Growth Objectives, Nutrient Requirements, Weaning and Post-weaning Diets and Management

Mike Van Amburgh and Rodrigo Molano

Dept. of Animal Science

Email:mev1@cornell.edu; cell: 607-592-1212

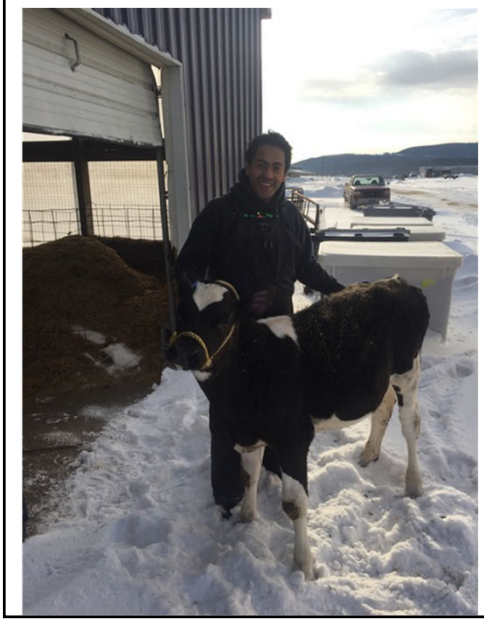
1

Overview of today's discussion

- Introduction – goals and objectives
- Nutrient requirements related to weaning
- Weaning and starter intake and composition – slowing the process down
- Nutrient supply at different stages of growth – late pregnancy as an example
- Summary

2

What are your growth objectives?



340 lb (154 kg) @ 91 days

Averaged 2.87 lb/d (1.3 kg/d) from birth

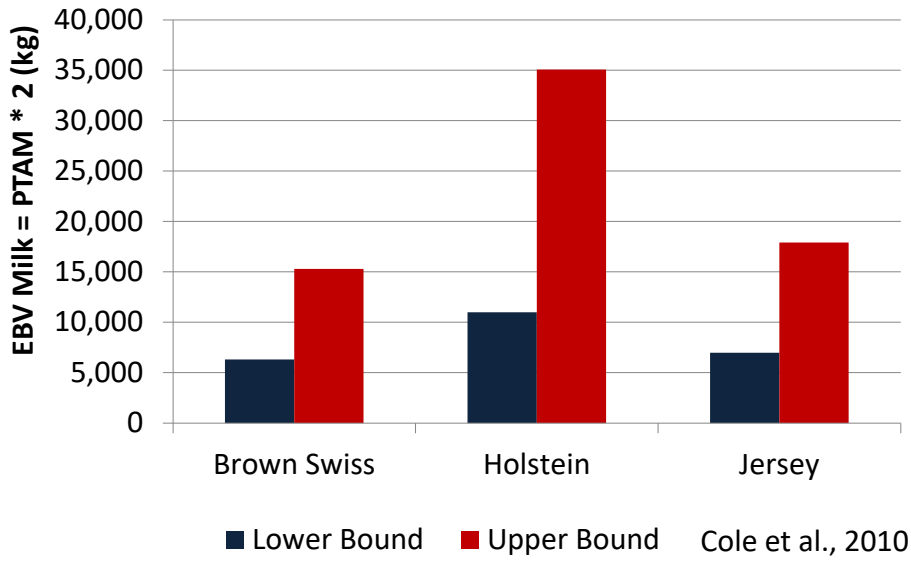
3

Herd Replacement Objectives

- Optimize profits by obtaining the highest quality heifer at the lowest possible cost usually in the least amount of time
- Focus on return on investment – over their productive life
- Minimize non-completion (animals that are born and either never milk or finish a lactation)
- Optimize the productivity of the animal over their productive life (manage them for their genetic potential starting at birth)

4

Genetic Potential: upper and lower bounds for Brown Swiss, Holstein and Jersey cattle



Cole et al., 2010

5

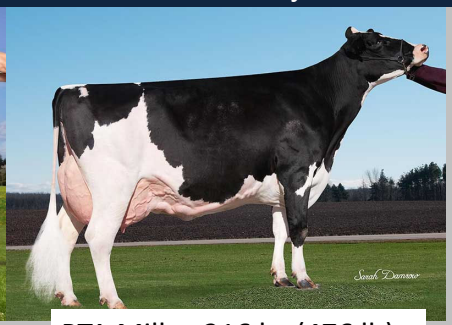
What are the limits? Two world record holders as examples

Selz-Pralle Aftershock 3918

PTA Milk = 228 kg (508 lb)
EBV Milk = 456 kg (1,005 lb)

35,467 kg + 34,601 kg=**70,068 kg (154,429 lb)**
Lower bound = **46,003 kg (101,390 lb)**

Ever-Green-View My Gold - ET



PTA Milk = 216 kg (476 lb)
EBV Milk = 431 kg (949 lb)

35,154 kg + 34,627 kg = **69,781 kg (153,781 lb)**
Lower bound = **46,170 kg (101,759 lb)**

Chad Dechow, 2019

6

Perspective

- Based on evaluations by J. Cole and C. Dechow, the genetic capacity for milk yield for Holsteins is approximately 75,000 lb
  - There are cows on commercial farms in central NY in high performing herds that are peaking in milk yield between 198 to 214 lb/d (~44,000 to 46,000 lb/lactation)
- My perspective is that many cows in a herd have this capacity.
- Leads to the question, what are we doing, and when, that either detracts from or fails to "turn on" that ability and when is that communicated to the animal?

7

Perspective

What are the detractors that prevent realization of genetic capacity?

When do they occur?

How do we manage the epigenetic signals to a positive outcome?

Simple questions:

Did they grow correctly?
Never get sick?
Were all of the essential nutrients supplied to them when needed?
Always have the correct climate from conception to lactation?
Have a good uterine environment prior to conception and when they were embryos and fetuses?

8

Growth Benchmarks to Optimize First and Subsequent Lactation Milk Yield

Birth to weaning: double body weight at minimum

Breeding and Pregnancy: 55-65% mature BW

Post-calving BW first lactation: 82 to 85% mature BW
Goal is to achieve 82% of mature size to achieve 80% of mature cow milk yield – minimize nutrient use for growth during lactation

Mature weight determined at middle of 3rd and 4th lactation – 80 to 200 days in milk on healthy cows, not cull cows

Van Amburgh et al., 1998, 2019; Fox et al., 1999; NRC, 2001

9

Body Composition Data Sets Available for Use in Evaluation and Model Building
Total of 451 calves and heifers

Study	n	BW range, kg	Titration	Breed
Blome	33	40 - 70	Energy	H
Diaz	60	40 – 105	Energy	H
Tikofsky	30	40 – 85	Fat:Carb	H
Bartlett	48	45 - 60	Energy & Protein	H
Bascom	33	30 - 42	Protein & Fat	J
Mills	36	46 - 88	Fatty acids	H
Stamey	42	40 - 100	Energy & Protein	H (W)
Meyer	78	40 - 350	Energy	H (W)
Smith	27	123 - 320	Fat – CLA vs Sat.	H (W)
Waldo	64	170 - 328	Energy	H (W)

10

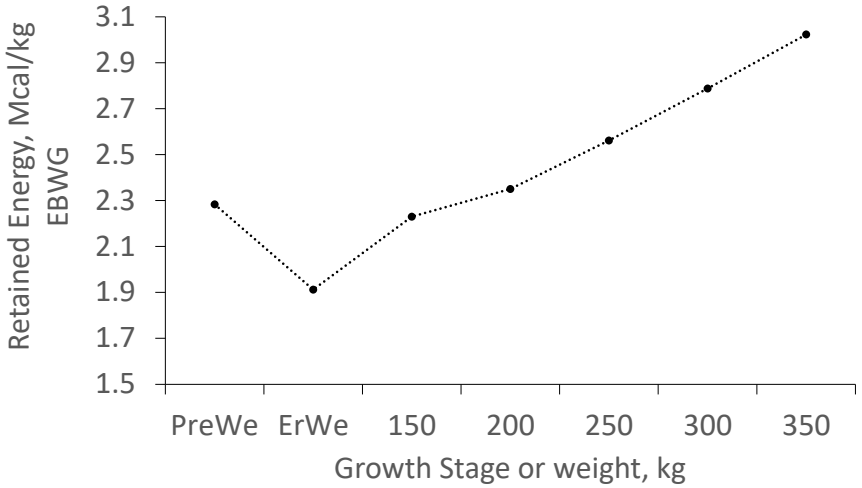
Nutrient Requirements of a 100 lb (45 kg) Calf Under Thermoneutral Conditions

Rate of gain, lb/d or kg/d	ME[a], mcal/d	DMI, lb/d	CP, g/d	CP, % DM
0.44/0.2	2.35	1.12	94	18.0
0.88/0.4	2.89	1.40	150	23.4
1.32/0.6	3.48	1.67	207	26.6
1.76/0.8	4.13	1.98	253	27.5
2.20/1	4.80	2.39	307	28.7

Van Amburgh and Drackley, 2005

11

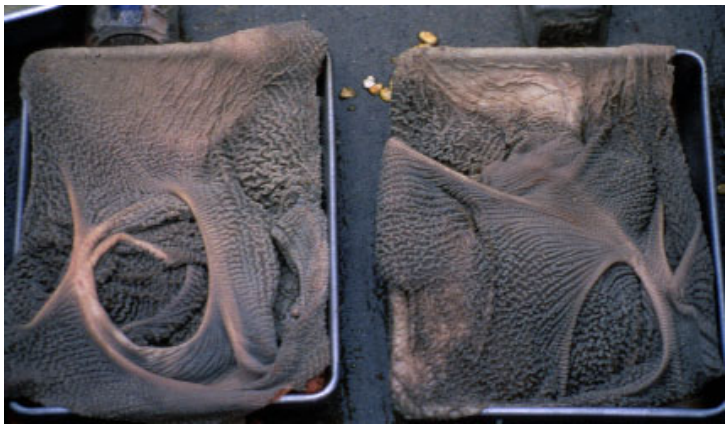
Retained energy in empty body gain during different stages of growth and EBW of dairy heifers.



Van Amburgh et al., 2019

12

What does energy and protein requirements look like during development of the GIT?

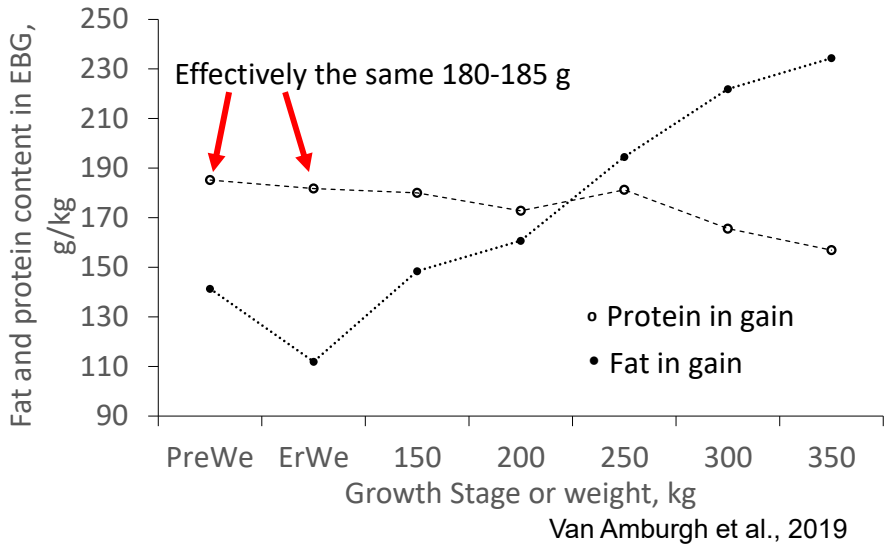


Photos from Dr. Akira Saito from Japan

Have two data sets: Stamey et al
Meyer et al.

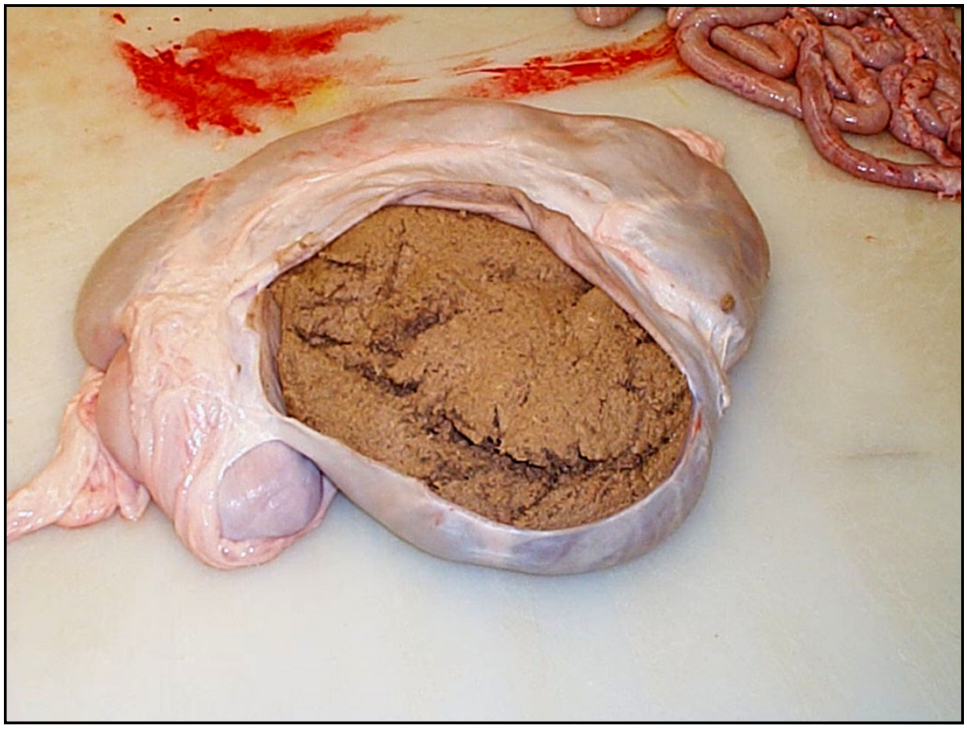
13

Protein and fat contained in the body of calves and heifers during different stages and body weight



Van Amburgh et al., 2019

14



15

Weaning and Dry Matter Intake of Starter

- Behavior is most likely the primary factor affecting a majority of the studies that have evaluated calf starter intake and preferences.
- Calves learn from their dams or the other calves around them as they are herd animals
- The dam teaches them what to eat and how to eat under pasture conditions
- Our approach generally create barriers, both physical and behavioral as to what calf starter is supposed to be

16

Weaning and Dry Matter Intake of Starter

- Minimizing nutrients from liquid feed to enhance hunger has been our strategy to encourage calves to consume nutrients from other sources
- Calves learn better if they are with their peers or can at least observe other herd animals – they engage in more risky behavior – think undergrads at university
- Creating an environment that allows calves to teach each other about starter grain intake is essential to enhance nutrient delivery and weaning efficiency in dairy calves and help avoid any post-weaning energy balance problems.

17

Weaning and Dry Matter Intake of Starter

- Adding flavors and odors to starter grain helps this process, especially for calves fed grain in situations where they receive no visual feedback about what other calves are doing.
- Making sure all nutrient requirements are met by the starter is also important – industry not willing to pay for that yet
- Other options are enzymes that enhance digestibility and reduce digestive stress

18

Starter intake is inhibited by high levels of milk intake

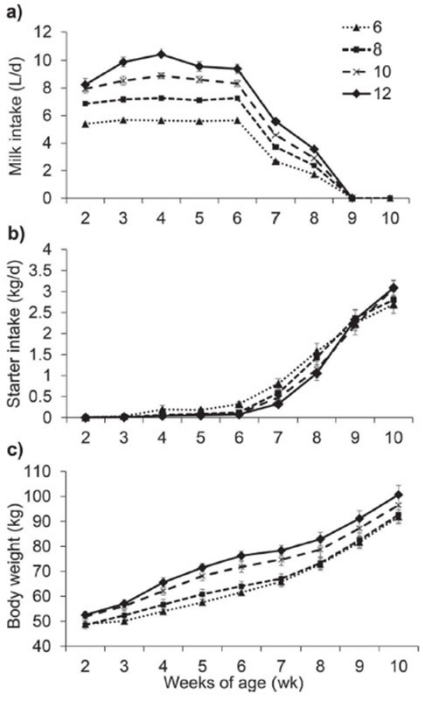
- A few reasons this might happen
  - Starter as a food is not obvious to the calf and not as palatable as milk or milk replacer and we are in a hurry
  - Starch content is too high and inhibits DMI – think Mike Allen's HOT theory and subacute ruminal acidosis
  - Papillae and rumen function can be developed with low intakes, but full digestion requires a large pool of bacteria and this is directly related to DMI and fermentable CHO intake

19

Weaning protocol – increasing the amount of time to wean

- **Gradual reduction of Liquid feed**
- **Weaning duration**
  At least 10 d

Rosenbergh et al., 2017



20

Starter chemical composition – somewhat random sampling from 2008 to 2019

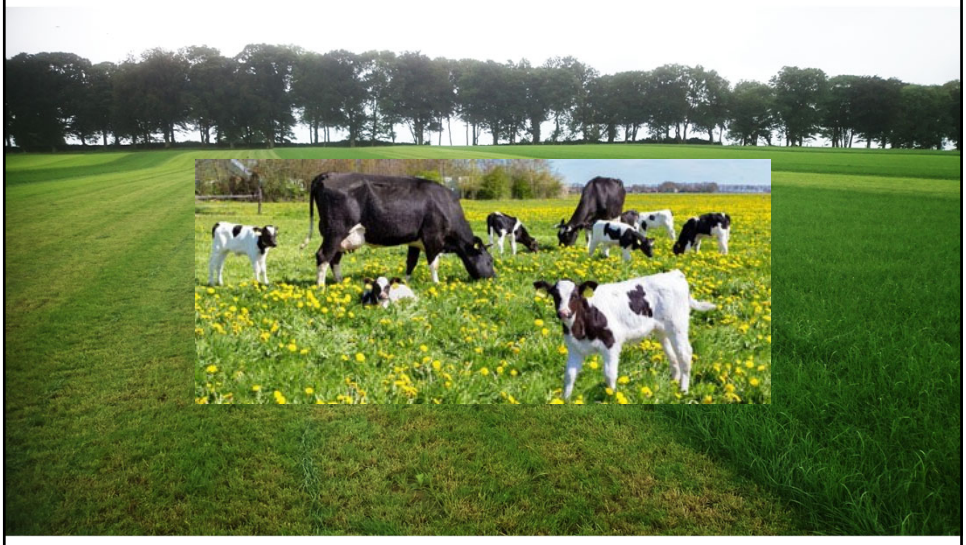
			% DM	
Authors	**NDF**	**Sugar**	**Starch**	**Sol. Fiber (*cal)**
Hill et al., 2008	38.4	5.2	**15.6**	5.7
	15.4	5.1	**43.5**	11.1
Chapman et al., 2016	15	6.1	**40.4**	11.3
Hill et al., 2016	13.6	7.7	**51.3**	
Suare				
Dennis et al., 2018	15.9	6.2	**37.2**	10.3
Quigley et al., 2019	15.5	7.3	**38.4**	7.5
Gelsinger et al., 2019	15.1	5.6	**47.2**	-
	25.3	6.2	**35.3**	3.4
Benetton et al., 2019	18.3	-	**37.3**	-
Hu et al., 2019	14.5	6.0	**43.9**	4.0

Mean starch content of studies and treatments: 37.8%

Do we believe that is an acceptable starch content?

21

Cornell University



22

Pasture grass feed chemistry

Item	Irish Summer Grass
DM, %	18.5
Chemical composition (% of DM)	
Crude protein	19.1
Crude fat	3.10
aNDFom	33.9
pdNDFom, %NDFom	90.7
Starch	**1.2**
Soluble fiber	12.4
Sugars	**24.6**
Ash	8.79
ME, Mcal/kg	2.74

Dineen et al, 2021

23

Starter Nutrient Content

	% Dry Matter
CP	25.6
Sol CP	6.2 (24.9)
aNDFom	21.0
ADF	10.0
Starch	21.2
Sugar	14.9
Soluble fiber	5.0
Ether extract	4.4
ME allowable gain, kg/d	1.16
MP allowable gain, kg/d	1.13

11

24

Rodrigo's calf starter

Pellet ingredients	**Amount, kg**	**% of DM**	**DM kg**
Wheat midds	0.6	0.199	397.09
Soyplus	0.6	0.199	397.09
Canola meal	0.2	0.066	132.36
Sugar	0.1	0.033	66.18
Dried whey	0.18	0.060	119.13
Blood meal	0.12	0.040	79.42
Metasmart dry	0.022	0.007	14.56
Minerals	0.02	0.007	13.24
Vitamins ADE	0.01	0.003	6.62
Rumensin premix	0.01	0.003	6.62
Flavor enhancer	0.01	0.003	6.62
Molasses	0.1	0.033	66.18
Fat	0.02	0.007	13.24
Yeast cell wall	0.02	0.007	13.24
External ingredients			
Beet pulp shreds	0.4	0.132	264.73
Flaked corn	0.61	0.202	403.71

25

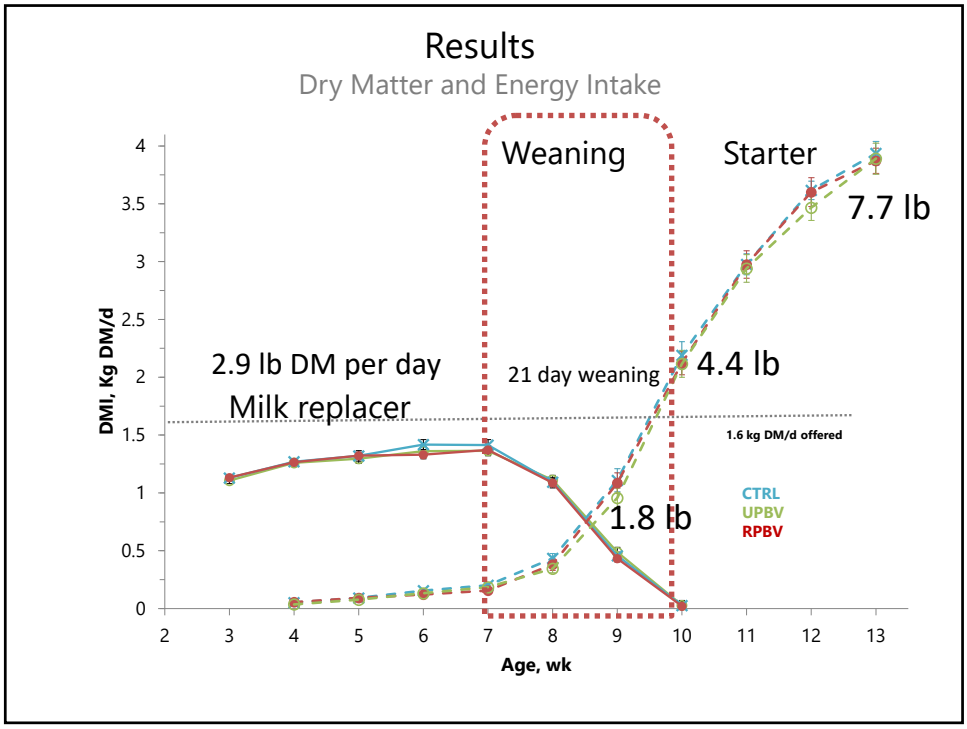
B-Vitamin study results

	RPBV	UPBV	CTRL
Overall			
ADG, lb/d	2.2	2.2	2.2
DMI, lb/d	4.2	4.1	4.3
Feed Efficiency*	0.53	0.52	0.53

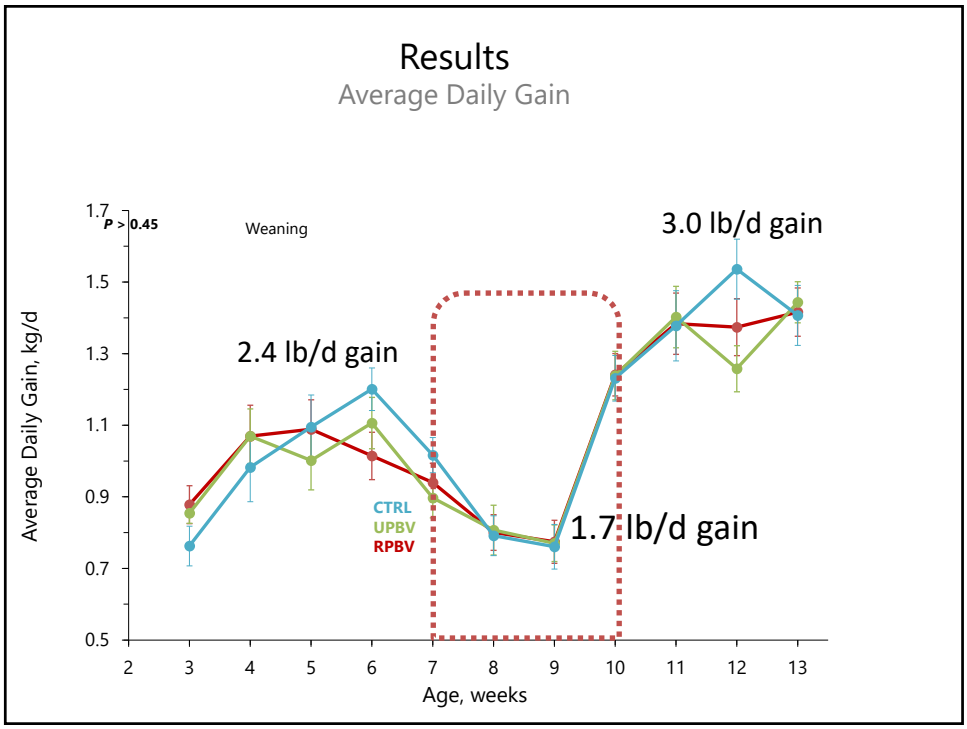
*lb ADG/lb DMI

14

26

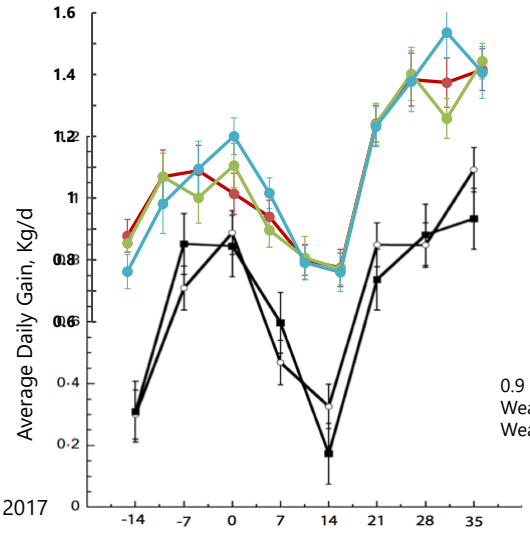

Results
Dry Matter and Energy Intake
Weaning
Starter
7.7 lb
2.9 lb DM per day
Milk replacer
21 day weaning
4.4 lb
1.6 kg DM/d offered
1.8 lb
CTRL
UPBV
RPBV
DMI, Kg DM/d
Age, wk

27


Results
Average Daily Gain
P > 0.45
Weaning
3.0 lb/d gain
2.4 lb/d gain
CTRL
UPBV
RPBV
1.7 lb/d gain
Average Daily Gain, kg/d
Age, weeks

28

"Post-weaning Slump" can be Reduced by altering the starter formulation and lengthening the weaning process



0.9 kg DM MR/d Max
Weaned Earlier (46 d)
Weaning shorter and less gradual

Molano et al, 2017

Adpated from Terré et al, 2006

29

29

Methionine requirement study - Starter formulation

Calf Starters

+ 0.16% DM Metabolizable Met

Ingredient inclusion, %DM	Control	HMBi	HMTBa	RPM
Pellet ingredients				
Wheat midds	22.2	22.2	22.2	22.0
Soybean Meal	6.9	6.9	6.9	6.8
AminoMax Pro	13.6	13.6	13.6	13.5
Sugar	3.4	3.4	3.4	3.4
Dried whey	6.2	6.2	6.2	6.2
Blood meal	5.9	5.9	5.9	5.8
MetaSmart (HMBi)	-	**0.7**	-	-
RumenSmart (HMTBa)	-	-	**0.4**	-
Minerals	1.2	1.2	1.2	1.2
Vitamins ADE	0.3	0.3	0.3	0.3
Bovatec	0.3	0.3	0.3	0.3
Flavor/odor enhancer				
Adisseo Vanilla	0.3	0.3	0.3	0.3
Fat	0.7	0.7	0.7	0.7
Celmanax	0.7	0.7	0.7	0.7
Beet pulp shreds	13.8	13.8	13.8	13.7
Flaked corn	21.0	21.0	21.0	20.8
Molasses	3.7	3.0	3.3	3.7
Smartamine (RP Met)	-	-	-	**0.3**

30

30

Calf Starters Composition

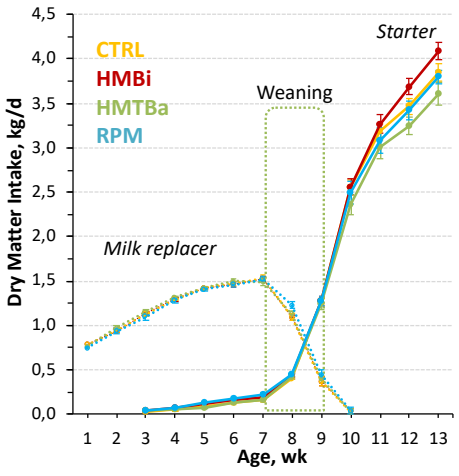
Chemical Composition, % DM	Control	HMBi	HMTBa	RPM
DM, % AF	88.7	88.6	88.3	88.7
Crude Protein	24.8	25.2	25.0	24.5
Crude Fat	3.3	3.2	4.1	3.4
aNDFom	21.2	20.6	20.9	21.5
Starch	20.6	18.8	18.6	20
Soluble Fiber	7.7	9.3	9.1	8.4
Sugars	14.8	15.0	14.7	14.6
Ash	7.7	7.9	7.7	7.5
ME, Mcal/kg	2.5	2.5	2.5	2.5

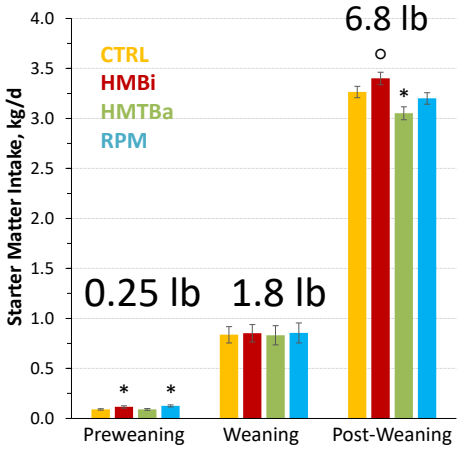
* Met and other AA analysis in progress.

31

31

Dry Matter Intake, kg/d

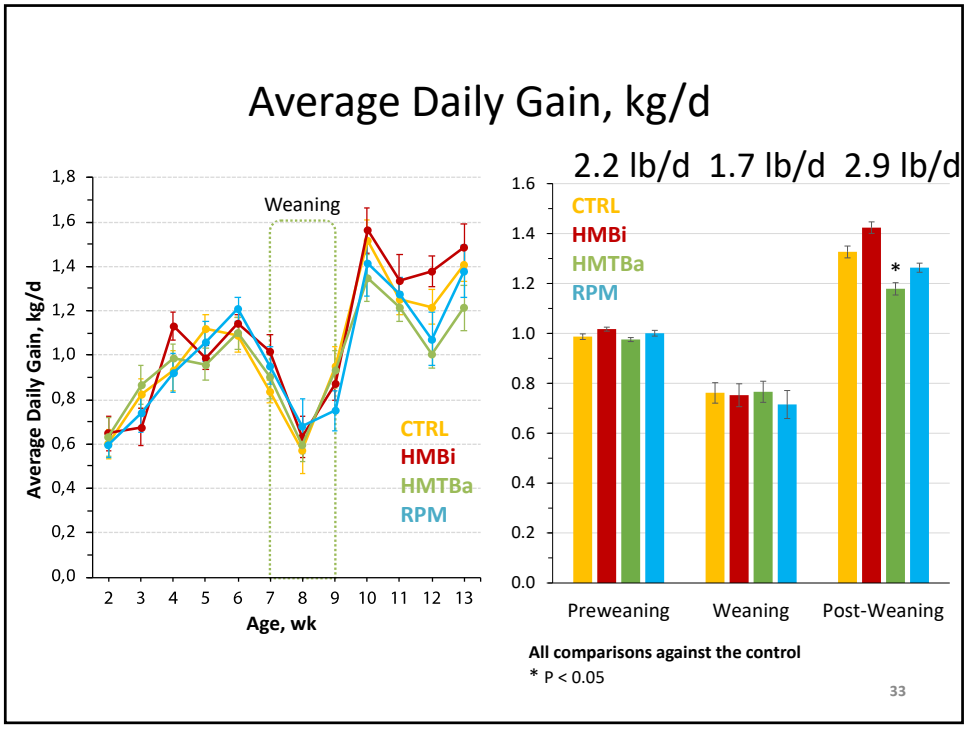




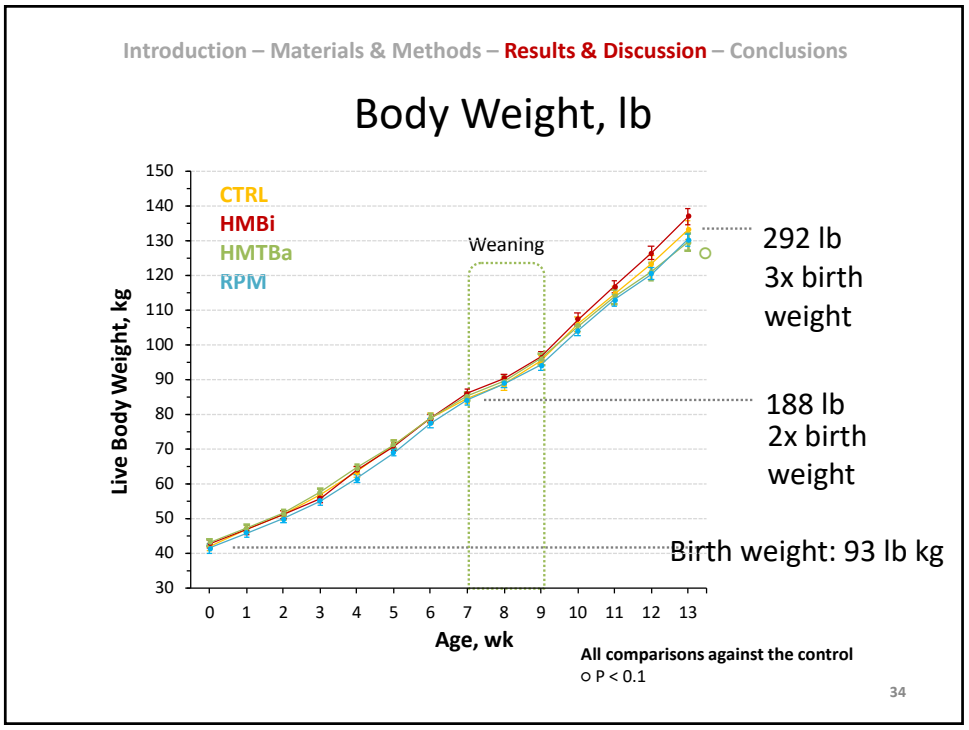
All comparisons against the control
* P < 0.05
○ P < 0.1

32

32


Average Daily Gain, kg/d
2.2 lb/d 1.7 lb/d 2.9 lb/d
Weaning
Average Daily Gain, kg/d
Age, wk
CTRL
HMBi
HMTBa
RPM
Preweaning
Weaning
Post-Weaning
All comparisons against the control
* P < 0.05
33

33


Introduction – Materials & Methods – Results & Discussion – Conclusions
Body Weight, lb
Live Body Weight, kg
Age, wk
Weaning
CTRL
HMBi
HMTBa
RPM
292 lb
3x birth weight
188 lb
2x birth weight
Birth weight: 93 lb kg
All comparisons against the control
○ P < 0.1
34

34

Feeding program

- Determine the target growth rate for the weaning weight objective (e.g. double the birth weight)
- Estimate the maintenance requirement
- The feeding requirements are established by these two factors
- If targeting more than 1.32 lb/d DM, consider 3x day feeding – does not have to be even hours (12.3 to 15% solids are acceptable ranges for milk replacer)
- Check the solids content of whole milk as waste milk can vary (9% to 15% solids based on sick cows, fresh cows and management)
- The milk replacer nutrient content will depend on the expected ADG

35

Feeding program

- First colostrum within 6 hr, second through fourth milkings to newborns.
- First 5 days post colostrum – 6 quarts/d
- Next 7 days, 8 to 10 quarts/d
- Day 15 to 49, 10 qt to 12 qt per day
- Day 50, 50% of volume from day 49 if feeding 2x and do that for 7 days and then remove liquid feed. If feeding 3x, then remove one feeding for 5 days, then remove 2nd feeding for 5 days and then 1x feeding for 4 days and wean.
- Calves should be consuming approximately 2.2 lb of starter at this point – more discussion on starter
- Don't move the calf for 10 days until starter intake is established
- Don't dehorn, vaccinate or conduct any other stressful activity at the time of weaning

36

Take Home Thoughts

- Calves have more growth potential that we are allowing them to realize
- Weaning management needs to evolve to allow for more rumen development prior to milk removal
- Calf managers should allow for more time in the weaning process – 10 to 14 days minimum
- Calf starter formulation needs to evolve to meet all tissue requirements and encourage feed intake and promote rumen and tissue growth

30

37

Take Home Thoughts

- Will have to accept a higher per ton cost to achieve greater returns – focus on feed efficiency and health
- Need to minimize post-weaning lag to optimize growth and minimize respiratory and other immune system related problems – again, this can be accomplished partly through more time
- Modify starters, make them more available, increase the weaning period, create an environment that is stress free and with more herd oriented

38

Part II: Post-weaning factors that detract from milk production and opportunities to fix them

39

The Need and Importance for Monitoring Body Weight

40

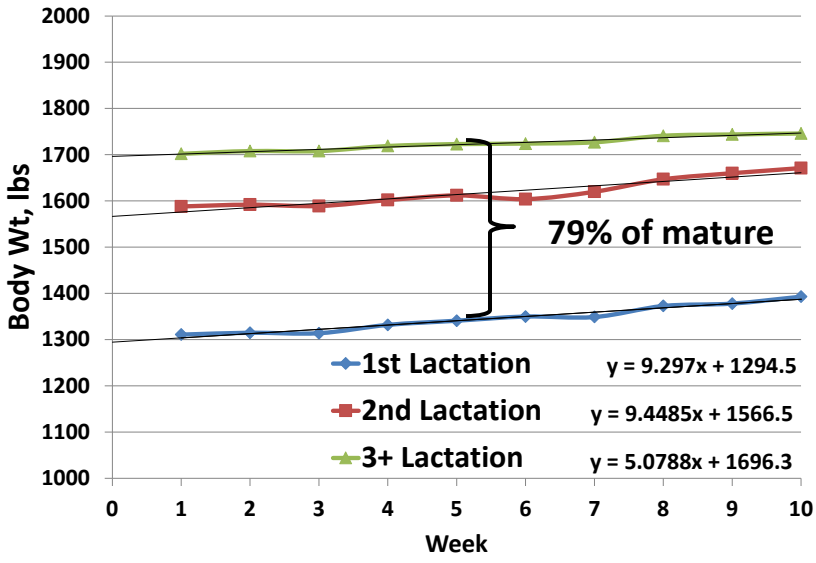
Cornell Research Dairy

1993 – mature body weight = 1,472 ± 125 lb

2016 – mature body weight = 1,770 ± 160 lb

41

Body weight by week



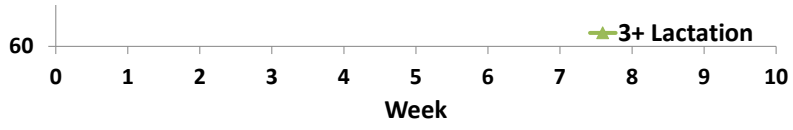
42

42

Milk production

20 yr of farm level observations suggest milk yield is nearly always within a couple units of the percent mature BW of 1st lactation cattle unless there is another constraint

Requirements for growth are always a higher priority than lactation



43

43

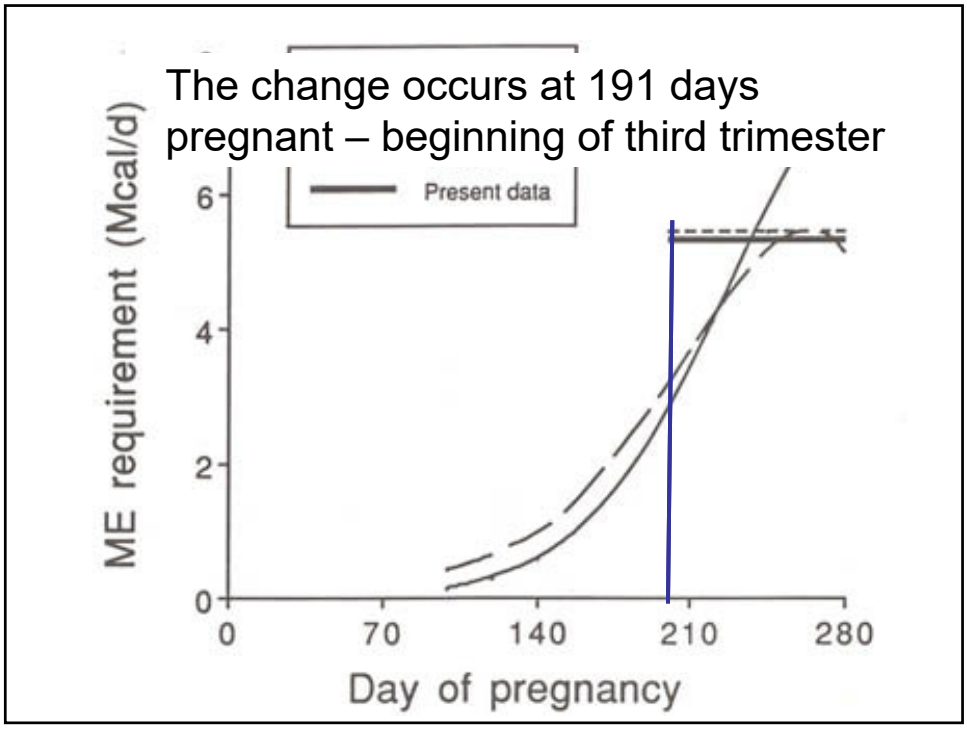
Fetal growth and requirements

Do you have a pregnant heifer group?

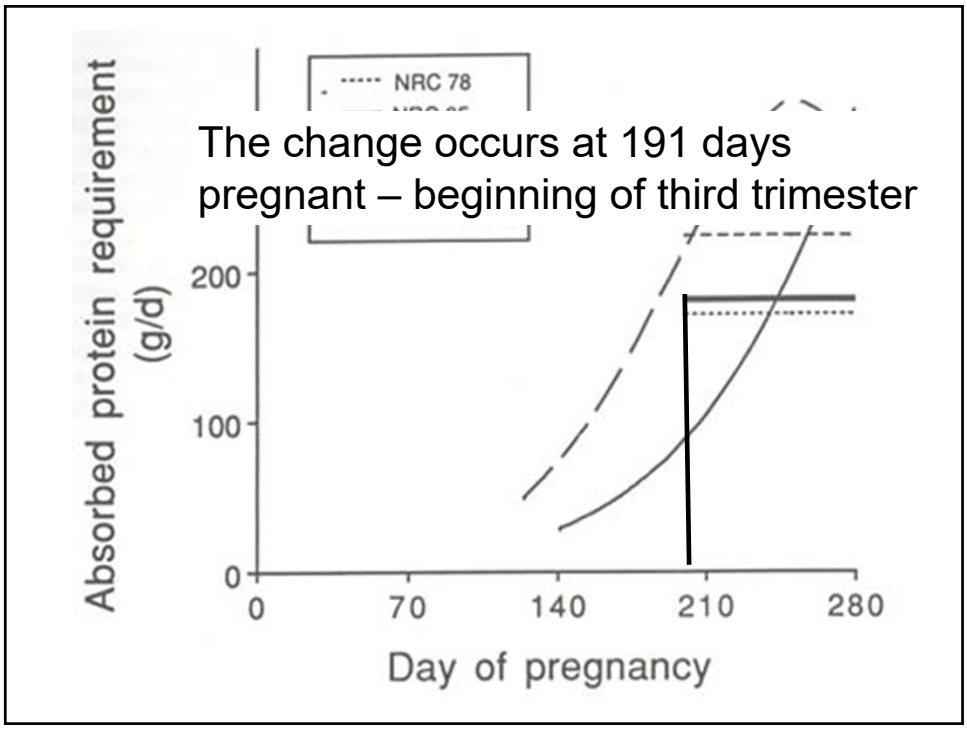
Do you have a late pregnant heifer group?

- Fetal requirements increase
- Mammary development accelerates
- Growth requirements still high
- Liver hypertrophy and colostrum production needs to be considered

44


The change occurs at 191 days pregnant – beginning of third trimester
Present data
ME requirement (Mcal/d)
0
2
4
6
0
70
140
210
280
Day of pregnancy

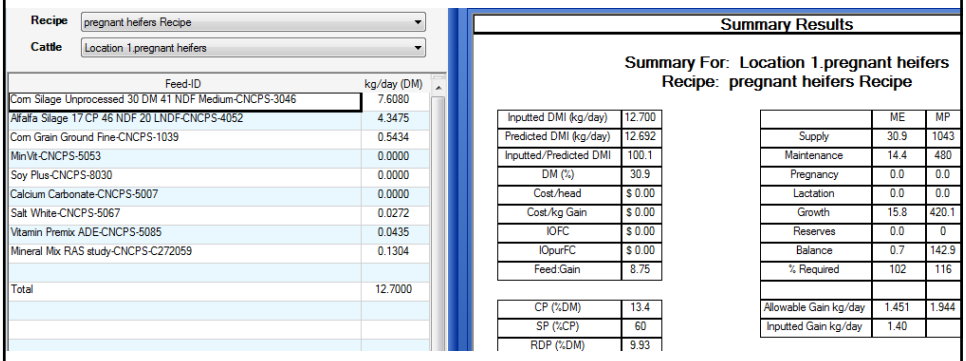
45


NRC 78
The change occurs at 191 days pregnant – beginning of third trimester
Absorbed protein requirement (g/d)
0
100
200
0
70
140
210
280
Day of pregnancy

46

Pregnant heifers – 1,209 lb, 1,770 lb mature BW

180 days pregnant – at the end of the 2nd trimester



Recipe: pregnant heifers Recipe
Cattle: Location 1.pregnant heifers

Feed-ID	kg/day (DM)
Corn Silage Unprocessed 30 DM 41 NDF Medium-CNCPS-3046	7.6080
Alfalfa Silage 17 CP 46 NDF 20 LNDF-CNCPS-4052	4.3475
Corn Grain Ground Fine-CNCPS-1039	0.5434
MinVit-CNCPS-5053	0.0000
Soy Plus-CNCPS-8030	0.0000
Calcium Carbonate-CNCPS-5007	0.0000
Salt White-CNCPS-5067	0.0272
Vitamin Premix ADE-CNCPS-5085	0.0435
Mineral Mix RAS study-CNCPS-C272059	0.1304
Total	12.7000

Summary Results

Summary For: Location 1.pregnant heifers
Recipe: pregnant heifers Recipe

Inputted DMI (kg/day)	12.700
Predicted DMI (kg/day)	12.692
Inputted/Predicted DMI	100.1
DM (%)	30.9
Cost/head	$ 0.00
Cost/kg Gain	$ 0.00
IOFC	$ 0.00
IOpurFC	$ 0.00
Feed:Gain	8.75
CP (%DM)	13.4
SP (%CP)	60
RDP (%DM)	9.93

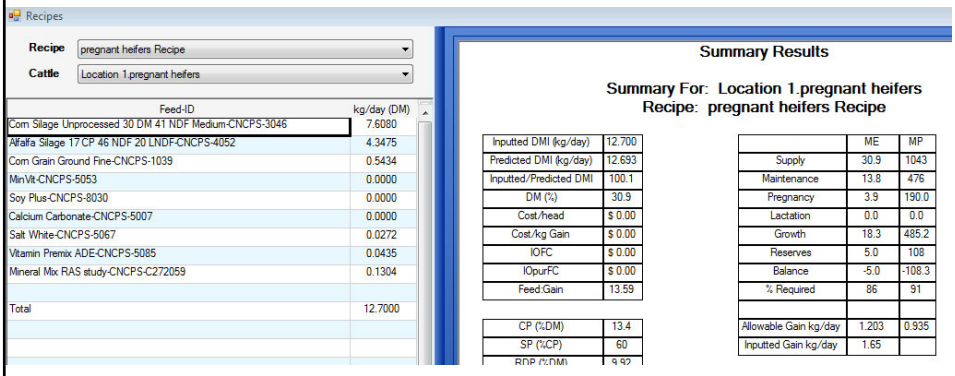
	ME	MP
Supply	30.9	1043
Maintenance	14.4	480
Pregnancy	0.0	0.0
Lactation	0.0	0.0
Growth	15.8	420.1
Reserves	0.0	0
Balance	0.7	142.9
% Required	102	116
Allowable Gain kg/day	1.451	1.944
Inputted Gain kg/day	1.40	

Target gain: 3.1 lb/d
ME allowable: 3.1 lb/d
MP allowable: 4.2 lb/d

47

Pregnant heifers – 1,278 lb; 1,770 lb mature BW

200 days pregnant – into the 3rd trimester



Recipes
Recipe: pregnant heifers Recipe
Cattle: Location 1.pregnant heifers

Feed-ID	kg/day (DM)
Corn Silage Unprocessed 30 DM 41 NDF Medium-CNCPS-3046	7.6080
Alfalfa Silage 17 CP 46 NDF 20 LNDF-CNCPS-4052	4.3475
Corn Grain Ground Fine-CNCPS-1039	0.5434
MinVit-CNCPS-5053	0.0000
Soy Plus-CNCPS-8030	0.0000
Calcium Carbonate-CNCPS-5007	0.0000
Salt White-CNCPS-5067	0.0272
Vitamin Premix ADE-CNCPS-5085	0.0435
Mineral Mix RAS study-CNCPS-C272059	0.1304
Total	12.7000

Summary Results

Summary For: Location 1.pregnant heifers
Recipe: pregnant heifers Recipe

Inputted DMI (kg/day)	12.700
Predicted DMI (kg/day)	12.693
Inputted/Predicted DMI	100.1
DM (%)	30.9
Cost/head	$ 0.00
Cost/kg Gain	$ 0.00
IOFC	$ 0.00
IOpurFC	$ 0.00
Feed:Gain	13.59
CP (%DM)	13.4
SP (%CP)	60
RDP (%DM)	9.92

	ME	MP
Supply	30.9	1043
Maintenance	13.8	476
Pregnancy	3.9	190.0
Lactation	0.0	0.0
Growth	18.3	485.2
Reserves	5.0	108
Balance	-5.0	-108.3
% Required	86	91
Allowable Gain kg/day	1.203	0.935
Inputted Gain kg/day	1.65	

Target gain: 3.6 lb/d
ME allowable: 2.6 lb/d
MP allowable: 2.1 lb/d

48

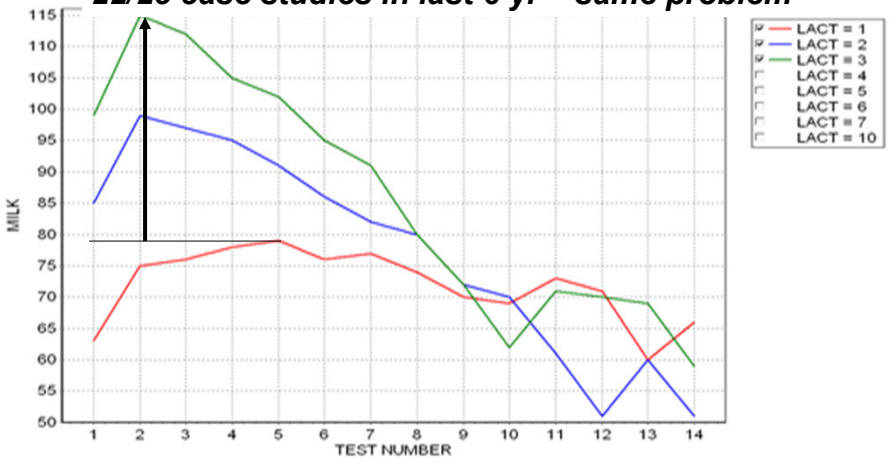
3rd Trimester Heifer Nutrition

- Need to consider a diet that meets their needs
- Might require consideration of another group to overcome feeding higher nutrient density to the entire pregnant heifer group
- Improving the nutrient supply during this period will help overcome poor colostrum production and lower overall milk yields in the first lactation

49

PLOT MILK BY LACT

Overall lactation ~ 69% of mature cows
22/25 case studies in last 6 yr – same problem



50

Current scenario for many herds – value of monitoring for case study herd at 69% of lactation milk
Expected milk if target met: ~ 88 lb at peak

Assume ~225 lb for every lb at peak

11 lb greater peak * 225 = 2,475 lb unrealized milk due to not meeting the 82% mature size benchmark

Net milk: $16.80/CWT

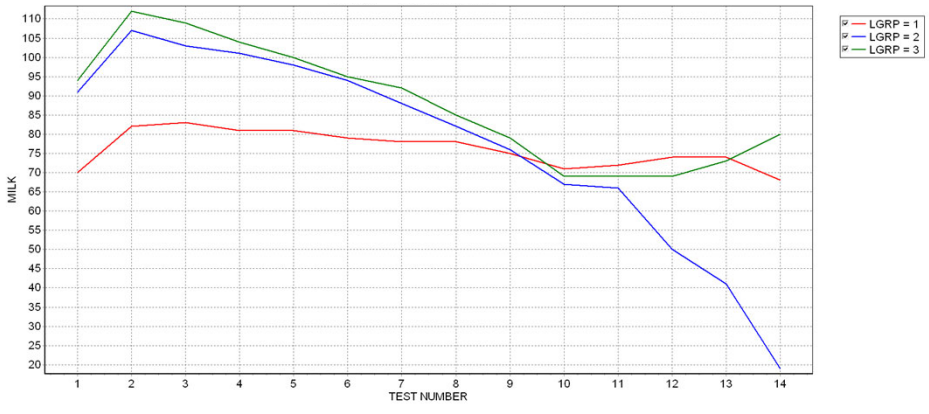
$8.33 IOFC margin (Net milk – feed cost per CWT)

$8.33 * 25 CWT = $215.20 per 1st lactation heifer IOFC

800 cow herd * 40% 1st lactation heifers = 320 heifers * $215.20 IOFC =$68,852 IOFC not realized ($86/lact. cow)

51

PLOT MILK BY LACTGRP – Fellows Case Study last spring – heifers producing at 82% of mature cows. 2x herd averaging 88 lb/d



52

Thank you for your attention

53