XXII Novos Enfoques na Produção e Reprodução de Bovinos
Uberlândia, Brasil – 14 à 15 de Março de 2019

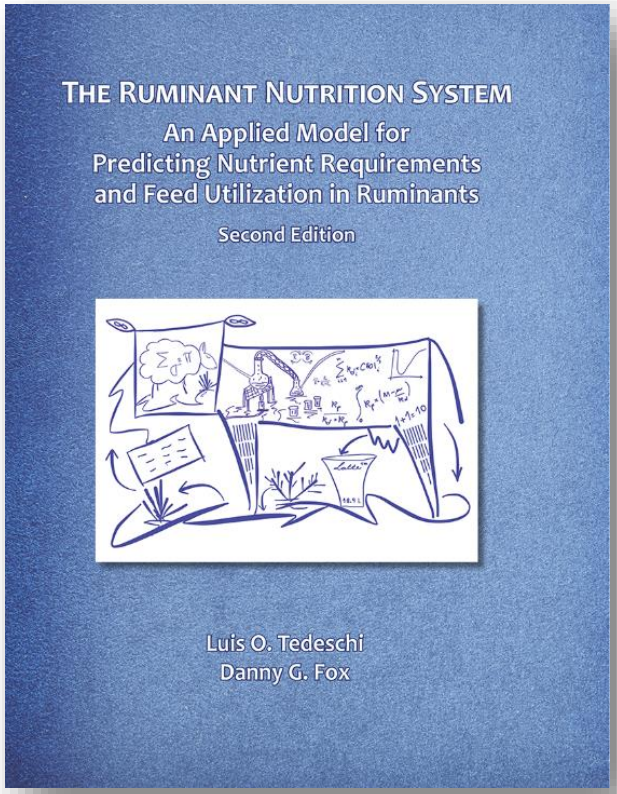
Advancements in Nutritional Requirements of Beef Cattle: *Heifers*

Luis Orlindo Tedeschi

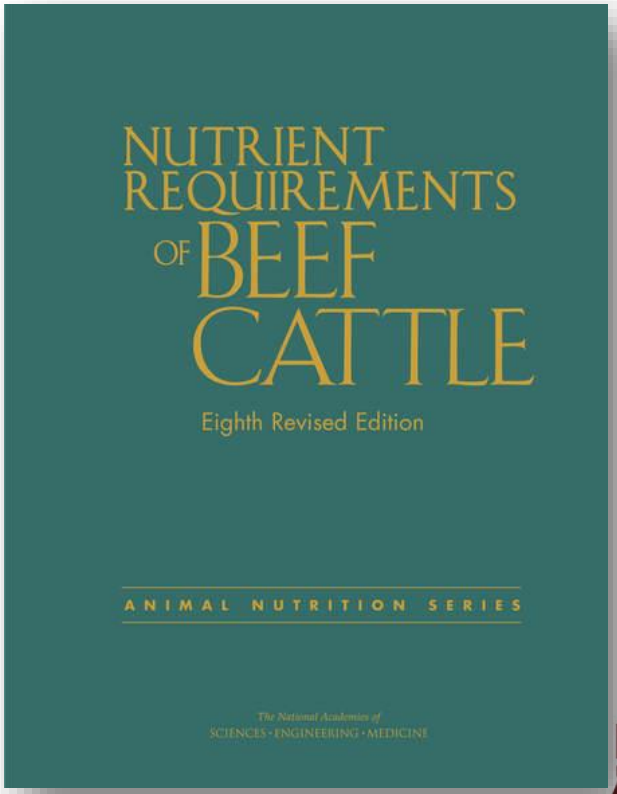
Texas A&M University

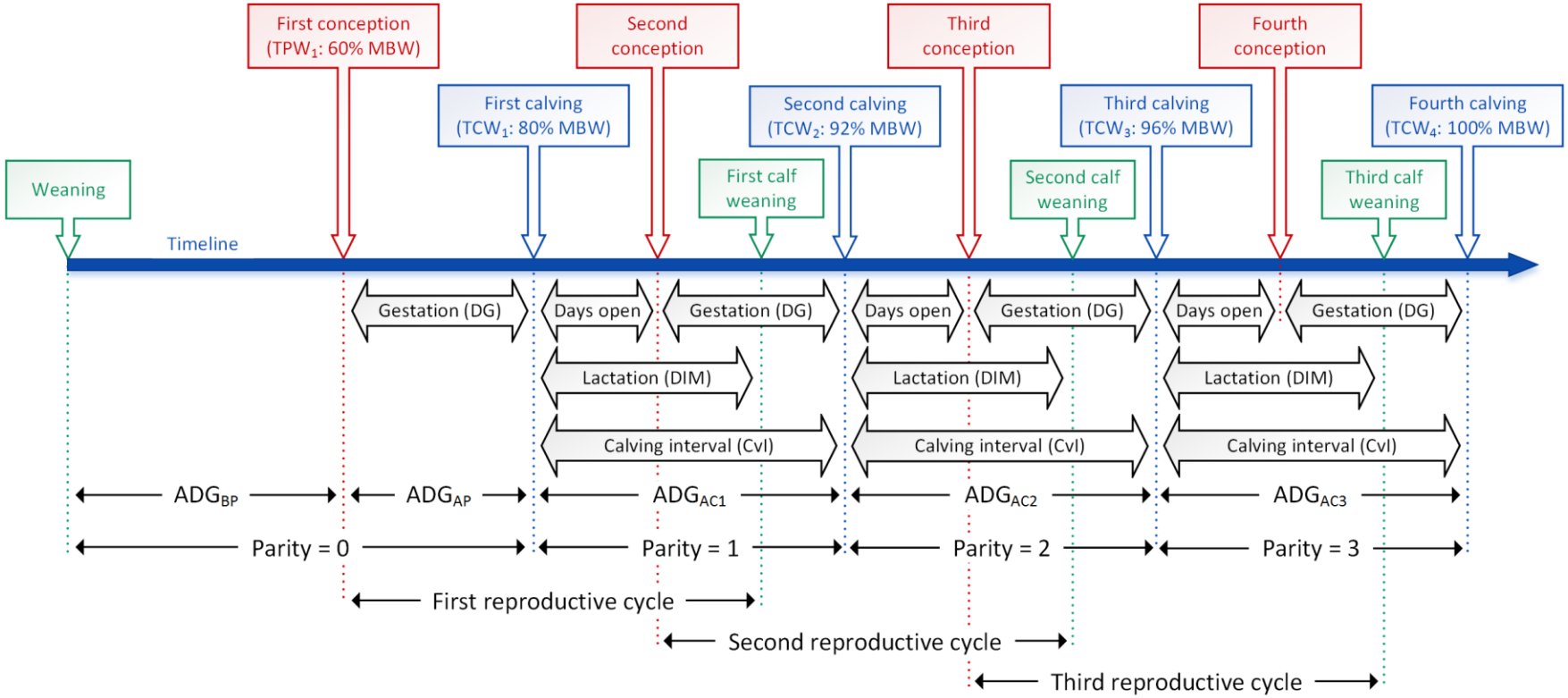
Where to Learn More?

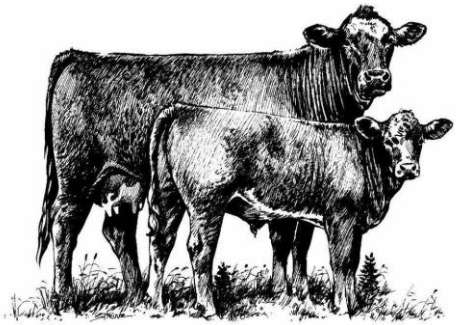
Ruminant Nutrition System

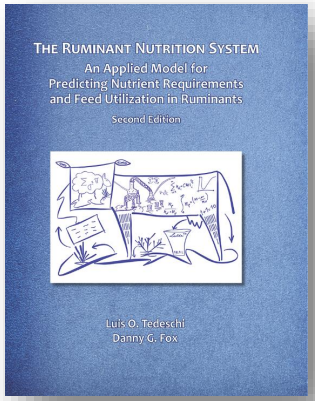


"NRC" (2016)

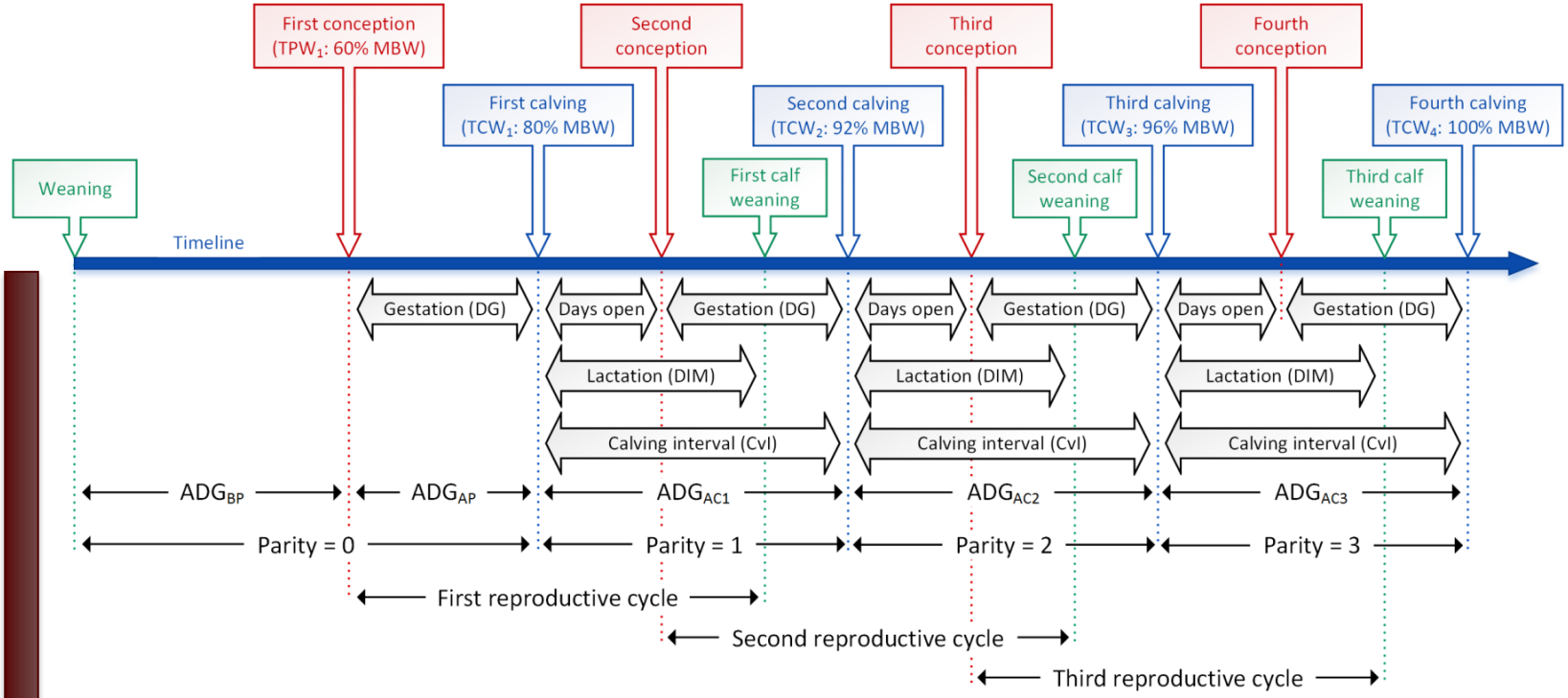



First conception
(TPW1: 60% MBW)
Second conception
Third conception
Fourth conception
First calving
(TCW1: 80% MBW)
Second calving
(TCW2: 92% MBW)
Third calving
(TCW3: 96% MBW)
Fourth calving
(TCW4: 100% MBW)
Weaning
First calf weaning
Second calf weaning
Third calf weaning
Timeline
Gestation (DG)
Days open
Gestation (DG)
Days open
Gestation (DG)
Days open
Gestation (DG)
Lactation (DIM)
Lactation (DIM)
Lactation (DIM)
Calving interval (CvI)
Calving interval (CvI)
Calving interval (CvI)
ADGBP
ADGAP
ADGAC1
ADGAC2
ADGAC3
Parity = 0
Parity = 1
Parity = 2
Parity = 3
First reproductive cycle
Second reproductive cycle
Third reproductive cycle



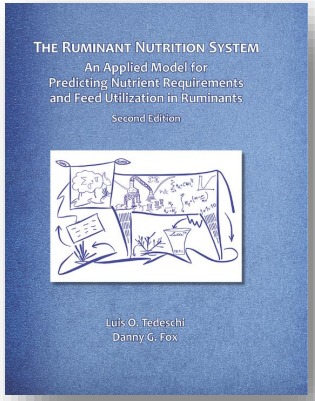

The Ruminant Nutrition System
An Applied Model for
Predicting Nutrient Requirements
and Feed Utilization in Ruminants
Second Edition
Luis O. Tedeschi
Danny G. Fox

Are our cows in good nutritional condition?



Heifer age and growth rate from birth to weaning accounted for more variation in puberty status and AI pregnancy rate than post-weaning growth (Funston, 2012a)

Are our cows in good nutritional condition?



$$TPW_1 = MBW \times \begin{cases} 0.55 & \text{Dual-purpose or dairy breeds} \\ 0.60 & \textit{Bos taurus}\text{ breeds} \\ 0.65 & \textit{Bos indicus}\text{ breeds} \end{cases} \quad [15.30]$$

$$TPA_1 = TCA_1 - 280 \quad [15.31]$$

$$ADG_{BP} = \begin{cases} \left(TPW_1 - WW\right)/\left(TPA_1 - WA\right) & \text{Ideal growth conditions} \\ \left(TPW_1 - SBW\right)/\left(TPA_1 - Age\right) & \text{Current growth conditions} \end{cases} \quad [15.32]$$

$$TCW_1 = MBW \times \begin{cases} 0.85 & \text{Dairy breeds} \\ 0.80 & \text{All other breeds} \end{cases} \quad [15.33]$$

$$ADG_{AP} = \begin{cases} \left(TCW_1 - TPW_1\right)/\left(280 - DG\right) & \text{Ideal growth conditions} \\ \left(TCW_1 - SBW\right)/\left(280 - DG\right) & \text{Current growth conditions} \end{cases} \quad [15.34]$$

$$TCW_2 = MBW \times 0.92 \quad [15.35]$$

$$TCW_3 = MBW \times 0.96 \quad [15.36]$$

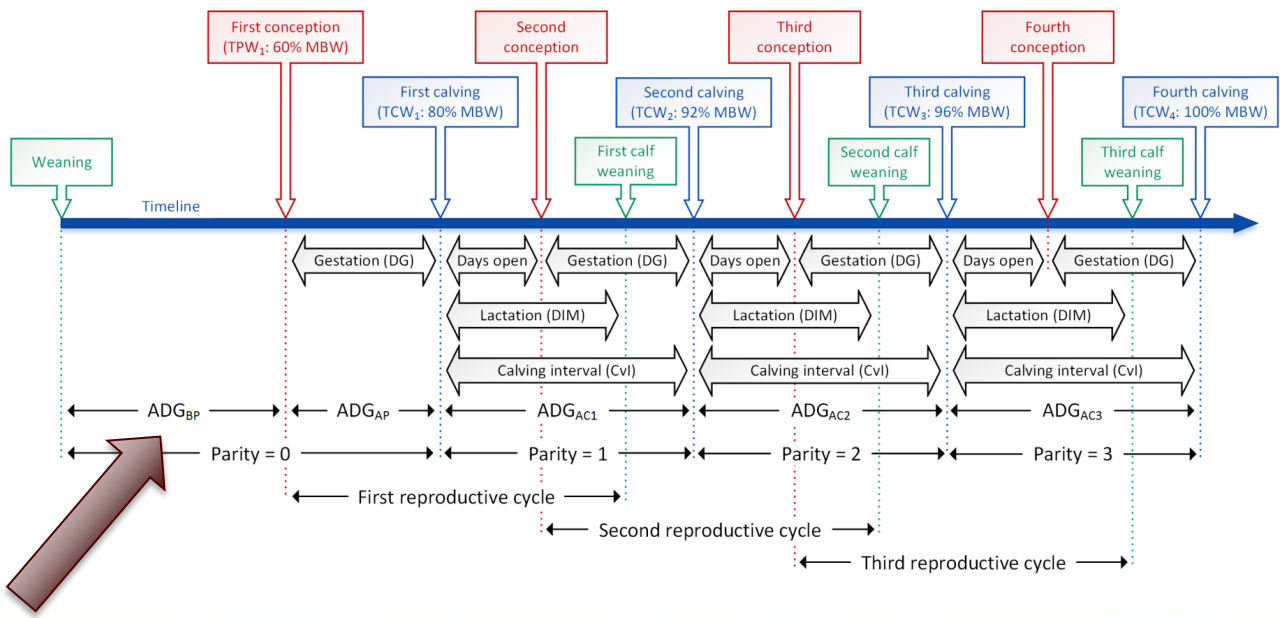
$$TCW_4 = MBW \times 1.0 \quad [15.37]$$

$$ADG_{ACx} = \begin{cases} \left(TCW_{x+1} - TCW_x\right)/CvI \mid x \geq 1 & \text{Ideal growth conditions} \\ \left(TCW_{x+1} - SBW\right)/\left(CvI - DIM\right) \mid x \geq 1 & \text{Current growth conditions} \end{cases} \quad [15.38]$$

Where ADG_{AC} is average daily gain after calving, kg/d; ADG_{AP} is average daily gain after first pregnancy, kg/d; ADG_{BP} is average daily gain before first pregnancy, kg/d; *Age* is current age, d; *CvI* is calving interval, d; *DG* is days in gestation (i.e., days pregnant), d; *DIM* is days in milk; *MBW* is mature body weight, kg; *SBW* is current shrunk body weight, kg; TCA_1 is target first calving days of age, d; TCW_1 is target first calving weight, kg; TCW_2 is target second calving weight, kg; TCW_3 is target third calving weight, kg; TCW_4 is target fourth calving weight, kg; TPA_1 is target first pregnant age, d; TPW_1 is target first pregnant weight, kg; *WA* is weaning age, d; and *WW* is weaning weight, kg.

Are our cows in good nutritional condition?

- Assuming a MBW of 500 kg:
  - For every 10 kg increase in weaning weight there is a reduction of 6.5% in the ADG_{BP} for the replacement heifer



What is Mature Weight?

- Mature weight refers to the BW reached by 5 years of age in cows of the same genotype in <u>nonrestrictive environment</u>

What is the Ideal Breeding BW?

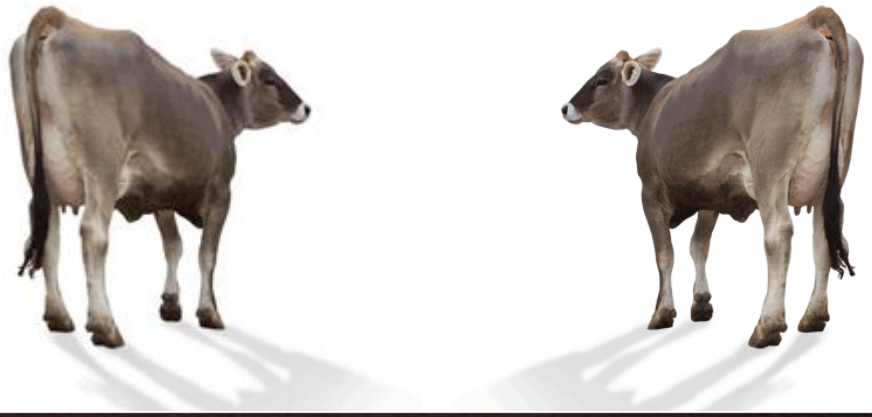
- Heifer puberty and reproductive performance are directly influenced by energy balance and plane of nutrition

$$TPW_1 = MBW \times \begin{cases} 0.55 & \text{Dual-purpose or dairy breeds} \\ 0.60 & \textit{Bos taurus}\ \text{breeds} \\ 0.65 & \textit{Bos indicus}\ \text{breeds} \end{cases}$$

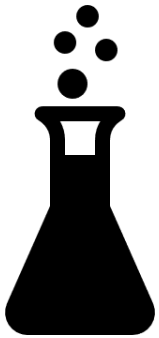
- Heifers of *B. indicus* breeds generally reach puberty at older ages and at heavier weights (65% mature weight)

- Feed cost and cost per pregnant heifer can be decreased if a target weight is 55% of expected mature weight was used (Funston et al., 2012a)

- Minimizing heifer BW gain until 47 or 56 d before breeding or until later in the postweaning period did not influence reproductive performance, calving rate age at calving or postpartum interval (Lynch et al., 2001; Freetly et al., 2001)



Theory of Cumulative Energy



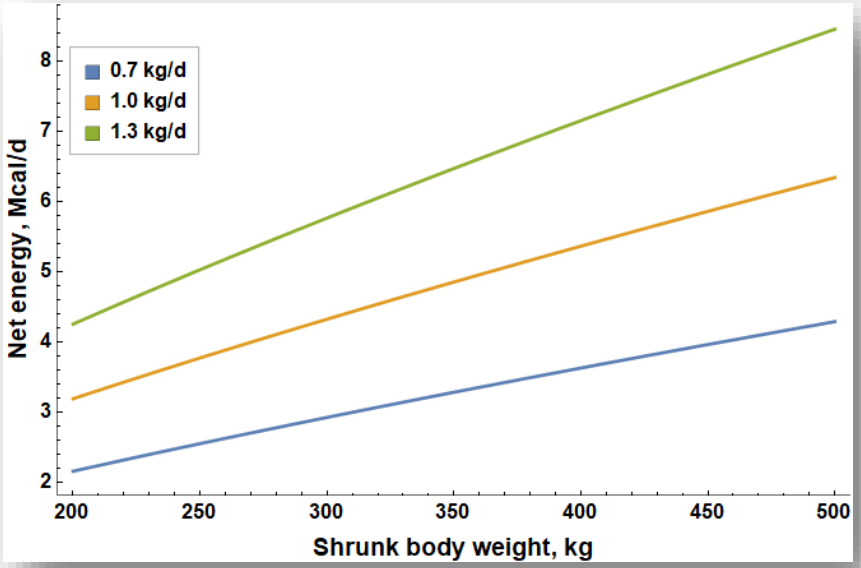
- Why preselected "target" weight at a given age? (NASEM, 2016)

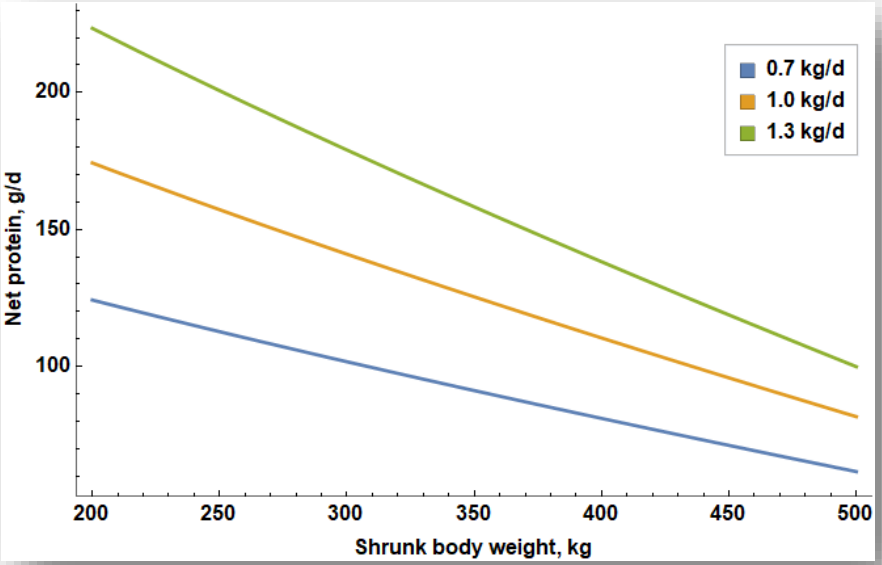
- Heifers programmed for either continuous growth or slow early growth followed by rapid late growth between weaning and breeding to reach a similar target weight, had minimal differences in calving rate, age at calving, PPI, or second-year pregnancy rates, <u>but total energy required to reach target weight can be decreased by using a slow followed by more rapid gain strategy</u> (Lynch et al., 2001; Freetly et al., 2001)
  - Low maintenance in the beginning
  - Compensatory growth at the end

- Theory: "puberty seems to be reached when an specific amount of energy has been accumulated in the body of heifers"
  - ⇧ dam's milk yield ⇩ age at puberty (*B. taurus*→13 to 15 mo)
  - Propionate- vs Acetate-type diets

Heifer Development: Fat x Protein

- Intensive heifer development systems may maximize pregnancy rates, but not necessarily optimize profit or sustainability (NASEM, 2016)

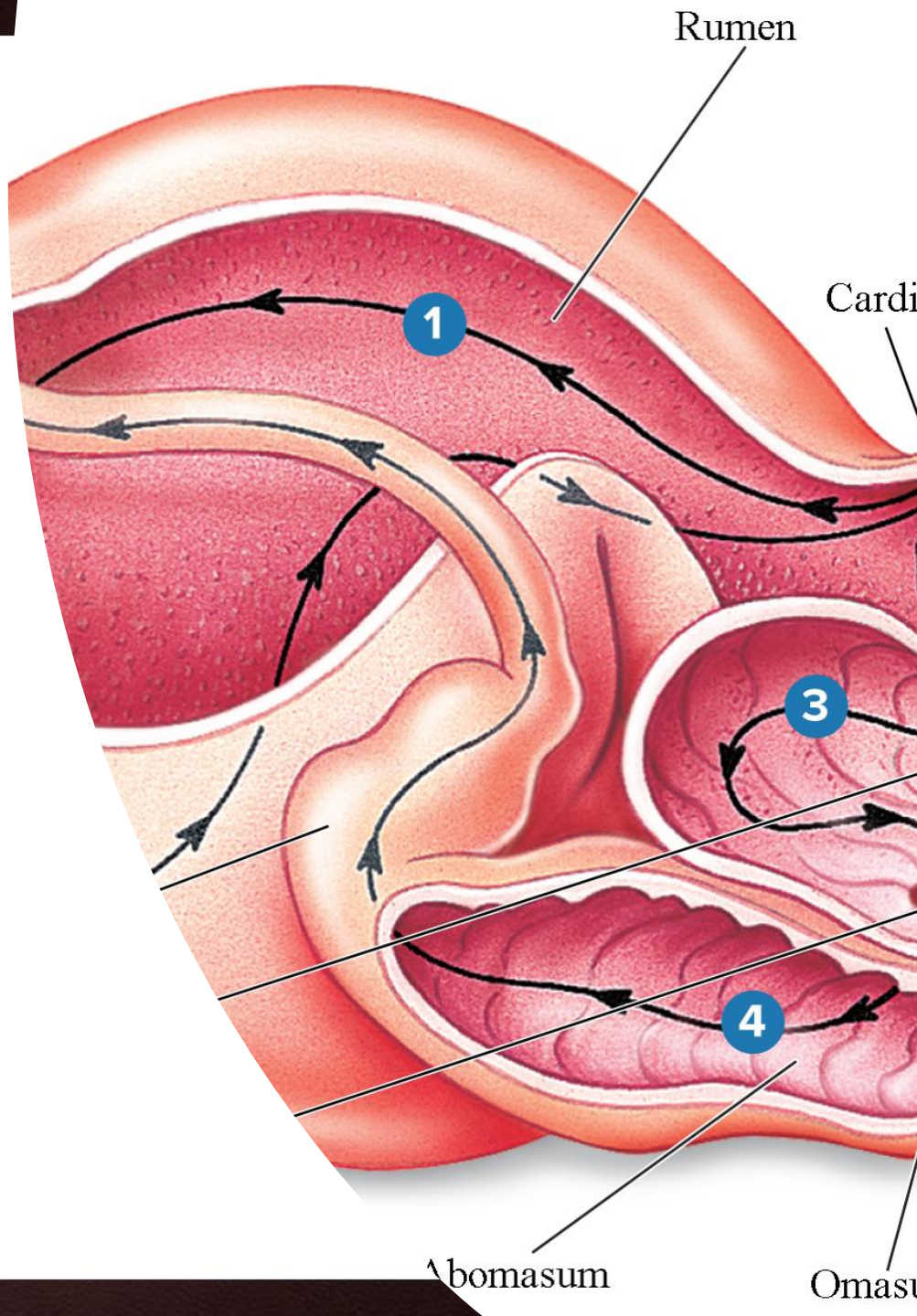




Nutritional Strategies Postweaning

- Total energy intake, and possibly heifer development costs, may be reduced by limiting heifer gain early in the postweaning period followed by accelerated gains (Lynch et al., 2001; Freetly et al., 2001)

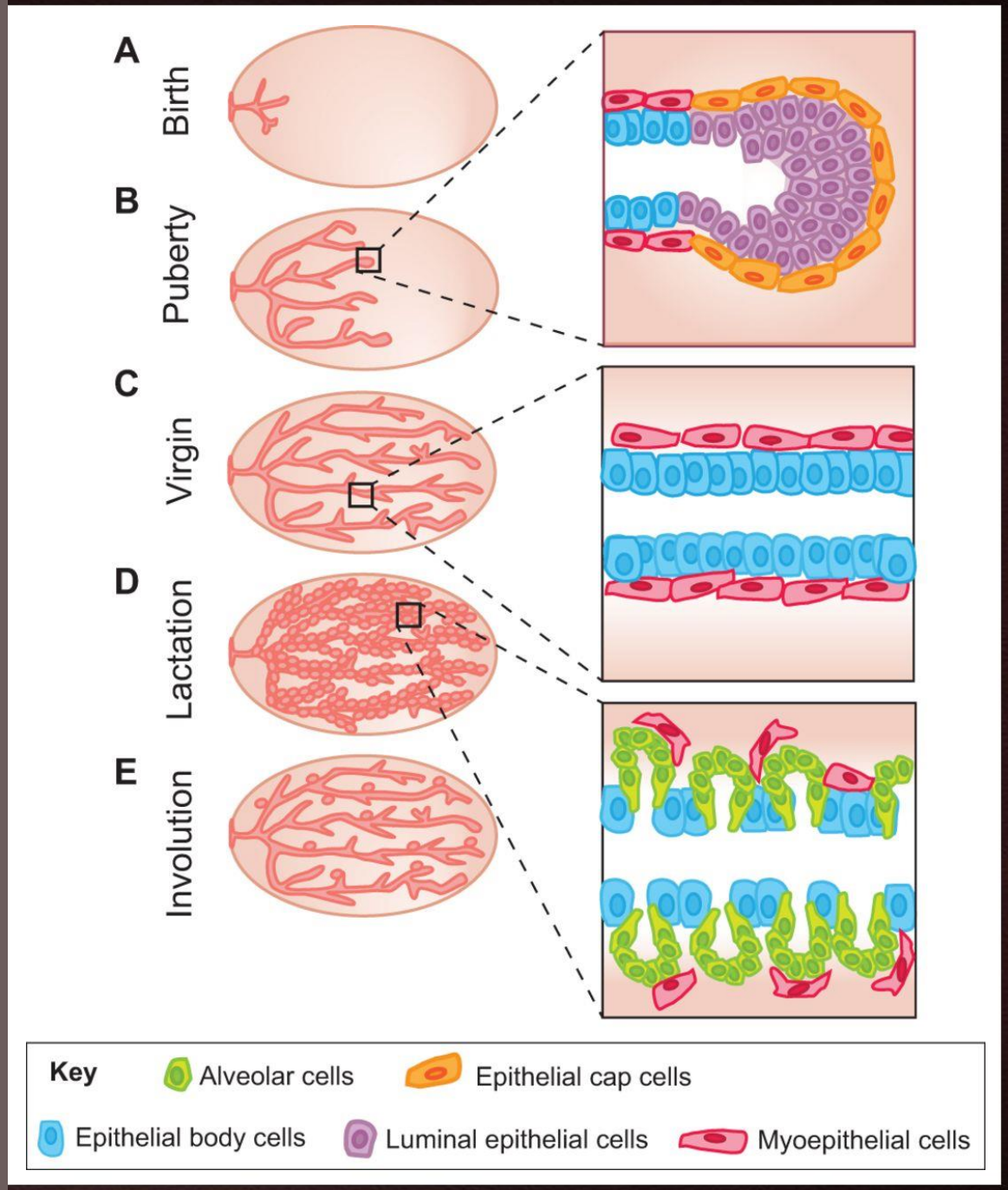
- Increasing concentration of rumen propionate results in hormonal alterations that would lead to an earlier age at puberty in heifers (Rutter et al., 1983; McCartor et al., 1979; and Moseley et al., 1977, 1982)



Mammary Development

Mammary development is negatively affected by the accumulation of excess body energy reserves (i.e., fat)

- Heifers that are creep-fed decreased weaning weight (Martin et al., 1981)
- Milk production is decreased when dairy heifers are developed to weights that create excess body energy reserves (Swanson, 1967)



Inman et al. (2015)

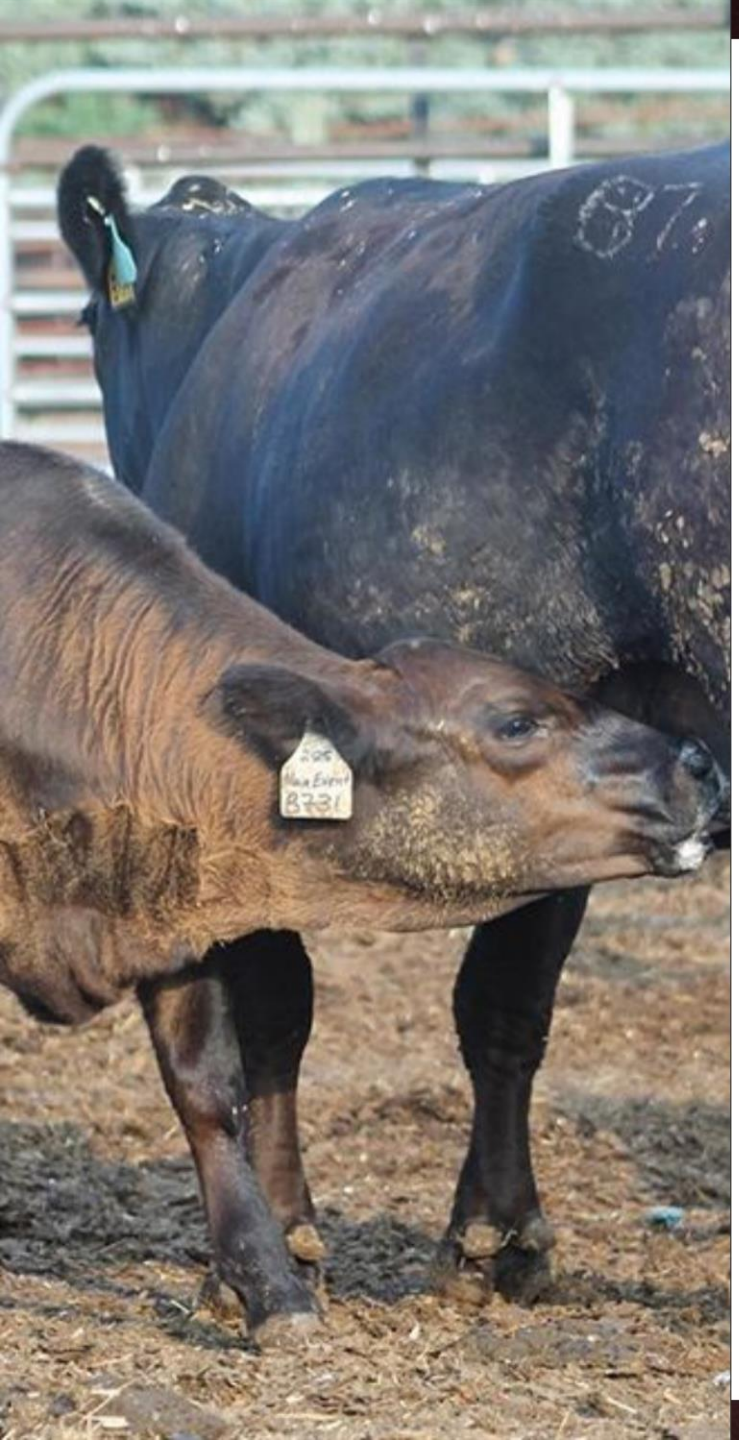
Target Weight

Higher target weight (60% to 65%)

- Higher feed cost/pregnant heifer
- Decrease age at puberty
- Increase percentage of pubertal heifers with more than one estrous cycle before breeding season
- Less risk of environmental stress

Preferred to

- Spring calving with larger cow size, *B. indicus*
- Risk of environmental stress



Target Weight

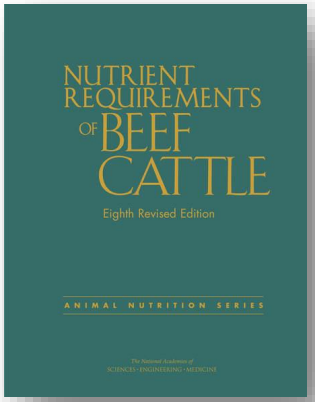
Lower target weight (51% to 57%)

- Decrease feed cost
- Decrease BW at puberty
- Potential to decrease mature cow weight with lower maintenance energy requirements

Preferred to

- Fall calving
- Small to moderate cow size
- Breed type with more milk production
- Low risk of environmental extremes (allow to compensatory growth)
- Progestin is used in an estrous synchronization

Requirements for Pregnancy



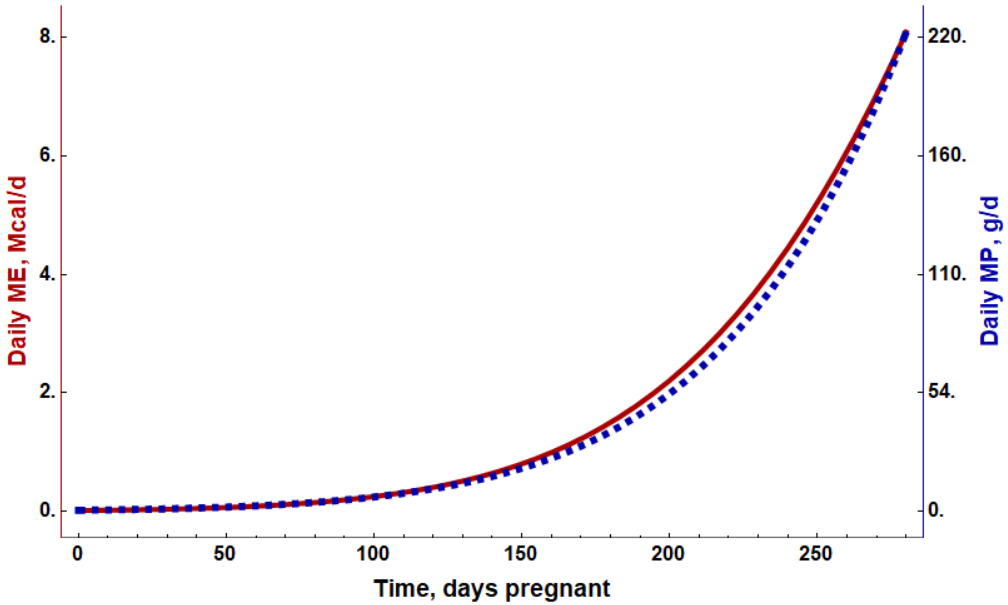
$$NEy = CBW \times (0.05855 - 0.0000996 \times DP) \times e^{0.0323 \times DP - 0.0000275 \times DP^2}/1{,}000 \quad \text{(Eq. 19-37)}$$

$$MEy = NEy/0.13 \quad \text{(Eq. 19-38)}$$

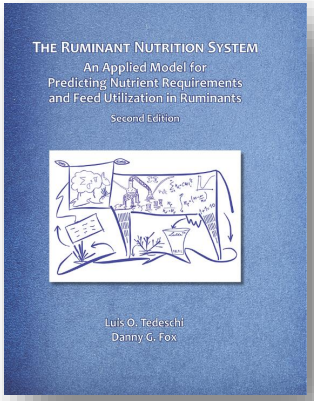
$$FFP = MEy/ME \quad \text{(Eq. 19-39)}$$

$$Ypn = CBW \times (0.001669 - 0.00000211 \times DP) \times e^{0.0278 \times DP - 0.0000176 \times DP^2} \times 6.25 \quad \text{(Eq. 19-40)}$$

$$MPy = Ypn/0.65 \quad \text{(Eq. 19-41)}$$



Requirements for Pregnancy



$$GUW = \begin{cases} (CBW\ /\ 47) \times (0.664 \times t - 102) & \text{Dairy and } 190 \le \text{t} \le 270 \\ (CBW\ /\ 41) \times 0.7439 \times e^{\left(0.02 \times t - 0.0000143 \times t^2\right)} & \text{Beef} \end{cases} \quad [14.2]$$

$$ADG_{GU} = \begin{cases} (CBW\ /\ 47) \times 0.100 & \text{Dairy and t}<190 \\ (CBW\ /\ 47) \times 0.664 & \text{Dairy and t} \ge 190 \\ (CBW\ /\ 41) \times 0.7439 \times (0.02 - 0.0000286 \times t) \times e^{(0.02 \times t - 0.0000143 \times t^2)} & \text{Beef} \end{cases} \quad [14.3]$$

$$NEpr = \begin{cases} (CBW\ /\ 47) \times (0.00318 \times t - 0.0352) & \text{Dairy and } 190 \le \text{t} \le 270 \\ \dfrac{(CBW\ /\ 41) \times 69.73 \times (0.0323 - 0.000055 \times t) \times \mathrm{e}^{\left(0.0323 \times t - 0.0000275 \times t^2\right)}}{1000} & \text{Beef} \end{cases} \quad [14.4]$$

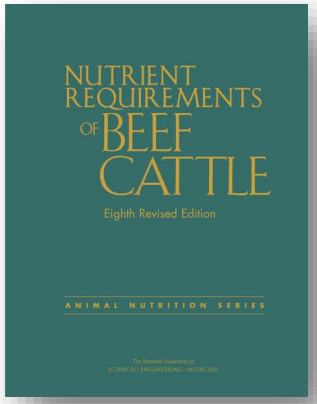
$$MEpr = \begin{cases} NEpr\ /\ 0.14 & \text{Dairy and } 190 \le \text{t} \le 270 \\ NEpr\ /\ 0.13 & \text{Beef} \end{cases} \quad [14.5]$$

$$NPpr = \begin{cases} (CBW\ /\ 47) \times (0.69 \times t - 69.2) & \text{Dairy and } 190 \le \text{t} \le 270 \\ \dfrac{(CBW\ /\ 41) \times 2.312 \times (0.0278 - 0.0000352 \times t) \times e^{\left(0.0278 \times t - 0.0000176 \times t^2\right)}}{0.16} & \text{Beef} \end{cases} \quad [14.6]$$

$$MPpr = \begin{cases} NPpr\ /\ 0.33 & \text{Dairy and } 190 \le \text{t} \le 270 \\ NPpr\ /\ 0.50 & \text{Beef} \end{cases} \quad [14.7]$$

Where ADG_{GU} is average daily gain of gravid uterus during pregnancy, kg/d; *CBW* is calf birth weight, kg, and it can be estimated as mature BW×0.06275; *GUW* is gravid uterus weight, kg; *MEpr* is metabolizable energy required for pregnancy, Mcal/d; *MPpr* is metabolizable protein required for pregnancy, g/d; *NEpr* is net energy required for pregnancy, Mcal/d; *NPpr* is net protein required for pregnancy, g/d; and *t* is days pregnant.

Nutrition of Primiparous

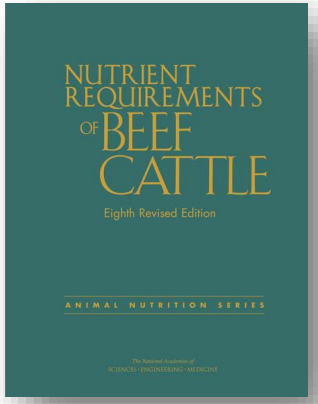


- Primiparous female which maintained moderate BCS had better pregnancy rate than those that achieved moderate BCS after calving (Lalman et al., 1997)

- It takes between 33 and 38.6 kg of weight change to gain one BCS, but only 8.6 kg to lose one BCS for primiparous beef females (Lalman et al., 1997; Graffam et al., 1992)

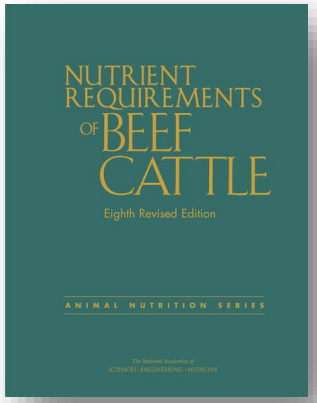
- Primiparous beef females required 70.2 kg and 61.7 kg of liveweight change, respectively, to increase one BCS (Ripberger, 1997; Bradford, 1998)

- Literature averaged SBW/BCS change is 50.9 kg



- A difference in weight change per unit of BCS between multiparous and primiparous females makes sense because the primiparous female would need to **gain weight** (skeletal growth and muscle) to just maintain body condition

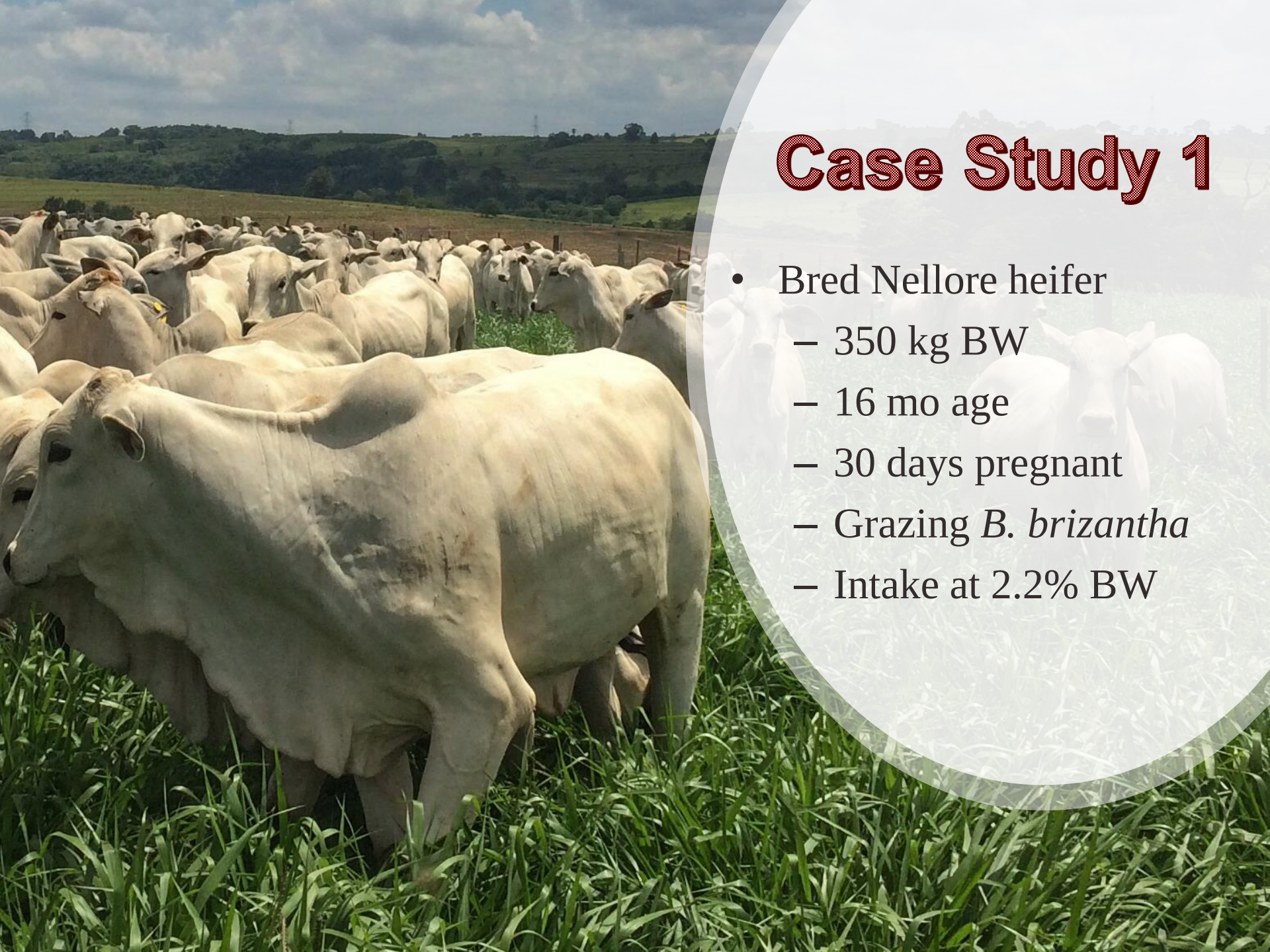
- However, this difference in SBW/BCS for primiparous females was not accounted for in the NASEM (2016) model, but the committee recognizes that change in SBW associated with growth should be accounted for



- The previous literature shows that adjustment of 0.4 (losing) and 1.6 (gaining) should be made to the mature cows SBW/BCS value of 7.105% for primiparous females

Case Studies

Assisted Management with Nutrition Models



Case Study 1

- Bred Nellore heifer
  - 350 kg BW
  - 16 mo age
  - 30 days pregnant
  - Grazing *B. brizantha*
  - Intake at 2.2% BW

Animal Description

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

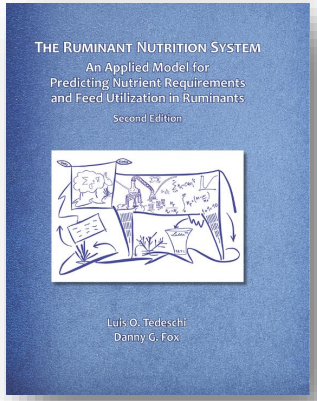
Solution
Level 2

```
Animal Information
==============================================================================
Description:
   Species      : Cattle        Type         : Meat/Beef     Sex          : Female
   Age          : 16 mo         Count        : 100           Ionophore    : No
   Hide         : Thin          Hair depth   : 2.54 cm (1.00 in)

Body weight and condition:
   Option       : MEAN                       BW type      : Full
   Mean BW      : 350.0 kg (771.6 lb)        Full BW      : 350.0 kg (771.6 lb)
   Mature BW    : 480.0 kg (1058.2 lb)       Shrunk BW    : 336.0 kg (740.8 lb)
   Mean BCS     : 5.00 (scale 1_9)           Empty BW     : 299.4 kg (660.0 lb)

Breeding system:
   Breeding     : Straightbred               Breed        : Nellore

Pregnancy:
   Stage           : Replacement                     Stage days         : 0
   Days pregnant   : 30                              First calving age  : 25.5 mo
   Calf birth BW   : 38.0 kg (83.8 lb)               Conception, %BW    : 65.0 %
                                                     Calving interval   : 0   mo
==============================================================================
```



Modeling Pregnancy Requirements

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2

Energy and Protein Requirements for Pregnancy

Pregnancy information		
Days pregnant	:	30.000
Calf birth weight, kg	:	38.000
Uterus weight, kg	:	1.240
Uterus average daily growth, kg/d	:	0.024

Energy required for pregnancy		
Net energy (NEpr), Mcal/d	:	0.005
Metabolizable energy (MEpr), Mcal/d	:	0.039
Efficiency of use, %	:	13.000
Feed required for pregnancy, kg/d	:	0.017
Dietary net energy for pregnancy, Mcal/kg	:	0.300
Dietary metabolizable energy, Mcal/kg	:	2.307

Protein required for pregnancy		
Net protein, g/d	:	0.81
Metabolizable protein, g/d	:	1.62
Efficiency of use, %	:	50.000

BW adjusted for uterus weight

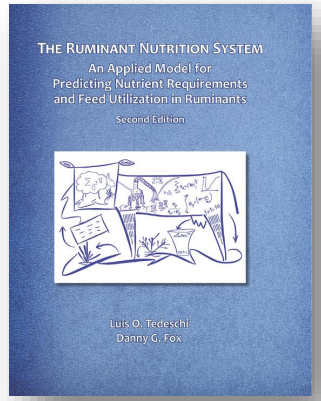
Weight	Original	Adjusted
Full	350.0	348.8
Shrunk	336.0	334.8
Empty	299.4	298.1

Metabolizable amino acids required for pregnancy

Amino acids		Tissue, %	Effic., %	g/d
Methionine, Met	:	1.97	35.00	0.046
Lysine, Lys	:	6.37	53.00	0.098
Histidine, His	:	2.47	32.00	0.063
Phenylalanine, Phe	:	3.53	48.00	0.060
Tryptophan, Trp	:	1.18	85.00	0.011
Threonine, Thr	:	3.90	57.00	0.056
Leucine, Leu	:	6.70	42.00	0.129
Isoleucine, Iso	:	2.84	32.00	0.072
Valine, Val	:	4.03	32.00	0.102
Arginine, Arg	:	3.30	38.00	0.070

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2



Body Fat and Protein Reserves: Mean Body Condition Score

Current body condition score and body composition		Next body condition score and body composition	
Body condition score (BCS1)	5.000	Body condition score (BCS2)	4.000
Empty body weight (EBW1), kg	285.9	Empty body weight (EBW2), kg	264.7
Body fat (BF1), %	19.35	Body fat (BF2), %	14.67
Body protein (BP1), %	17.43	Body protein (BP2), %	18.32
Body ash (BA1), %	5.08	Body ash (BA2), %	5.44
Body water (BWt1), %	58.14	Body water (BWt2), %	61.58
Body fat, kg	55.32	Body fat, kg	38.82
Body protein, kg	49.84	Body protein, kg	48.49
Body ash, kg	14.53	Body ash, kg	14.39
Body water, kg	166.24	Body water, kg	162.99
Body energy, Mcal	804.10	Body energy, Mcal	641.29

Time to Change Body Condition Score (1-9 scale)

Net energy: BCS1 -> BCS2, Mcal	-162.8
Net protein: BCS1 -> BCS2, g	-1349.4
Dietary ME balance, Mcal/d	-9.33
Dietary NE balance, Mcal/d	-7.00
ME to NE efficiency, %	75.00
Time to lose 1 BCS, days	23
Empty weight gain, kg/d	-0.913
Shrunk weight gain, kg/d	-1.073
Full weight gain, kg/d	-1.118

Empty body composition and energy associated with BCS changes

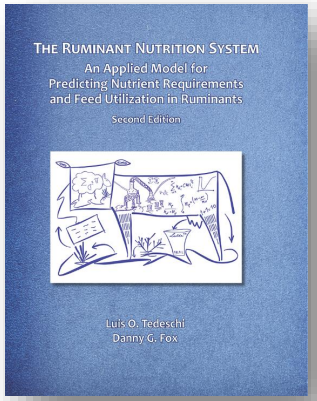
BCS1-9	BCS1-5	BCS0-5	EBW, kg	EBF, kg	EBP, kg	TE, Mcal	dTE, Mcal
1.000	1.000	0.000	200.96	1.25	42.18	252.14	0.00
2.000	1.500	0.625	222.20	11.78	44.66	365.32	113.17
3.000	2.000	1.250	243.45	24.31	46.77	495.03	129.72
4.000	2.500	1.875	264.69	38.82	48.49	641.29	146.26
5.000	3.000	2.500	285.94	55.32	49.84	804.10	162.81
6.000	3.500	3.125	307.18	73.81	50.81	983.45	179.35
7.000	4.000	3.750	328.43	94.29	51.41	1179.34	195.89
8.000	4.500	4.375	349.67	116.76	51.62	1391.78	212.44
9.000	5.000	5.000	370.92	141.22	51.46	1620.76	228.98

WITHOUT SUPPLEMENTATION

- Report shows body composition at BCS 5 (left) and BCS 4 (right)
  - Body fat decreases from 19.35% to 14.67%
- Bred heifer grazing will lose BCS (5 to 4) in 23 days, if not supplemented
- She needs 162.8 Mcal of NE (217 Mcal of ME) to keep BCS

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2



Body Fat and Protein Reserves: Mean Body Condition Score

Current body condition score and body composition		Next body condition score and body composition	
Body condition score (BCS1)	5.000	Body condition score (BCS2)	6.000
Empty body weight (EBW1), kg	285.9	Empty body weight (EBW2), kg	307.2
Body fat (BF1), %	19.35	Body fat (BF2), %	24.03
Body protein (BP1), %	17.43	Body protein (BP2), %	16.54
Body ash (BA1), %	5.08	Body ash (BA2), %	4.73
Body water (BWt1), %	58.14	Body water (BWt2), %	54.70
Body fat, kg	55.32	Body fat, kg	73.81
Body protein, kg	49.84	Body protein, kg	50.81
Body ash, kg	14.53	Body ash, kg	14.52
Body water, kg	166.24	Body water, kg	168.04
Body energy, Mcal	804.10	Body energy, Mcal	983.45

Time to Change Body Condition Score (1-9 scale)

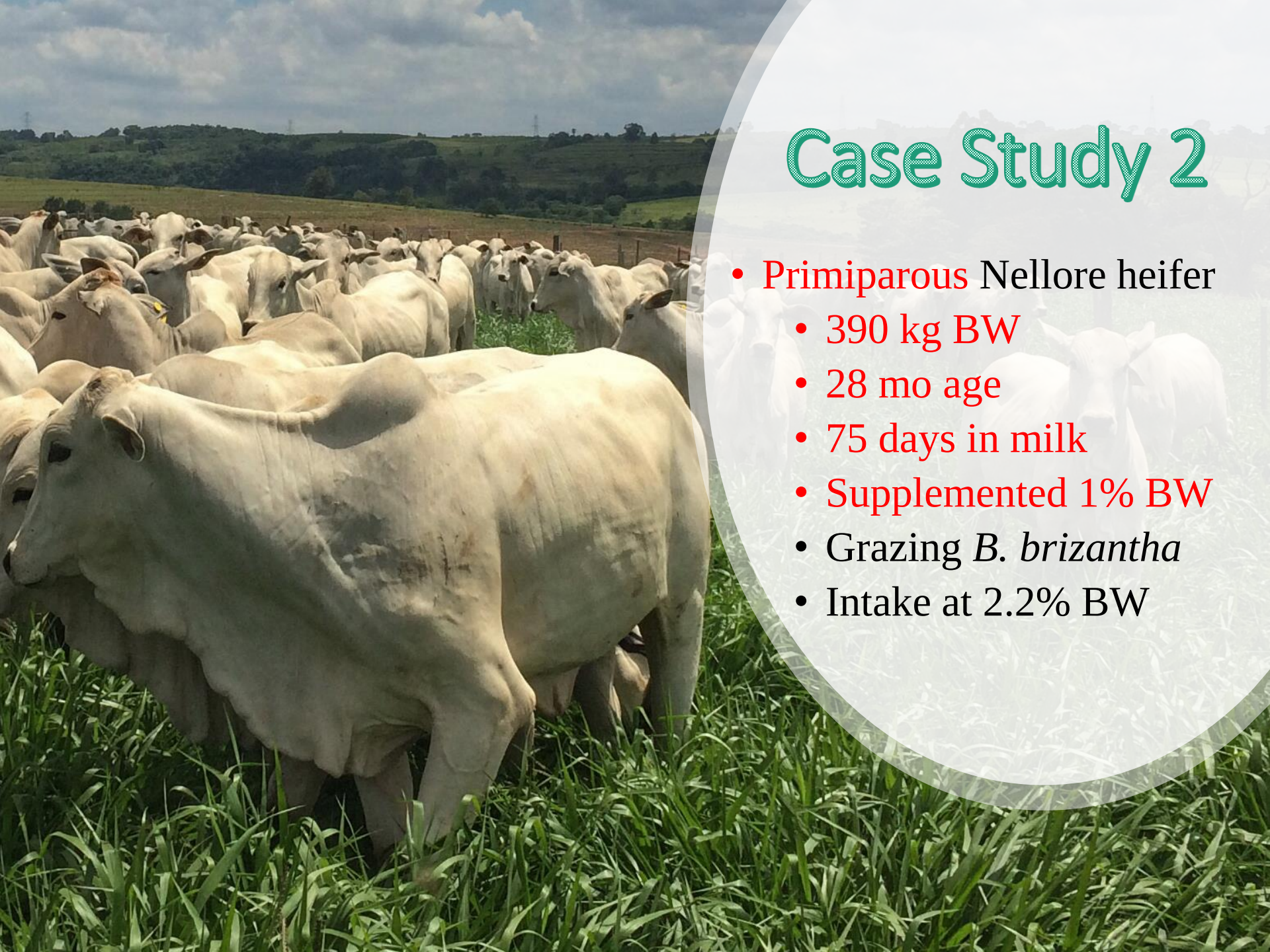
Net energy: BCS1 -> BCS2, Mcal	179.3
Net protein: BCS1 -> BCS2, g	971.5
Dietary ME balance, Mcal/d	2.90
Dietary NE balance, Mcal/d	1.74
ME to NE efficiency, %	60.00
Time to gain 1 BCS, days	103
Empty weight gain, kg/d	0.206
Shrunk weight gain, kg/d	0.242
Full weight gain, kg/d	0.252

Empty body composition and energy associated with BCS changes

BCS1-9	BCS1-5	BCS0-5	EBW, kg	EBF, kg	EBP, kg	TE, Mcal	dTE, Mcal
1.000	1.000	0.000	200.96	1.25	42.18	252.14	0.00
2.000	1.500	0.625	222.20	11.78	44.66	365.32	113.17
3.000	2.000	1.250	243.45	24.31	46.77	495.03	129.72
4.000	2.500	1.875	264.69	38.82	48.49	641.29	146.26
5.000	3.000	2.500	285.94	55.32	49.84	804.10	162.81
6.000	3.500	3.125	307.18	73.81	50.81	983.45	179.35
7.000	4.000	3.750	328.43	94.29	51.41	1179.34	195.89
8.000	4.500	4.375	349.67	116.76	51.62	1391.78	212.44
9.000	5.000	5.000	370.92	141.22	51.46	1620.76	228.98

WITH SUPPLEMENTATION (1% BW)

- Report shows body composition at BCS 5 (left) and BCS 6 (right)
  - Body fat increases from 19.35% to 24.03%
- Bred heifer grazing and supplemented will gain BCS (5 to 6) in 103 days
- Practically, keeping her BCS



Case Study 2

- Primiparous Nellore heifer
  - 390 kg BW
  - 28 mo age
  - 75 days in milk
  - Supplemented 1% BW
  - Grazing *B. brizantha*
  - Intake at 2.2% BW

Animal Description

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2

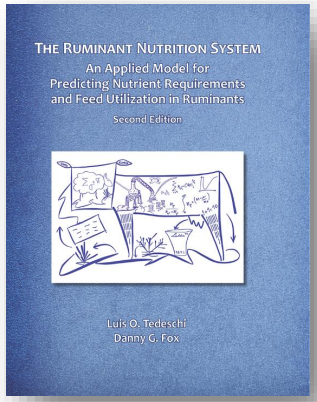
```
Animal Information
==============================================================================
Description:
   Species      : Cattle        Type         : Meat/Beef    Sex          : Female
   Age          : 28 mo         Count        : 100          Ionophore    : No
   Hide         : Thin          Hair depth   : 2.54 cm (1.00 in)

Body weight and condition:
   Option       : MEAN                       BW type      : Full
   Mean BW      : 390.0 kg (859.8 lb)        Full BW      : 390.0 kg (859.8 lb)
   Mature BW    : 480.0 kg (1058.2 lb)       Shrunk BW    : 374.4 kg (825.4 lb)
   Mean BCS     : 5.00 (scale 1_9)           Empty BW     : 333.6 kg (735.4 lb)

Breeding system:
   Breeding     : Straightbred               Breed        : Nellore

Lactation:
   Stage        : Lactating                            Stage days        : 0
   Days in milk: 75                                    Lactation #       : 1
   Peak milk    : 7.0 kg/d (15.4 lb/d)                 Relative MY       : 3 (1 to 5)
   Peak fat     : 4.0 %         Peak protein: 3.8 %

Pregnancy:
   Days pregnant  : 30                                 First calving age : 25.5 mo
   Calf birth BW  : 38.0 kg (83.8 lb)                  Conception, %BW   : 65.0 %
                                                       Calving interval  : 0   mo
==============================================================================
```



Modeling Maintenance Requirements

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2

Energy and Protein Requirements for Maintenance

Net energy (NE) required for maintenance (NEmr)

Basal metabolism	
Basal metabolic rate, coefficient (a1):	0.070
Effective temperature index, previous :	31.479
Acclimatization coefficient (a2) x1000:	-1.790
Compensatory factor (comp) :	1.000
Lactation factor (L) :	1.200
Sex factor (sex) :	1.000
NEmrBasal, Mcal/d :	6.980
Physical activity/locomotion	
Time standing, h :	18.0
Position changes :	6.0
Walking - horizontal, m/d :	2000.0
Walking - slopped, m/d :	0.0
NEmrAct, Mcal/d :	1.331
Cold stress	
Surface area, m^2 :	4.901
Metabolizable energy intake, Mcal/d :	16.935
NE for lactation (NElr), Mcal/d :	3.531
NE for pregnancy (NEpr), Mcal/d :	0.005
NE for growth (NEgr), Mcal/d :	0.000
Heat production, Mcal/d :	6.420
Insulation, hair coat factor :	1.000
Insulation, hide factor :	0.800
Insulation, external, oC.m^2.d/Mcal :	11.070
Insulation, tissue, oC.m^2.d/Mcal :	9.000
Insulation, total, oC.m^2.d/Mcal :	20.070
Lower critical temperature, oC :	16.65
NEmrCS, Mcal/d :	0.000
Heat stress	
Panting factor (Bos indicus) :	1.000
Effective temperature index, current :	29.553
NEmrHS, Mcal/d :	0.000

Protein required for maintenance

Metabolizable protein, g/d :	203.094
Urinary protein, g/d :	79.419
Scurf protein, g/d :	10.446
Fecal protein, g/d :	113.229
Net protein, g/d :	116.824
Efficiency of use, % :	57.522

Metabolizable AA required for maintenance

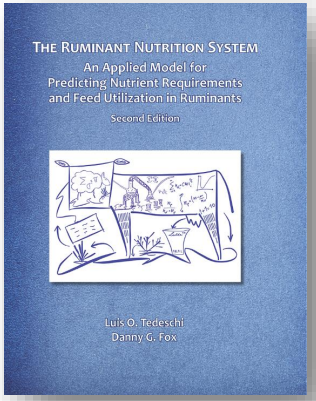
Amino acids	Tissue %	Effic. %	Amount g/d
Methionine, Met :	1.97	85.00	2.708
Lysine, Lys :	6.37	85.00	8.755
Histidine, His :	2.47	85.00	3.395
Phenylalanine, Phe :	3.53	85.00	4.852
Tryptophan, Trp :	1.18	85.00	1.622
Threonine, Thr :	3.90	85.00	5.360
Leucine, Leu :	6.70	66.00	11.859
Isoleucine, Iso :	2.84	66.00	5.027
Valine, Val :	4.03	66.00	7.133
Arginine, Arg :	3.30	85.00	4.536

Urea cost

Ruminal N balance, g/d :	138.151
Ruminal recycled N, g/d :	44.535
Metabolizable protein balance, g/d :	0.000
NEmrUrea, Mcal/d :	0.457

Energy required for maintenance

Net energy (NEmr), Mcal/d :	8.769
Metabolizable energy (MEmr), Mcal/d :	13.105
Efficiency of use, % :	66.912
Feed required for maintenance :	4.595
Dietary NE for maintenance, Mcal/kg :	1.908
Dietary metabolizable energy, Mcal/kg :	2.852



Modeling Lactation Requirements

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2

Energy and Protein Requirements for Lactation

Lactation information

Days in milk (DIM)	:	75.000
Milk production, kg/d	:	4.488
Peak milk production, kg/d	:	7.000
Peak milk fat, %	:	4.000
Peak milk true protein, %	:	3.800
Peak milk crude protein, %	:	4.086

Days in milk adjusted values

DIM adjusted milk fat, %	:	3.674
DIM adjusted milk true protein, %	:	3.636
DIM adjusted milk crude protein, %	:	3.910

Energy required for lactation

Net energy (NElr), Mcal/d	:	3.531
Metabolizable energy (MElr), Mcal/d	:	5.482
Efficiency of use, %	:	64.400
Feed required for lactation, kg/d	:	1.922
Dietary NE for lactation, Mcal/kg	:	1.837
Dietary metabolizable energy, Mcal/kg	:	2.852

Protein required for lactation

Net protein, g/d	:	170.54
Metabolizable protein, g/d	:	254.54
Efficiency of use, %	:	67.000

Metabolizable amino acids required for lactation

Amino acids		Tissue, %	Effic., %	g/d
Methionine, Met	:	2.71	100.00	4.622
Lysine, Lys	:	7.62	82.00	15.848
Histidine, His	:	2.74	96.00	4.868
Phenylalanine, Phe	:	4.75	98.00	8.266
Tryptophan, Trp	:	1.51	85.00	3.030
Threonine, Thr	:	3.72	78.00	8.134
Leucine, Leu	:	9.18	72.00	21.744
Isoleucine, Iso	:	5.79	66.00	14.961
Valine, Val	:	5.89	62.00	16.202
Arginine, Arg	:	3.40	35.00	16.567

Forage dry matter intake of nursing calves

Net protein, g/d : 170.54
Peak milk rate, kg/d : 7.00

CalfBW	75	100	125	150	175	200	225	250
ForageDE								
2.2	0.17	0.55	1.09	1.73	2.41	3.09	3.76	4.41
2.4	0.17	0.54	1.08	1.71	2.38	3.06	3.73	4.37
2.6	0.17	0.56	1.12	1.77	2.46	3.16	3.85	4.52
2.8	0.18	0.59	1.18	1.87	2.61	3.35	4.08	4.78
3	0.19	0.64	1.27	2.00	2.79	3.58	4.36	5.11
3.2	0.21	0.68	1.36	2.15	2.99	3.84	4.68	5.48

Modeling Pregnancy Requirements

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2

Energy and Protein Requirements for Pregnancy

Pregnancy information

Days pregnant	:	30.000
Calf birth weight, kg	:	38.000
Uterus weight, kg	:	1.240
Uterus average daily growth, kg/d	:	0.024

BW adjusted for uterus weight

Weight	Original	Adjusted
Full	390.0	388.8
Shrunk	374.4	373.2
Empty	333.6	332.4

Energy required for pregnancy

Net energy (NEpr), Mcal/d	:	0.005
Metabolizable energy (MEpr), Mcal/d	:	0.039
Efficiency of use, %	:	13.000
Feed required for pregnancy, kg/d	:	0.014
Dietary net energy for pregnancy, Mcal/kg	:	0.371
Dietary metabolizable energy, Mcal/kg	:	2.852

Metabolizable amino acids required for pregnancy

Amino acids		Tissue, %	Effic., %	g/d
Methionine, Met	:	1.97	35.00	0.046
Lysine, Lys	:	6.37	53.00	0.098
Histidine, His	:	2.47	32.00	0.063
Phenylalanine, Phe	:	3.53	48.00	0.060
Tryptophan, Trp	:	1.18	85.00	0.011
Threonine, Thr	:	3.90	57.00	0.056
Leucine, Leu	:	6.70	42.00	0.129
Isoleucine, Iso	:	2.84	32.00	0.072
Valine, Val	:	4.03	32.00	0.102
Arginine, Arg	:	3.30	38.00	0.070

Protein required for pregnancy

Net protein, g/d	:	0.81
Metabolizable protein, g/d	:	1.62
Efficiency of use, %	:	50.000

Modeling Body Reserves

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
t. (979)-845-5065 & f. (979)-845-5292

Solution
Level 2

Body Fat and Protein Reserves: Mean Body Condition Score

Current body condition score and body composition		Next body condition score and body composition	
Body condition score (BCS1)	5.000	Body condition score (BCS2)	4.000
Empty body weight (EBW1), kg	318.6	Empty body weight (EBW2), kg	294.9
Body fat (BF1), %	19.35	Body fat (BF2), %	14.67
Body protein (BP1), %	17.43	Body protein (BP2), %	18.32
Body ash (BA1), %	5.08	Body ash (BA2), %	5.44
Body water (BWt1), %	58.14	Body water (BWt2), %	61.58
Body fat, kg	61.64	Body fat, kg	43.25
Body protein, kg	55.54	Body protein, kg	54.04
Body ash, kg	16.19	Body ash, kg	16.04
Body water, kg	185.24	Body water, kg	181.62
Body energy, Mcal	896.00	Body energy, Mcal	714.58

Time to Change Body Condition Score (1-9 scale)

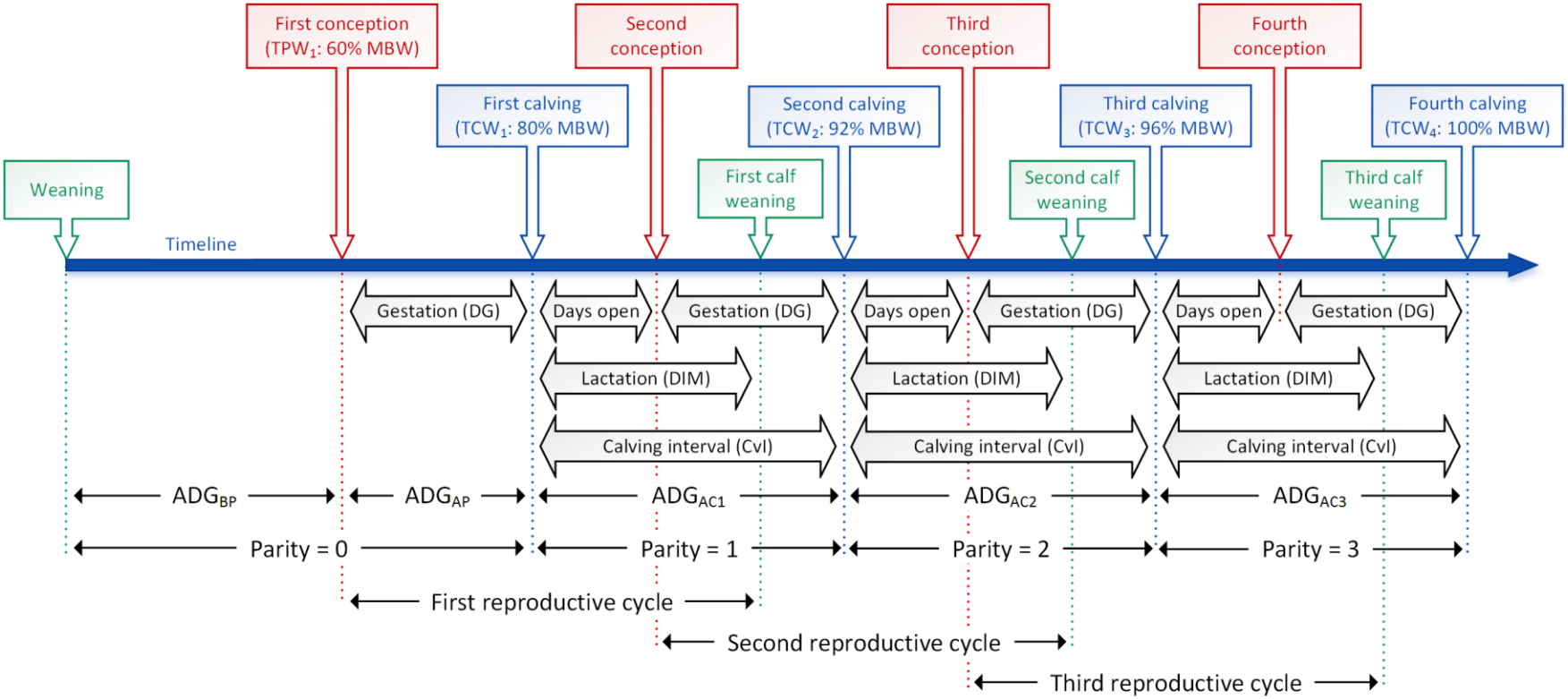
Net energy: BCS1 -> BCS2, Mcal	-181.4
Net protein: BCS1 -> BCS2, g	-1503.6
Dietary ME balance, Mcal/d	-1.69
Dietary NE balance, Mcal/d	-1.27
ME to NE efficiency, %	75.00
Time to lose 1 BCS, days	143
Empty weight gain, kg/d	-0.165
Shrunk weight gain, kg/d	-0.194
Full weight gain, kg/d	-0.203

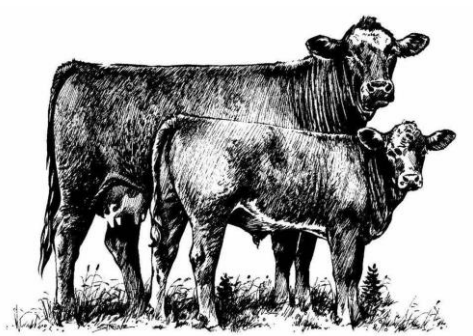
Empty body composition and energy associated with BCS changes

BCS1-9	BCS1-5	BCS0-5	EBW, kg	EBF, kg	EBP, kg	TE, Mcal	dTE, Mcal
1.000	1.000	0.000	223.92	1.39	47.00	280.96	0.00
2.000	1.500	0.625	247.60	13.13	49.76	407.07	126.11
3.000	2.000	1.250	271.27	27.08	52.11	551.61	144.54
4.000	2.500	1.875	294.94	43.25	54.04	714.58	162.98
5.000	3.000	2.500	318.61	61.64	55.54	896.00	181.41
6.000	3.500	3.125	342.29	82.24	56.62	1095.84	199.85
7.000	4.000	3.750	365.96	105.07	57.28	1314.12	218.28
8.000	4.500	4.375	389.63	130.10	57.52	1550.84	236.72
9.000	5.000	5.000	413.31	157.35	57.34	1805.99	255.15

WITH SUPPLEMENTATION (1% BW)

- Even with supplementation, this cow will lose BCS in 143 days
- Confirming that energy requirements increase drastically after parturition (milk synthesis and growth), so type/amount of supplement needs to be changed





SUPPLEMENTATION STRATEGY

- Each reproductive cycle may need a different level/type of supplementation to comprise with energy and protein needs

Acknowledgements

Luiz Fernando Diaz Batista

lfdiasbatista@tamu.edu

"Justin"

That’s All Folks!

Thank you