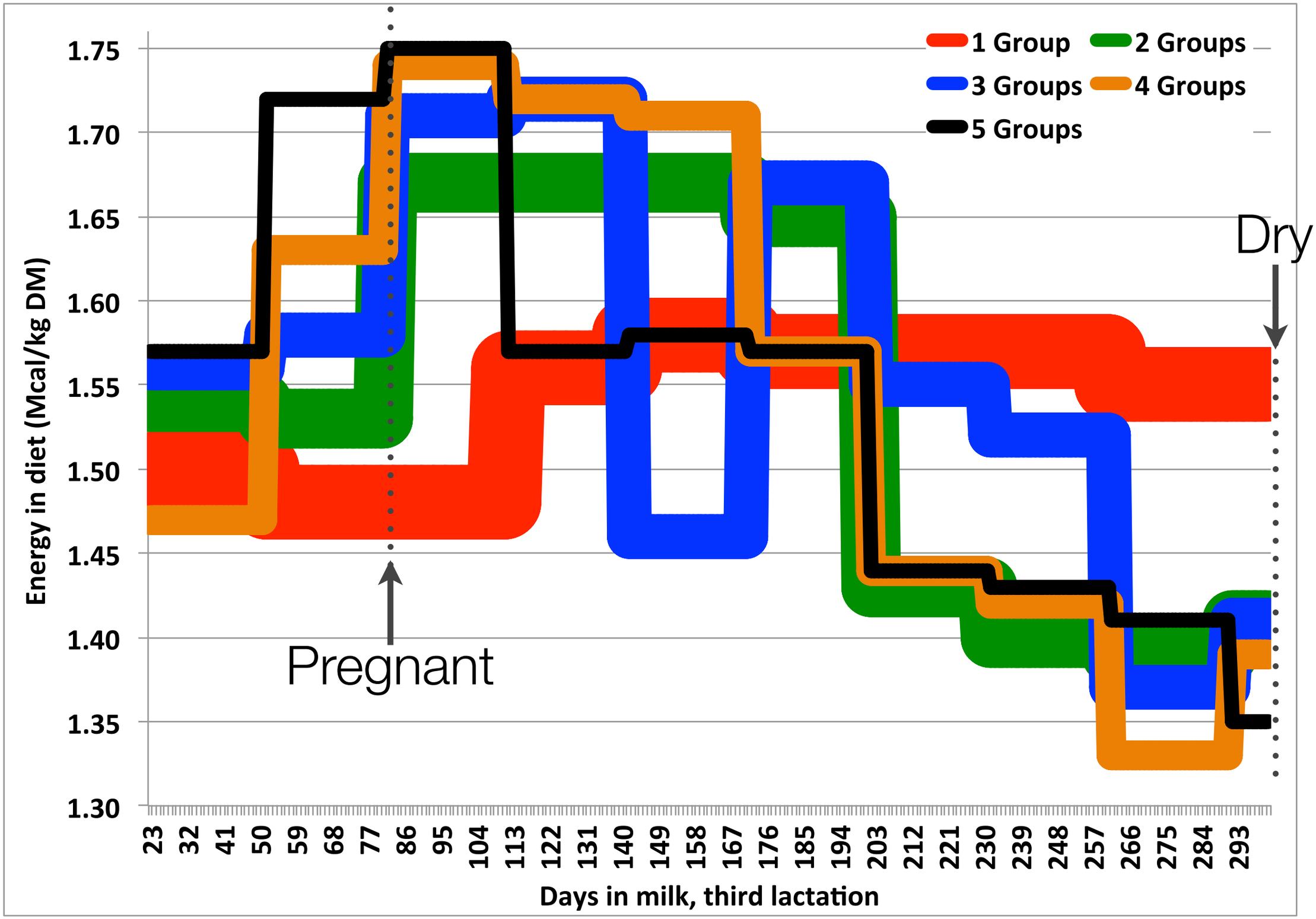
# Herd 787, nutritional diets



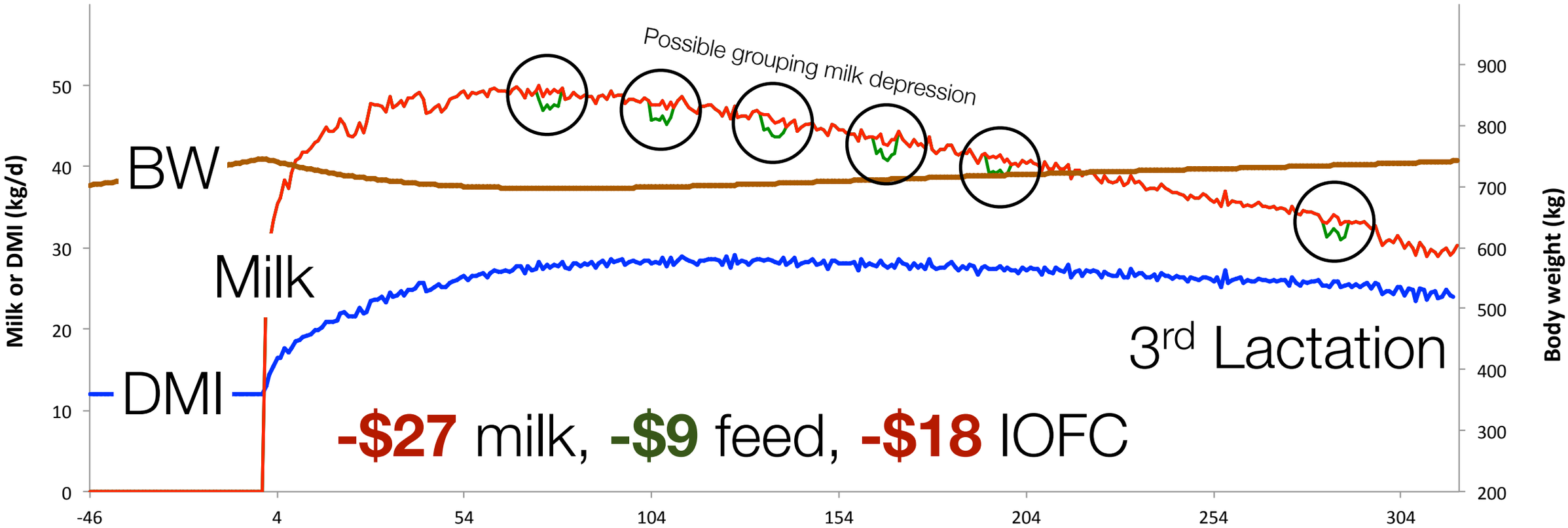
# Herd 331, nutritional diets

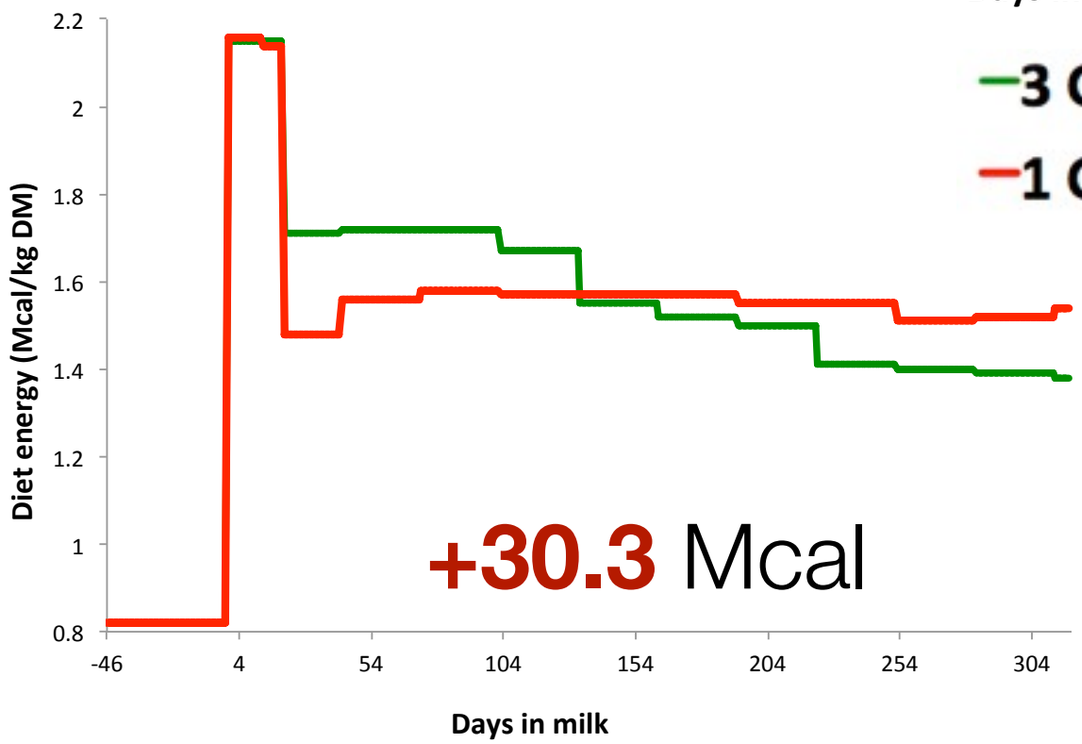


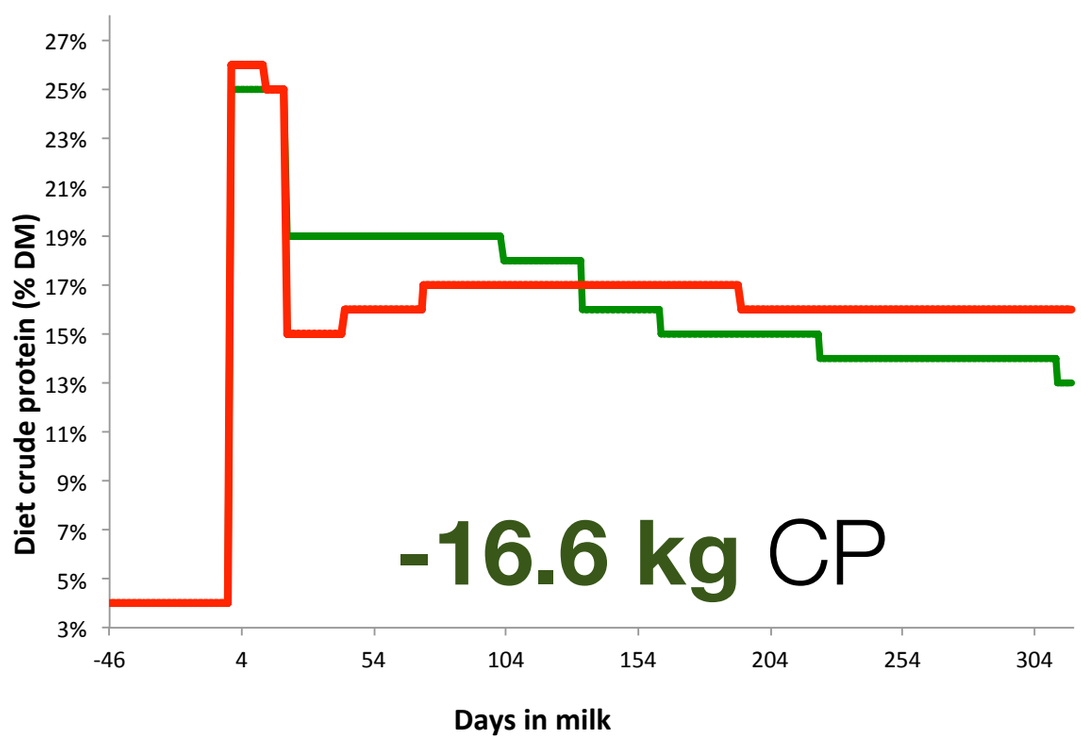
# Cow 6320 (727) = 100% milk



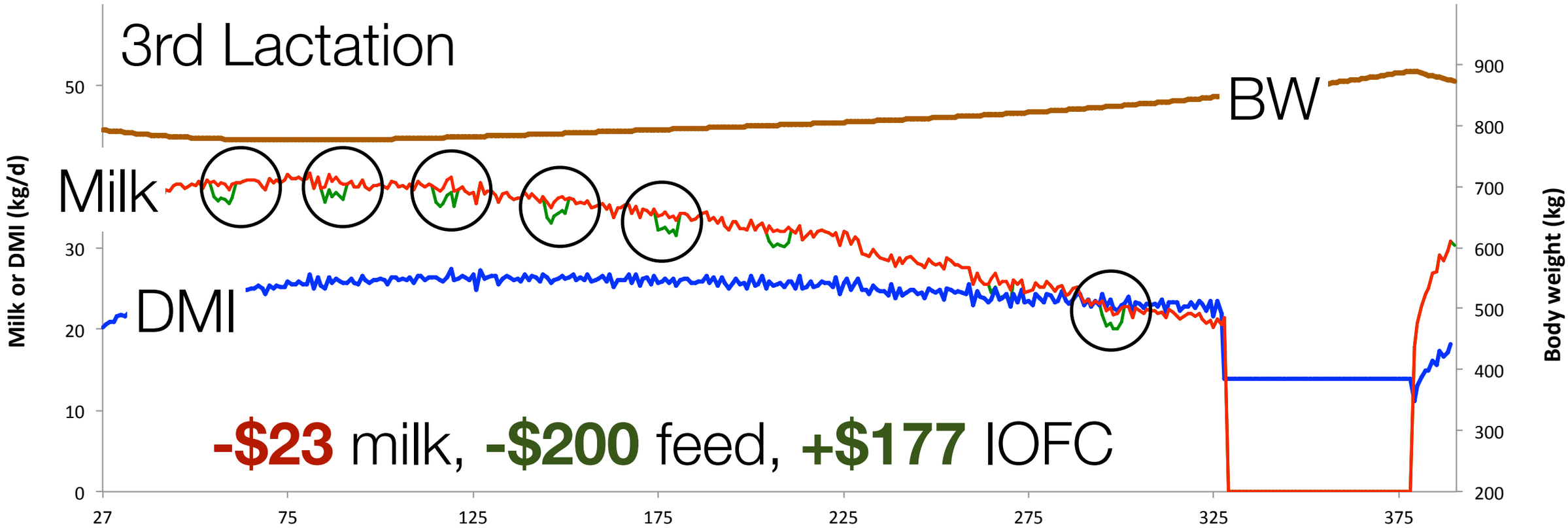
# Cow 928(727) = 109% milk, 1 yr

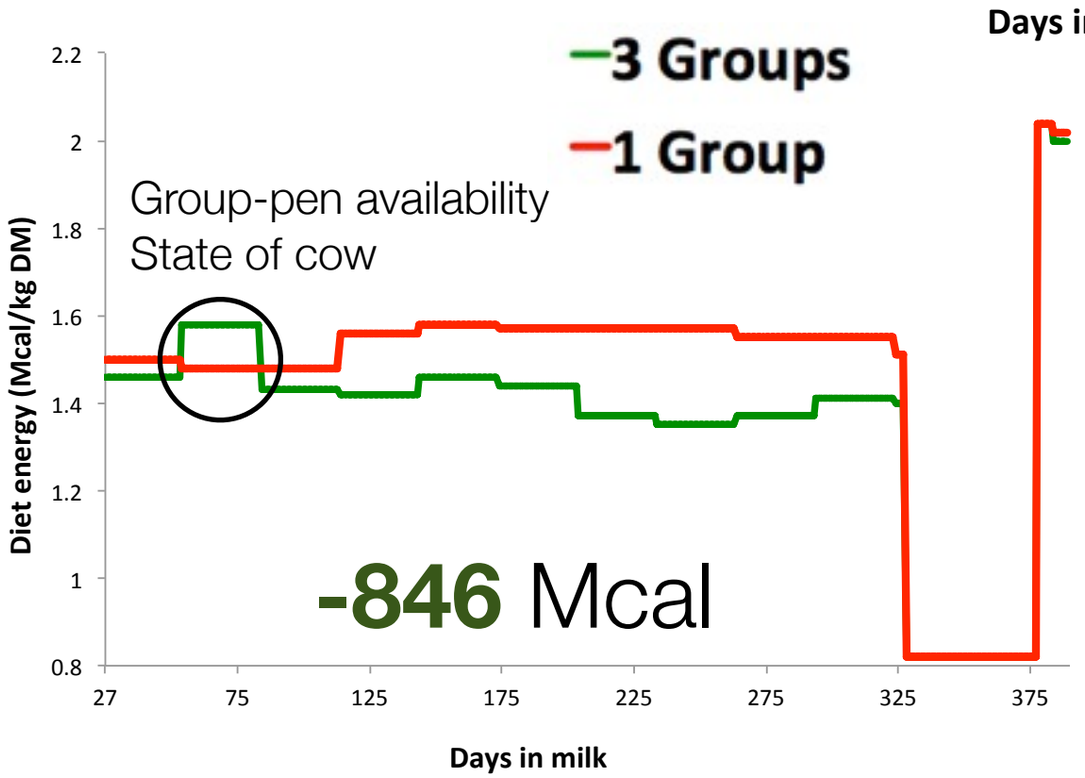


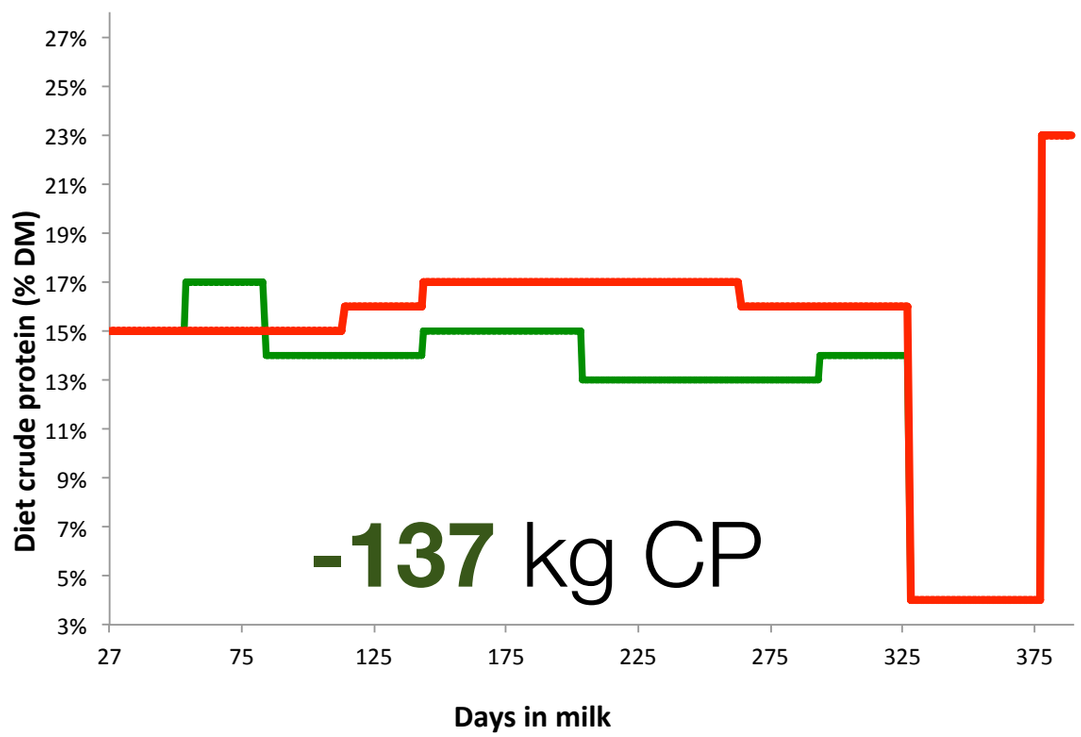



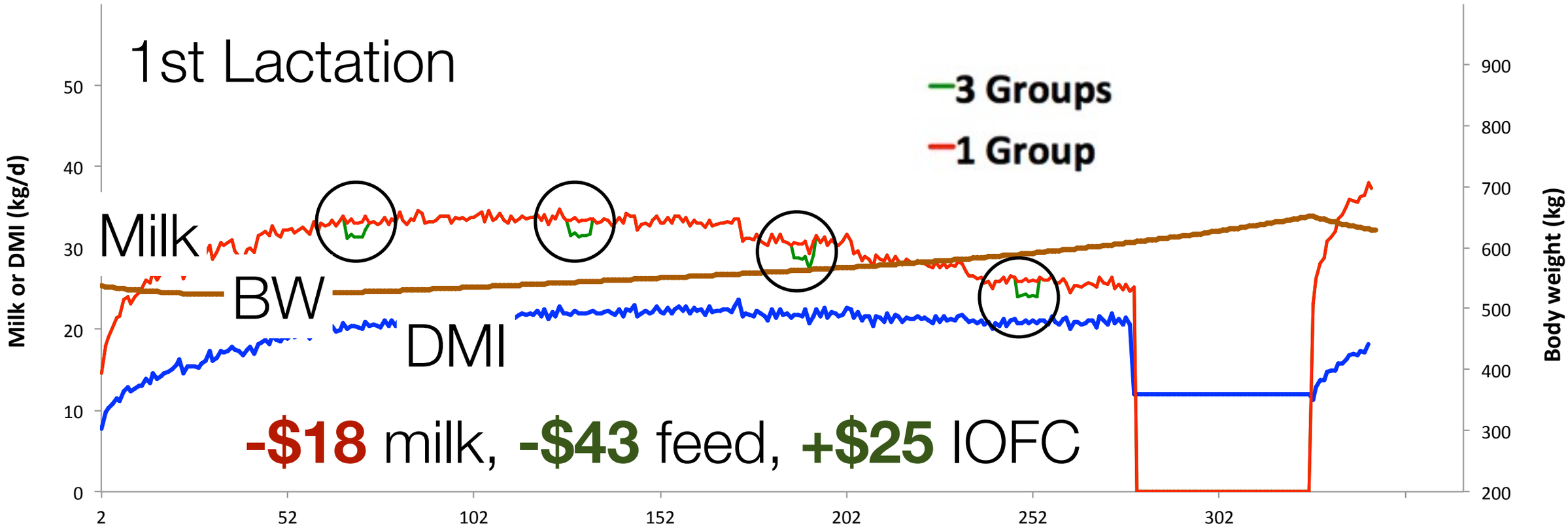
# Cow 6338(727) = 78% milk, 1 yr

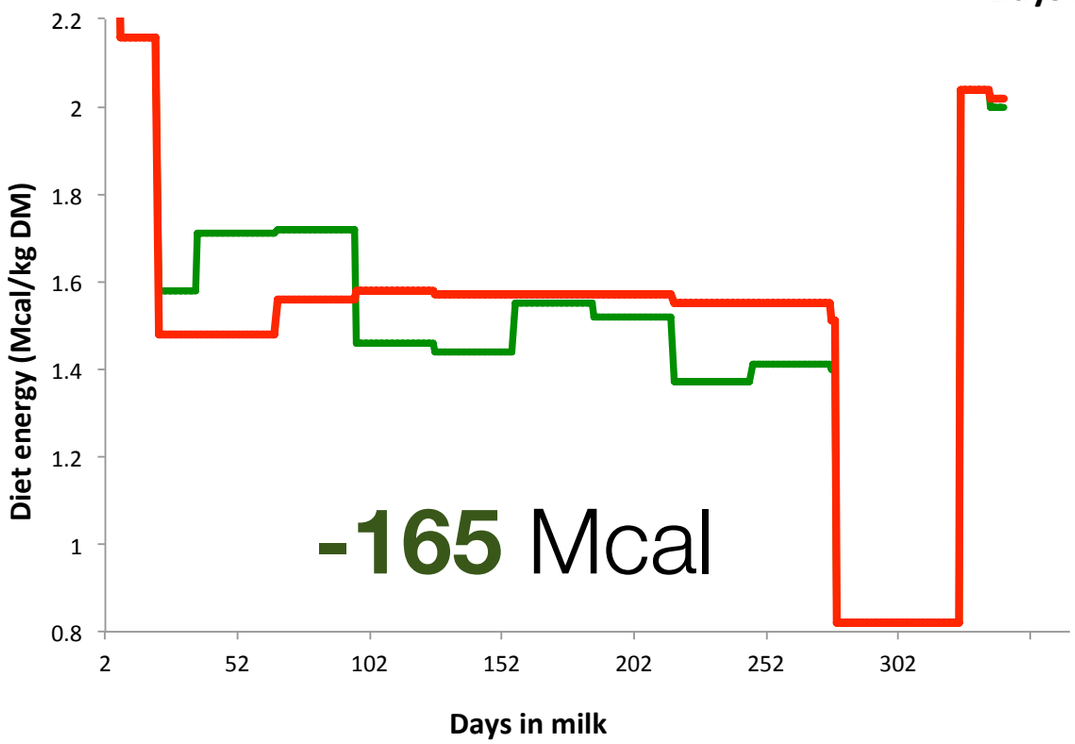


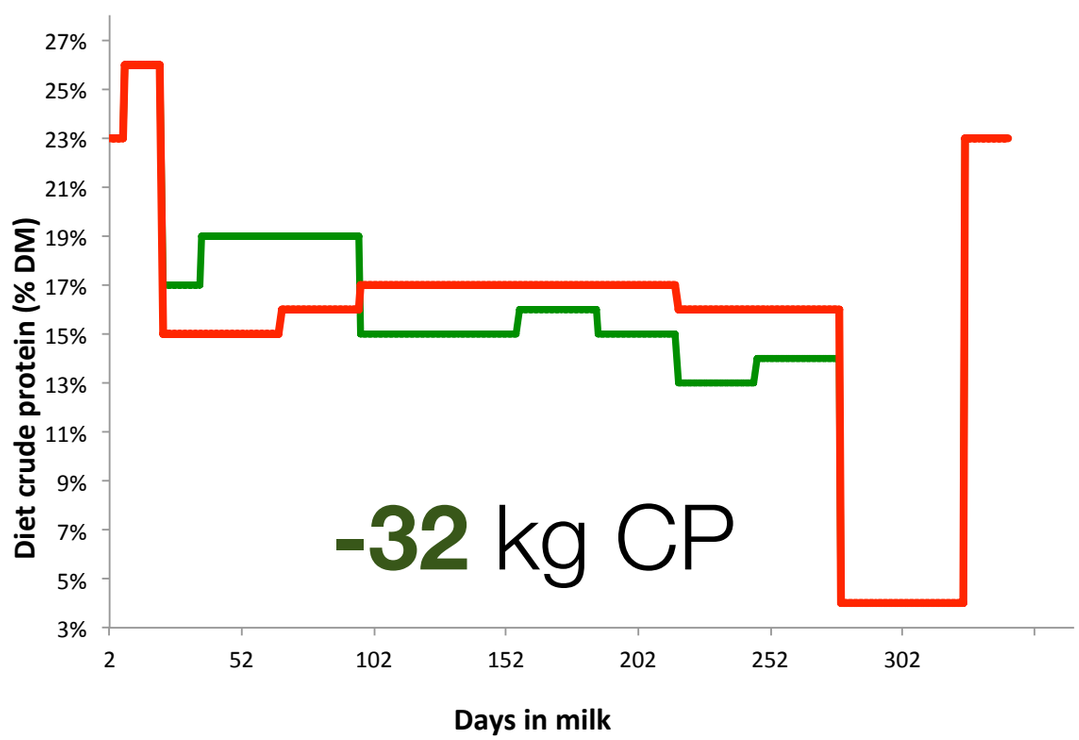



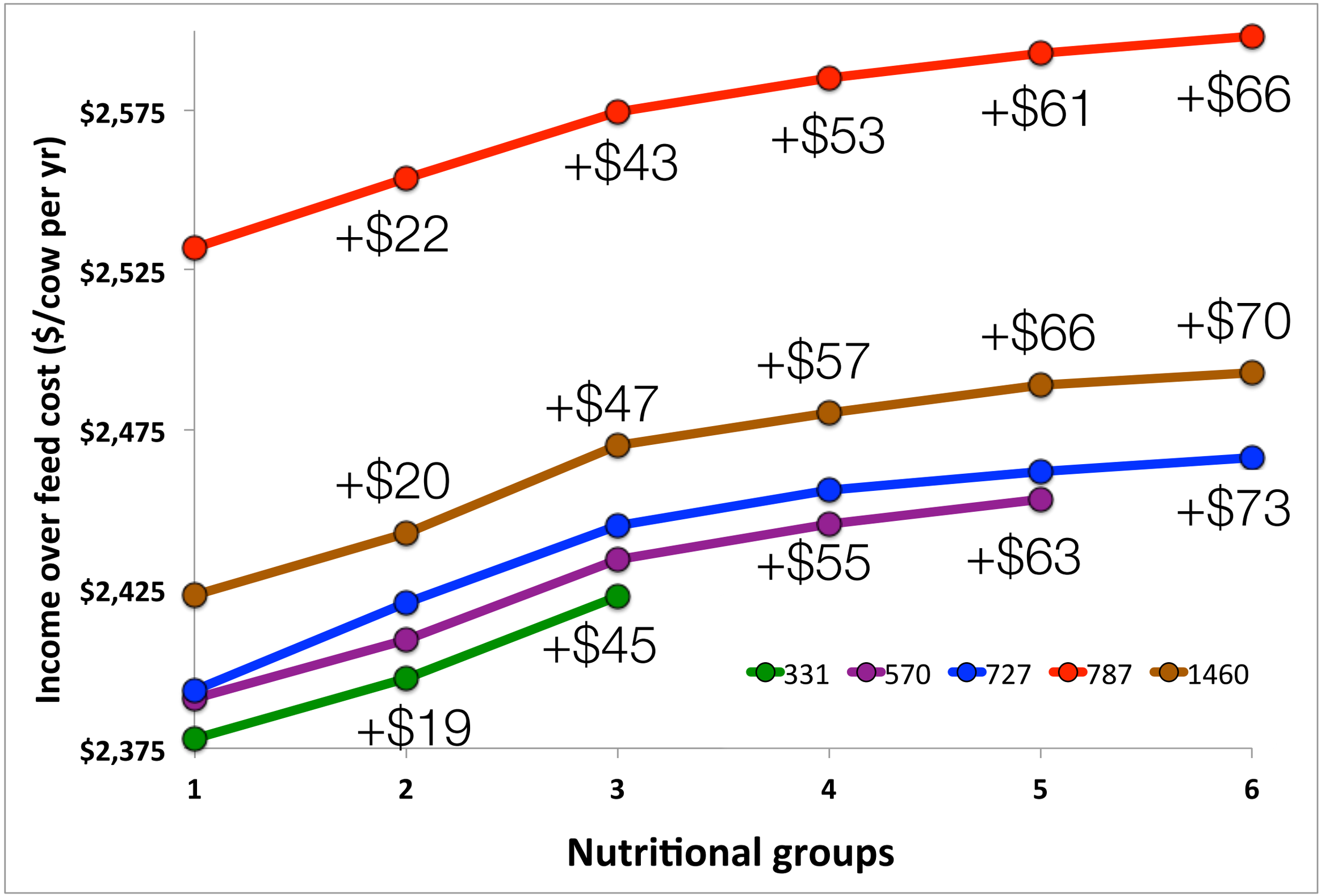
# Cow10020(727) = 92% milk, 1 yr



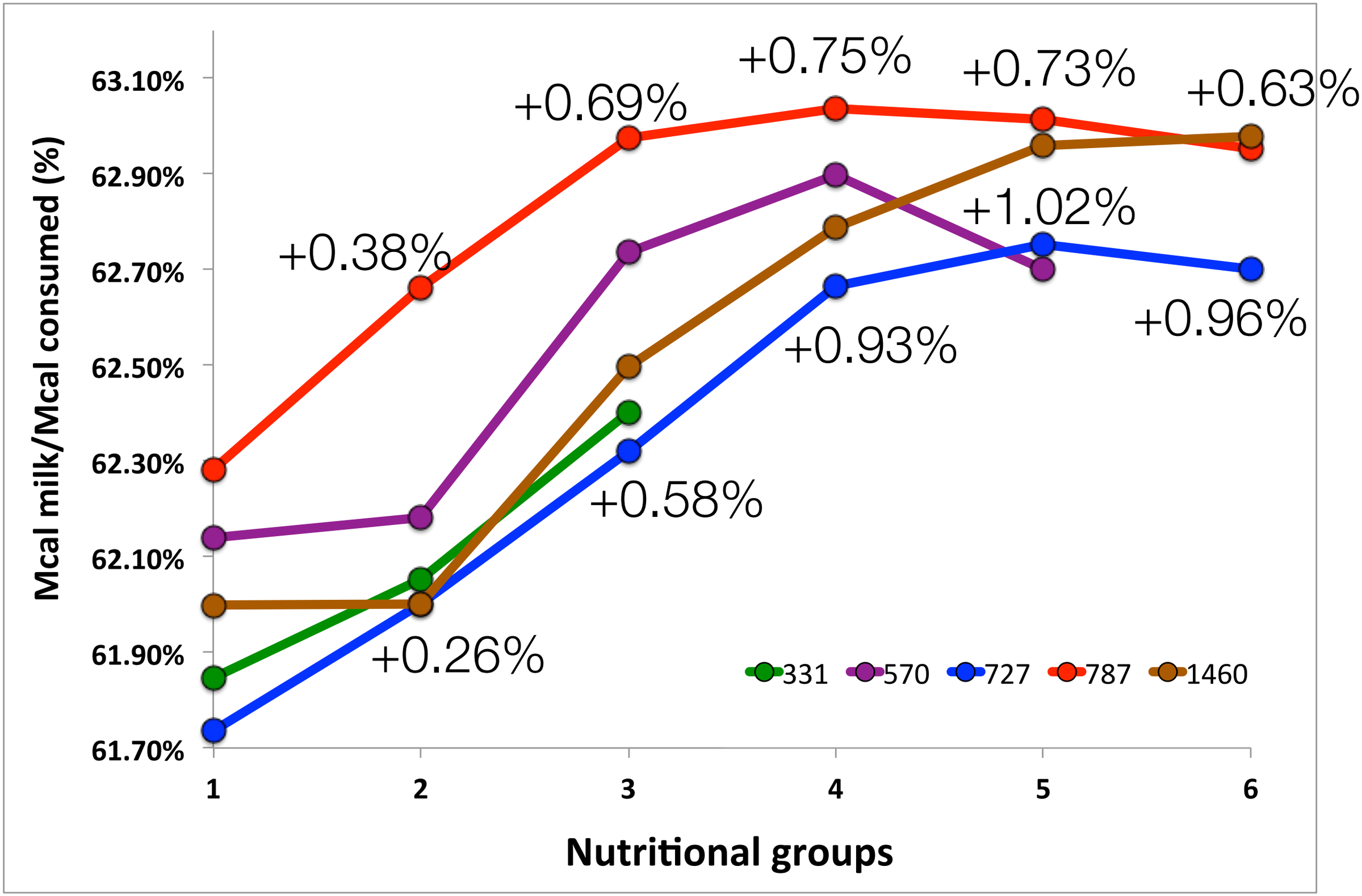



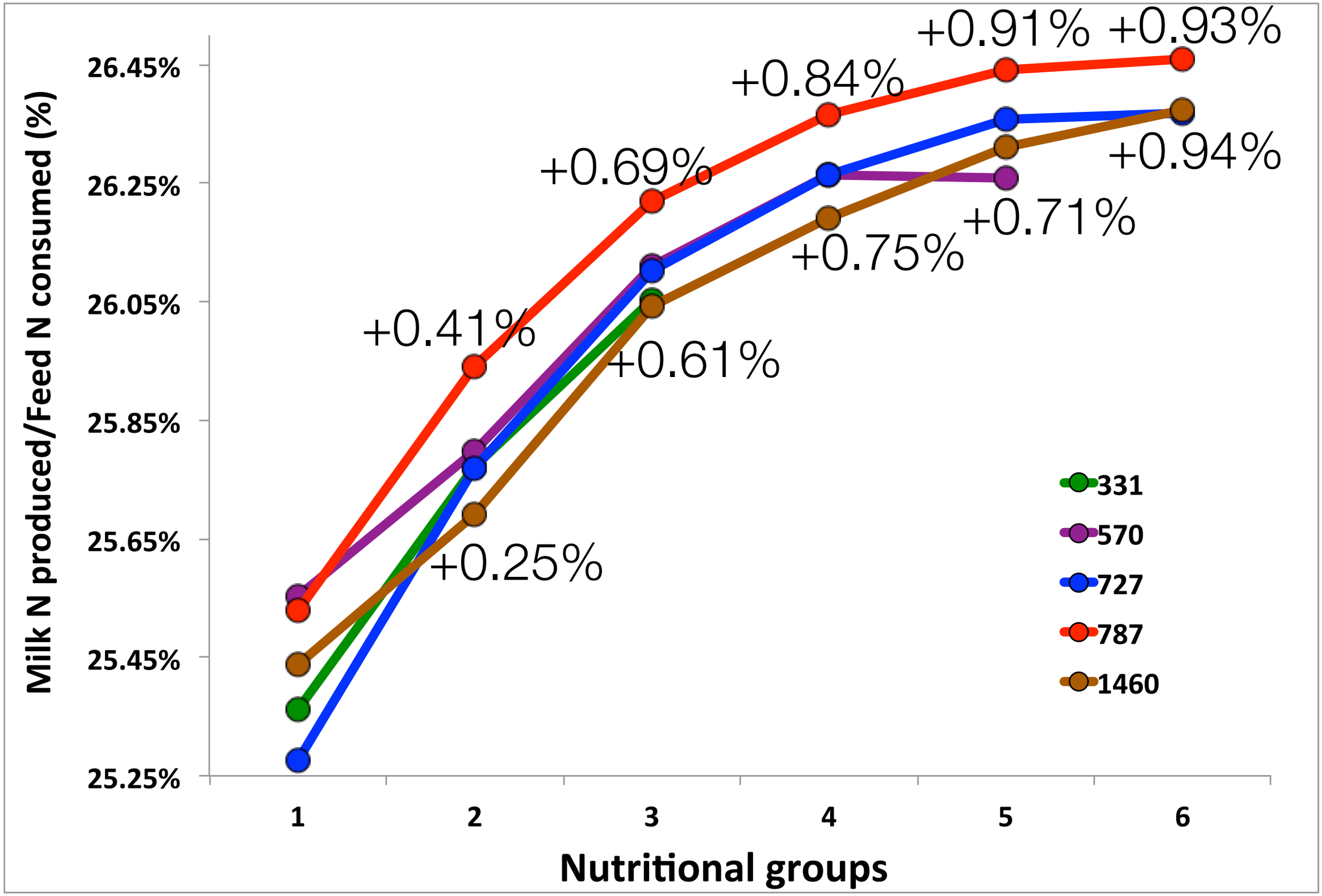
# Economic efficiency



# Energy efficiency

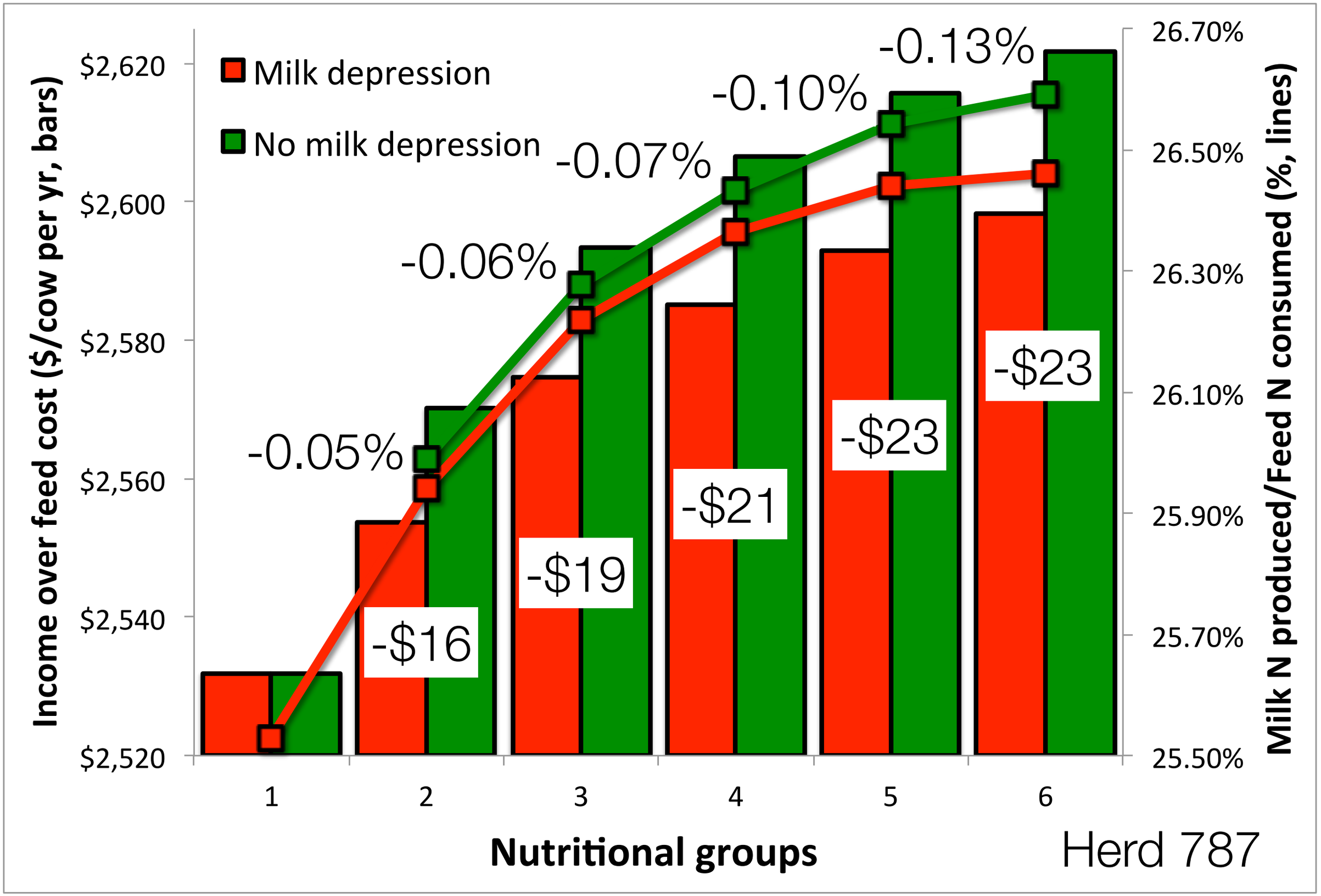


# Nitrogen efficiency

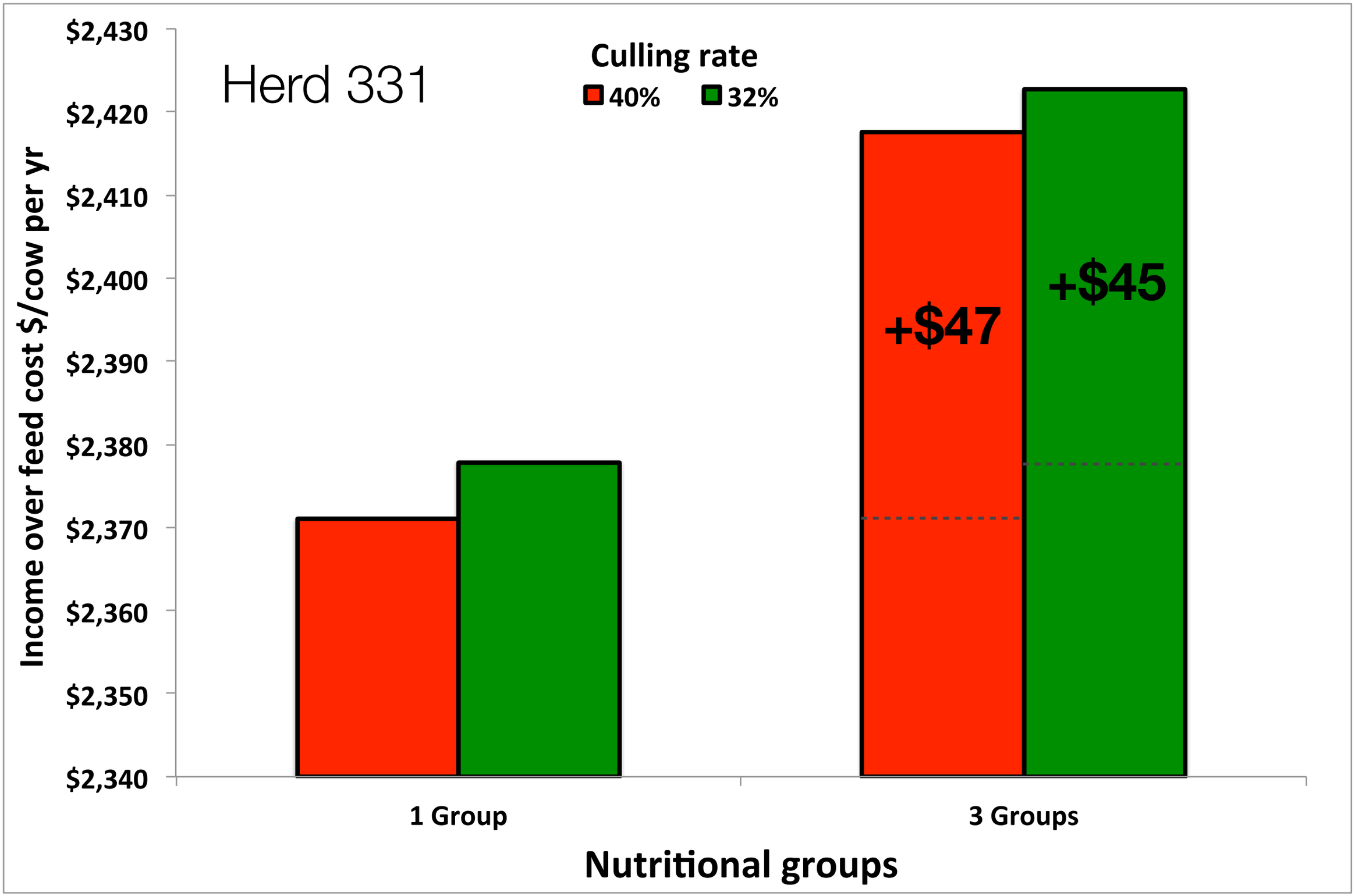


# Effect of milk depression

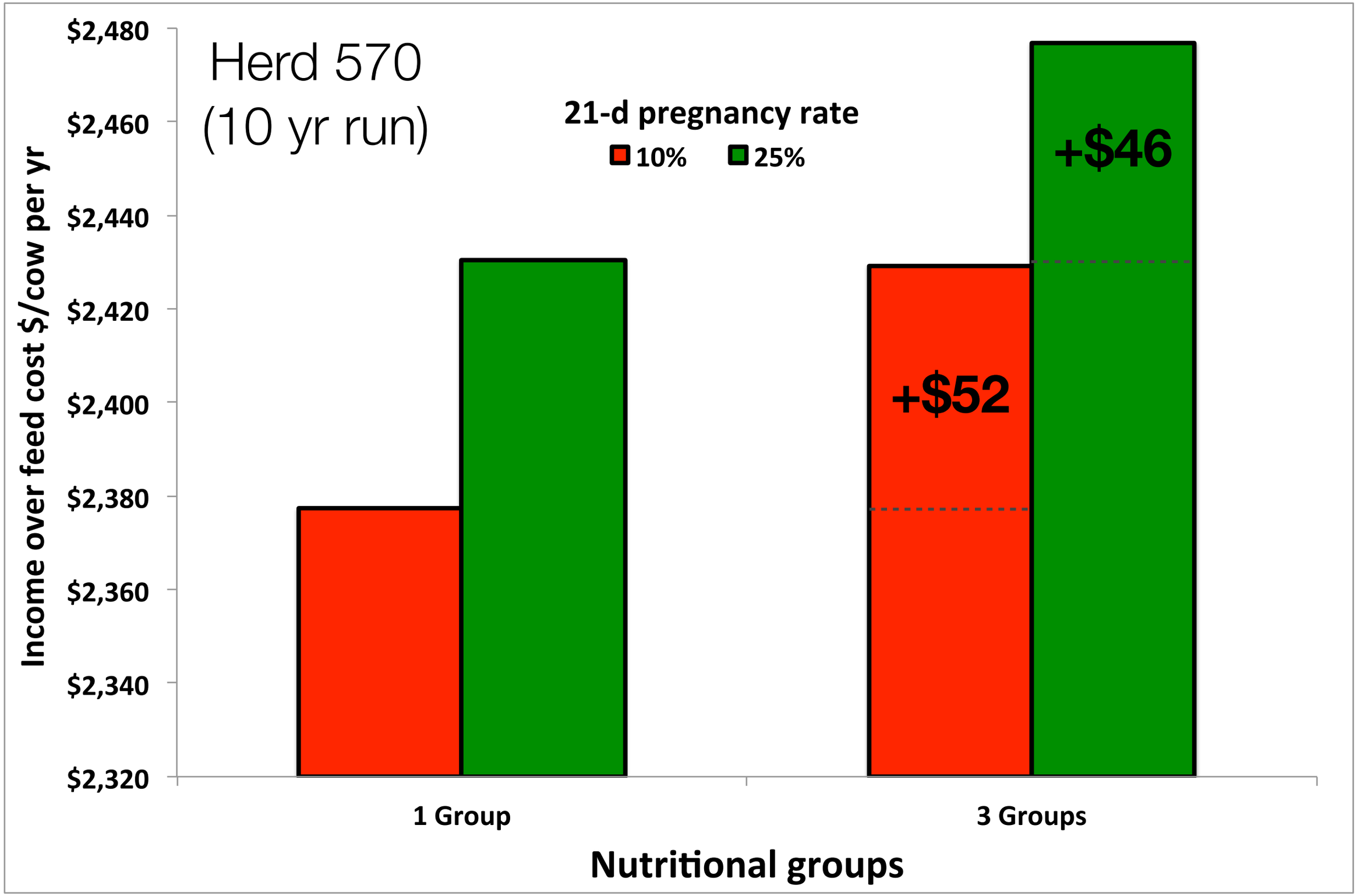
9.1 kg
Δgroup



# Interaction with culling



# Interaction with reproduction



# A simplified online tool

## Herd-specific assessments (DairyMGT.info)

# Additional costs and benefits

## Impacts grouping feeding strategies

**Management cost**

- Additional labor
- Extra management

**Avoid costs**

- Additives and supplements savings

**Milk depression**

- Cow social interactions

# Tool illustration

## Economic impact of grouping

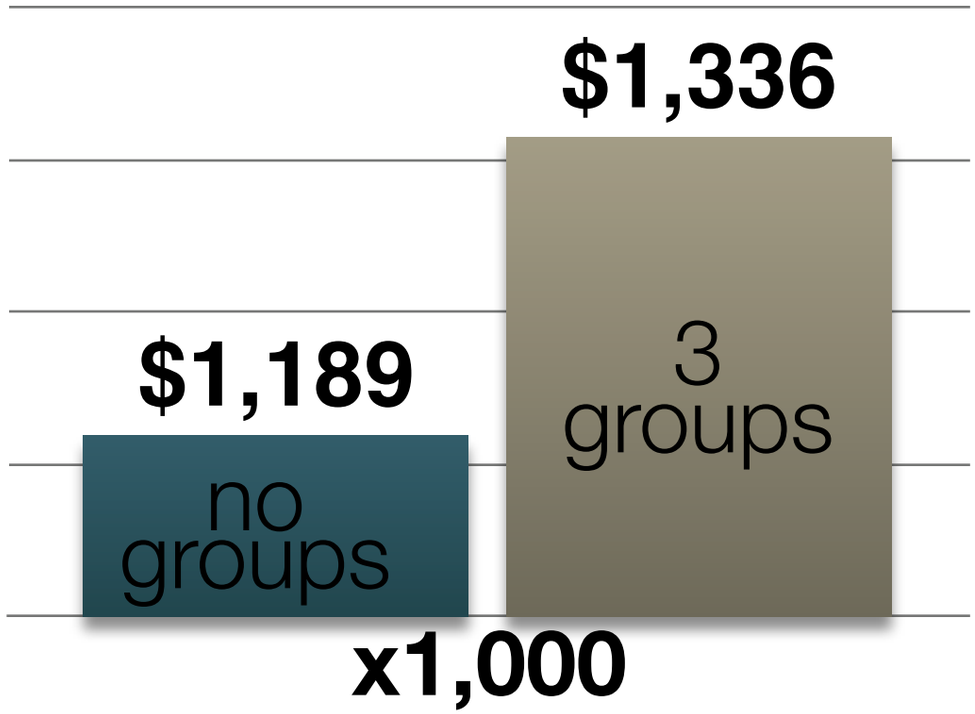
| Current situation | |
|---|---|
| Lactating cows | 470 |
| Number groups | 1 |
| NEL, Mcal/lb DM | 0.80 |
| CP, % DM | 17% |

| Possible situation | |
|---|---|
| Number groups | 3 |
| Group sizes | 100, 100, 270 |
| Added cost, $ | $1,000/month |
| Milk loss | 2.27 kg/cow |
| Milk loss time | 4 days |
| Saved cost, $ | $0 |

# Decision support system illustration

## Cluster grouping criteria

| | Possible situation | | | |
|---|---|---|---|---|
| | Cow numbers | NEL, Mcal/lb | CP, % | IOFC, $/cow/day |
| Group 1 | 270 | 0.71 | 16.05 | 9.3 |
| Group 2 | 100 | 0.65 | 14.18 | 7.2 |
| Group 3 | 100 | 0.62 | 13.07 | 4.7 |




Annual value of grouping
**$147,000**/470 cows

Cabrera et al., 2012

# Analysis from dairy farm records

30 Wisconsin dairy farms

**No grouping vs. 3 groups**

- Same size groups

**Cluster grouping**

- 83rd percentile CP and NEL

**Current diet**

- 1.75 Mcal/kg DM
- 17% CP

**Same prices for all**

- $0.35/kg milk
- $0.315/kg CP
- $0.1174/Mcal NEl

**Projected body weight**

- 500 kg primiparous
- 600 kg multiparous

# Analysis from dairy farm records

## 30 Wisconsin dairy farms

| | Number of lactating cows (n=30) | Income over Feed Cost (no grouping) | Income over Feed Cost (3 groups) |
|---|---|---|---|
| | | $/cow per year | |
| Mean | 788 | $2,311 | **$2,707** |
| Minimum | < 200 | $697 | **$1,059** |
| Maximum | > 1,000 | $2,967 | **$3,285** |

**Increase of IOFC ($/cow per year)**

- Between 7 and 52%
- Mean = $396
- Range = $161 to $580

Cabrera et al., 2012

# Acknowledgements

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# Thanks