Thirty five years of Calf Nutrition and Management- How Things Change!

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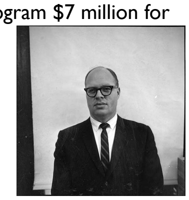
Well a bit more than 35 years!

- M.S. student - Carl Polan advisor
  - What do you want to do?
  - Beginning of the Va. Set-aside Program $7 million for Va. Tech DASC.
- Virginia DHI -
- Ph.D. with Carl
- On to WVU



Where have we been?

- Dr. Don Otterby - Review – 75th anniversary of ADSA – <1981
  - Colostrum absorption –
    - Closure by 24 – 36 h
    - E. coli absorbed.
    - Role of intestinal bacteria an IgG uptake – R. E. James – 1978.
    - Stott et al. large dairies - 42% FPT when left with Dam, 30% when hand fed.
    - Colostrometer

Feeding calves

- Whole milk @ 8% of body weight -
  - 6.8 lb. for 85 lb. calf = 3 quarts
  - Dilute 1:1 or 2:1 with water.

- Fat sources – lard, tallow and white grease - 10% fat, limit to 20%
- 15% solids was "optimal" DM%
- Sour colostrum - dilute 1:1 or 2:1 with water
  - Natural fermentation
  - Propionic or citric acid addition.
- Waste milk – more concerned with spread of mastitis to calves

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- Milk Replacers
  - Ingredients
    - Skim, whey, casein
    - Alternative proteins
      - Soy, wheat, potato, fish, meat solubles
  - Change in milk price led to skim – casein – whey protein use as protein source
  - Low cost effort – "cheaper" protein sources.

Feeding management

- Bucket or bottle?
- Once a day feeding was adequate
- Old or warm liquid
  - More diarrhea with cold.
- Early weaning
  - 21 days – no difference in weight at 12 week vs. 6 week weaning.

Calf starter grains

- Various protein sources considered – amino acid supplementation
- Crude fiber <6% was not recommended – bloat
- Pelleted starter not recommended
- Complete rations with 25% forage

Housing

- Hutches first mentioned ~ 1970's
- McKnight – Canada
  - Stress on calves
  - Need for more feed
  - Less labor efficiency

Raising Dairy Replacements in the 21st Century - 1993.

- Emphasis on post-weaning growth
  - Adequate but not excessive growth
  - Prepubertal period – Mammary gland growth is faster relative to BW growth
- Impact of additives on growth performance
  - Lasalocid and Deccox in CMR
  - Ionophores on feed efficiency
  - Sodium bicarbonate in starter – inconsistent impact
  - Yeast response inconsistent

Early weaning

- Reduced feed costs
- Enhancing dry feed intake

Housing

- Low stress to calves of hutches
- Influence of environment on energy requirements
- Confinement of calves away from cows
- Slatted floors – NH_3, Reduced gain and feed efficiency

2001 NRC and Beyond

- 1989 NRC – Discussion of requirements not separated from lactating cow
- Appendix Table 2
  - Weight, gain, Estimate of intake retained from old data and energy requirements estimated from beef cattle data.
  - Minor importance of young stock in NRC.

2001 NRC

- Separate chapter (9) for the young calf
- Energy requirements based upon ME
- Milk or milk replacer only / veal calves vs. replacement heifers
- Extensive review of literature to predict maintenance and growth requirements based upon limited slaughter data.

- Tabular data from 1989 NRC could not be reproduced with information provided.
- 2001 uses factorial method to estimate protein requirements.
- Urinary and fecal metabolic nitrogen losses, gain and dry matter intake considered.
- Consideration given to energy intake in computing protein requirements.

Drackley - Vet Clin Food Animal Practice – 2008

- Consider needs of calves with liquid diets only (first 3 weeks), transition and weaned animals.
- Stringent limits on types and amount of ingredients without compromising growth or health
  - Protein and Carbohydrate digestibility in young calves!!!! (more later)

Energy allowable growth

- Protein requirements calculated to provide amino acids to support growth allowed by available energy.
- More growth / more intake
- CP required in diet is low for maintenance but increases as gain increases
- CP% plateaus around 27% (which is similar to milk solids)
- Why feeding more 20:20 makes less lean tissue and more fat in gain!
- Why feeding 28% CP at low rates (500g solids) per day wastes protein – it is excreted, because energy is limiting.

Table 1
Requirements for metabolizable energy and apparent digestible protein for a 50-kg calf at different rates of body weight gain under thermoneutral conditions

Rate of gain (kg/d)	ME (Mcal/d)	ADP (g/d)	Required DM intake[a] (kg/d)	CP required[b] (% of DM)
0	1.88	31	0.40	8.3
0.20	2.37	78	0.45	18.7
0.40	3.00	125	0.63	21.4
0.60	3.70	173	0.78	23.7
0.80	4.46	220	0.94	25.1
1.00	5.25	267	1.10	26.1

Drackley, 2008

Impact of temperature on Maintenance ME

Table 4
Maintenance requirements for metabolizable energy as affected by body weight and environmental temperature in calves less than 21 days old

	Environmental temperature (°C)				
	20	10	0	−10	−20
BW, kg	(Maintenance ME, Mcal/day)				
30	1.28	1.63	1.97	2.38	2.67
40	1.59	2.02	2.45	2.96	3.31
50	1.88	2.39	2.90	3.50	3.91
60	2.16	2.74	3.32	4.01	4.48

Data from National Research Council. Nutrient requirements of dairy cattle. 7th edition. Washington, DC: National Academy Press; 2001.

- Energy requirements and diets
  - 45 kg calf needs about 1.75 Mcal ME/day
  - Whole milk has 5.37 Mcal/kg of milk solids
  - Need about 325 g of solids or 2.6 L of whole milk
  - CMR has less energy /unit - 4.6 – 4.7Mcal/kg
  - Needs 380 g of solids or about 3 liters for maintenance.
- Protein requirements not influence by environment.

Environment

- Better environments will moderate ME needs for maintenance
  - Dry, deep bedding of housing
  - Calf jackets
- Impact of heat stress is not as well documented. Free choice water and sand bedding will help.

Impact of intake on feed efficiency

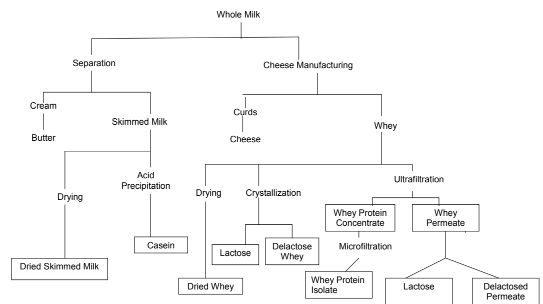
Table 2
Nutrient requirements and estimated gain/feed for a 50-kg calf under thermoneutral conditions, using the Cornell-Illinois equations

Rate of gain, kg/d	Dry matter intake, % BW	ME, Mcal/d	CP, g/d	CP, % of diet DM	Estimated gain/feed
0.2	1.05	2.34	94	18.0	0.38
0.4	1.30	2.89	150	22.4	0.63
0.6	1.57	3.49	207	26.6	0.77
0.8	1.84	4.40	253	27.4	0.86
1.0	2.30	4.80	318	28.6	0.87

Data from Van Amburgh M, Drackley J. Current perspectives on the energy and protein requirements of the pre-weaned calf. In: Garnsworthy PC, editor. Calf and heifer rearing. Nottingham (UK): Nottingham University Press; 2005. p. 67–82.

MILK FRACTIONATION

TJ Earleywine slide



Protein sources

- Digestibility of proteins
  - Milk proteins
    - Skim, Casein, Whey
    - Impact of processing
    - Delactosed whey – high ash
    - Difference in osmolality
  - Soy
    - Soy flours - acid treated to inhibit antigenicity of components
      - Decrease in villous height in calves < 3 weeks old
    - Soy protein concentrate and isolate ($$).
  - Wheat – wheat gluten –
    - acid or enzymatic hydrolysis
    - Growth of calves < 3 weeks old is 15 -30% less than with milk proteins
    - Low in lysine and threonine.

Carbohydrate sources

- Milk replacers are higher in Lactose than milk – lower protein and fat than milk
- Maybe some fermentation in hind gut with 2x feeding and DMI > 900g/day.
- Limited digestibility of starch for young calves
- Sucrose and fructose are not digestible.

Fat Source

- Tallow, lard and choice white grease
  - EU doesn't allow ruminant animal fats
- Palm and coconut
  - Fatty liver with coconut fat
- New blends of fats to increase MCFA and improve utilization.

Fatty Acids	Milk	Coconut	Tallow
8:0	1.4	8.8	
10:0	2.7	6.7	
12:0	3.3	48.4	
14:0	10.9	16.9	3.0
16:0	30.6	8.3	28.2
16:1	1.0		3.2
18:0	12.2	9.7	18.2
18:1	22.8	1.0	38.4
18:2	3.7	0.1	5.0
18:3	0.7		0.6

Additives

- Antibiotics
  - Oxytetracycline, neomycin……
  - VFD
- Deccox
- Ionophores – Lasalocid (Bovatec), Monensin (Rumensin)
- Yeast, Botanicals, Essential Oils

Water quality for calves

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Most farms rely on wells

- No EPA jurisdiction
- Recommend twice yearly sampling
  - Spring and fall
  - Near well and at end of distribution
  - Organic – hetertrophic plate, coliform, fecal coliform counts
  - Mineral analysis

Water quality

- Impact on sanitation
  - Hard water requires acid rinse (<pH 4), otherwise alkaline deposits
  - Additional challenge with autofeeders - water temperature and water quality

Mixing milk replacer

- Sample where water is used for mixing CMR
- Well source
- Pipes? Galvanized
  - High iron
  - High coliform bacteria levels

Sodium toxicity

- D. Sockett – WI Vet Diagnostic lab
- 10 dairies – calves <14 days of age.
- Fed milk replacer
- Morbidity and mortality – 25 to 100%
- No lesions on post mortem.
- Serum sodium – 155mmol/L, toxic is 160
- Brain sodium levels - >1800ppm, normal is 1400 ppm.
- Source of excessive sodium – some milk replacer, electrolytes, SOFTENED WATER.

- Softened water > 500 ppm
- Mixing errors
  - Na content of milk replacer varies
  - Calves can tolerate higher Na if adjust to it and water is not excessive in Na - <100 ppm
  - Drinking water less than 100 ppm. Na.

Osmolality of milk replacer liquid

Sample ID	%Solids	mOsm/Kg
22-20 10.0	10.0	364
22-20 12.5	12.5	452
22-20 15.0	15.0	559

Preventing Na toxicity – high osmolality

- Test water – especially if softened with Na
- Check milk replacer – some have very high Na.
- Weight powder and weight the water when mixing milk replacer.
- Keep solids 12.5 – 15%
  - Tolerate up to 20% solids IF, low Na water and consistency.
- Don't add electrolyte to milk or milk replacer!

Water for calves

- Common sense
- Test water 2x/year
- Water treatment when needed
- Prevent contamination
- Milk replacer quality
  - Weigh powder and water
  - Consistency

Milk Replacer Powder: Sodium Concentration

1.3%

Pink: Do not feed
Yellow: Feed with caution
Green: Safe to feed

% Total Solids	Na Conc (mmol/L) Distilled Water	Na Conc (mmol/L) Water: 50 ppm*	Na Conc (mmol/L) Water: 100 ppm*	Na Conc (mmol/L) Water: 150 ppm*	Na Conc (mmol/L) Water: 200 ppm*	Na Conc (mmol/L) Water: 250 ppm*	Na Conc (mmol/L) Water: 300 ppm*	Na Conc (mmol/L) Water: 400 ppm*	Na Conc (mmol/L) Water: 500 ppm*
17.6%	102.1	104.2	106.4	108.6	110.7	112.9	115.1	119.4	123.8
17.0%	98.6	100.7	102.9	105.1	107.2	109.4	111.6	115.9	120.3
16.5%	95.7	97.8	100.0	102.2	104.3	106.5	108.7	113.0	117.4
16.0%	92.8	94.9	97.1	99.3	101.4	103.6	105.8	110.1	114.5
15.5%	89.9	92.0	94.2	96.4	98.6	100.7	102.9	107.3	111.7
15.0%	87.0	89.1	91.3	93.5	95.7	97.8	100.0	104.3	108.7
14.5%	84.1	86.2	88.4	90.6	92.7	94.9	97.1	101.4	105.8
14.0%	81.2	83.3	85.5	87.7	89.9	92.0	94.2	98.6	102.9
13.5%	78.3	80.4	82.6	84.8	87.0	89.1	91.3	95.7	100.0
13.0%	75.4	77.5	79.7	81.9	84.0	86.2	88.4	92.7	97.1
12.5%	72.5	74.6	76.8	79.0	81.2	83.3	85.5	89.9	94.2
12.0%	69.6	71.7	73.9	76.1	78.3	80.4	82.6	86.9	91.3
11.5%	66.7	68.8	71.0	73.2	75.3	77.5	79.7	84.0	88.4
11.0%	63.8	65.9	68.1	70.3	72.5	74.7	76.8	81.2	85.5
10.5%	60.9	63.0	65.2	67.4	69.6	71.7	73.9	78.3	82.6
10.0%	58.0	60.1	62.3	64.5	66.7	68.8	71.0	75.3	79.7

*Sodium concentration of water used to mix up milk replacer.

Note: Saleable milk contains 30-40 mmol/L of sodium.

Source: D. Sockett

Analytical goals

Table 1. General guidelines for assessing drinking water quality for humans and livestock.

Analyte	Maximum Contaminant Level[a]	Upper Levels Livestock[b]	Maximum Upper Levels[c]	Expected[d]	Possible Cattle Problems[e]
Aluminum	(0.05 to 0.2)[f]	5.0	10.0		
Arsenic	0.01	0.2	0.2	< 0.05	> 0.20
Barium	2.0	1.0	1.0	< 1.0	> 10 (health)
Bicarbonate		1,000	1,000		
Boron		5.0	30.0		
Cadmium	0.005	0.01	0.05	0.01	> 0.05
Calcium		100	200	< 43	> 500
Chloride	(250)	100	300	< 200	
Chlorine (Cl_2)	4.0[g]				
Chromium	0.1	0.1	1.0	< 0.05	
Copper	1.3 (1.0)	0.2	0.5	0.6	> 0.6 to 1.0
Fluoride	4.0 (2.0)	2.0	2.0	1.2	> 2.4 (mottling)
Hydrogen sulfide[h]				< 2	> 0.1 (taste)
Iron	(0.3)	0.2	0.4	0.3	> 0.30 (taste, veal)
Lead	0.015	0.05	0.1	0.05	> 0.10
Magnesium		50	100	< 29	> 125
Manganese	(0.05)	0.05	0.5	< 0.05	> 0.05 (taste)
Mercury	0.002	0.01	0.01	0.005	> 0.01
Molybdenum		0.03	0.06	< 0.068	
Nickel		0.25	1.0		
Nitrate	44	89	100	< 44	
pH	6.5 to 8.5	6.0 to 8.5	8.5	< 6.8 to 7.5	< 5.1 to > 9.0[i]
Phosphorus		0.7	0.7	< 1.0	
Potassium		20	20	< 20	
Selenium	0.05	0.05	0.1		
Silica				< 10	
Silver	(0.1)	0.05	0.05		
Sodium		50	300	< 3	> 20 (veal calves)
Sulfate	(250)	50	300	< 250	> 2,000
Total bacteria (cells/100 mL)		1,000	1,000	< 200	> 1,000,000
Total dissolved solids	(500)	960	3,000	< 500	> 3,000
Total hardness				< 180	
Vanadium		0.1	0.1		
Zinc	(5.0)	5.0	25.0	5	> 25

[a]Values are parts per million (ppm; which is equal to mg/L) unless otherwise indicated. Adapted from US Environmental Protection Agency (EPA, 2009) as the National Primary Drinking Water Regulations (EPA-regulated concentrations for humans and(or) Treatment Technique action level to require treatment to remove contaminant).

Beede, 2013

Table 3. Guide for treatment to remove unwanted constituents (anti-quality factors) from drinking water[a]

Constituent	Treatment Method[b]									
	ACF	AS	C	D	C-A E	MF	RO	UR	O	OF
Chlorine	X[c]									
Coliform bacteria, other microorganisms			X					X	X	
Color	X		X		X				X	
Hydrogen sulfide		X	X[d]						X[d]	X
Inorganics [e.g., some macromineral elements and heavy metals (e.g., lead, mercury, arsenic, cadmium, barium)]	X[e]			X	X[f]		X			
Iron/ manganese – dissolved			X[g]		X[g]				X	X
Iron/ manganese – insoluble						X				X
Nitrate				X	X[h]		X			
Odor and off-taste	X	X	X	X	X		X		X	
Some pesticides	X[i]						X[i]			
Radium				X	X		X			
Radon gas	X	X								
Salt				X			X			
Sand, silt, clay (turbidity)						X				
Volatile organic chemicals	X	X		X[j]			X			
Water hardness					X					

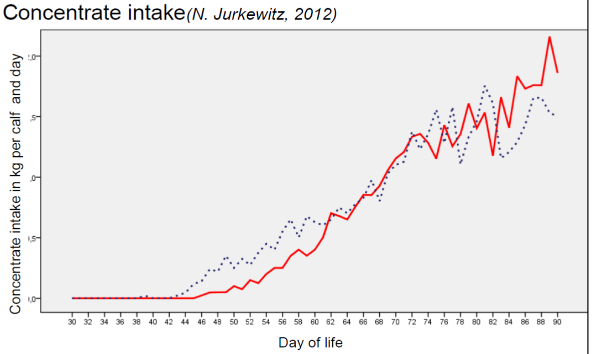
[a]Adapted from www.midwestlabs.com.
[b]ACF = activated carbon filter; AS = air stripping; C = chlorination; D = distillation; C-A E = cation or anion exchange; MF = mechanical filtration; RO = reverse osmosis; UR = ultraviolet radiation; O = ozonation; and, OF = oxidizing filters.
[c]Within the table "X" indicates method that can be used to remove part or all of the constituent present.
[d]When followed by mechanical filtration or an activated carbon filter.
[e]Mercury only.
[f]Barium only.
[g]When present in low concentrations.
[h]Anion exchange units will remove nitrate; but, cation exchange units will not.
[i]For information on ways to treat water for specific pesticides, obtain local pesticide health advisory summaries.
[j]Works for volatile organic chemicals with high boiling points.

Calf starters

- Palatable
- Molasses - ~5%
- Starch – 25 – 30%
- Fiber or forage? When incorporated with starter
  - Cottonseed hulls – 15%
- Confounded with liquid diet feeding program.

Comparison of restricted to 40 FIT program

Concentrate intake *(N. Jurkewitz, 2012)*



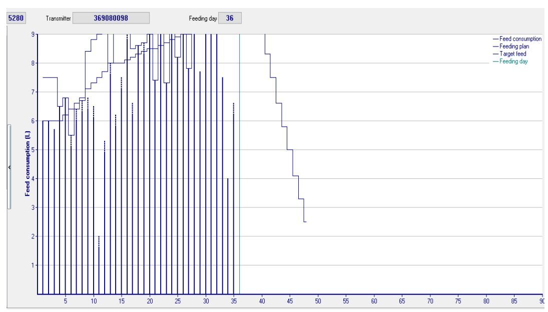
Automatic calf feeder systems

Feeding plan

	Feed			Concentration			Min.quantity		
Period	Days	Start qu	Final qu	Days	Start qu	Final qu	Days	Min.	Max.
	Group A								
1	3	6.0 L	6.0 L	48	150 g	150 g	3	1.5 L	2.0 L
2	10	6.0 L	8.0 L	0	0 g	0 g	10	1.5 L	2.0 L
3	25	8.0 L	10.0 L	0	0 g	0 g	25	1.5 L	2.5 L
4	10	10.0 L	2.5 L	0	0 g	0 g	10	1.5 L	2.0 L
5	0	0.0 L	0.0 L	0	0 g	0 g	0	0.0 L	0.0 L
Total	48		373 L	48		56 kg	48		

- How fast to increase feeding?
- Concentration - grams of solids added to 1,000 ml!
  - 150g/1150 = 13.04%
- Minimum and Maximums
  - 6 liters in 20 hours = .3 L/hour = 5 hours to "earn" minimum meal of 1.5L
  - Most important – minimum = 1 to 1.5 L
  - Max - 2.5 – 3.0 L

Feed intake



Individual vs. group housing – welfare impact?

Progress

- Treating the calf as a neonate.
- Meeting nutrient requirements for growth
- Designing systems which promote health and animal welfare
- Recognizing long term impact of nutrition of the preweaned calf.

The big changes

1. Feeding to meet nutrient requirements for growth – more nutrition early
2. The role of colostrum in lifetime performance and health
3. New housing systems
4. Emphasis on animal welfare – group housing systems.