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: *Cow*

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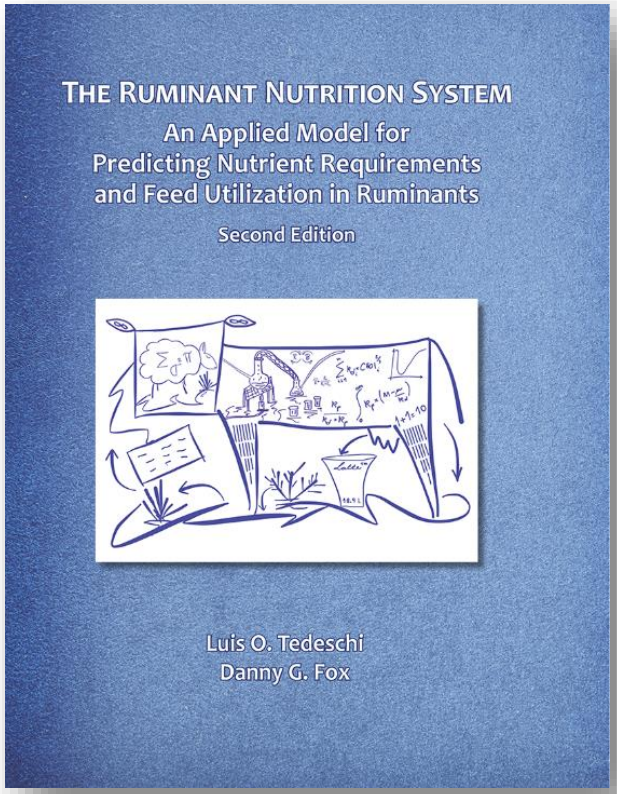
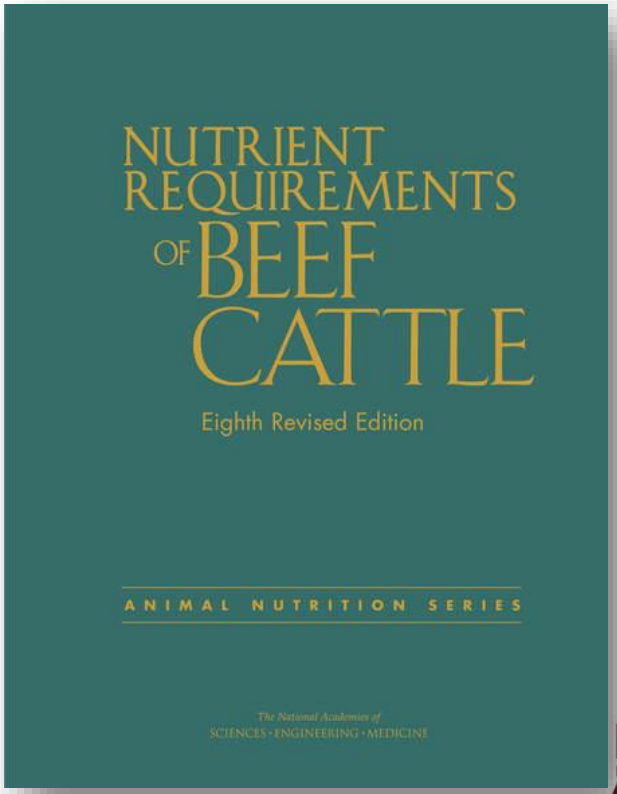
Where to Learn More?

Ruminant Nutrition System



"NRC" (2016)



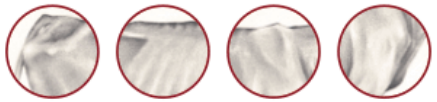
Why is Body Reserves Important?

What is Body Condition Score?

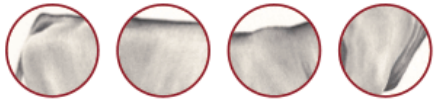
Body condition score gives us a snapshot in time of the animal's energy status. This indicates how well the animal is doing based on production stage and diet. Body condition score should be assessed on cows at different times of the year so that you can make management decisions based on their current condition. The three most critical times of the year are at calving, mid-lactation and mid-late gestation.

BODY CONDITION SCORE

1 **Hips:** no palpable fat **Ribs & Spine:** no palpable fat **Shoulder:** front of shoulder is slighty pointed **Brisket:** no palpable fat

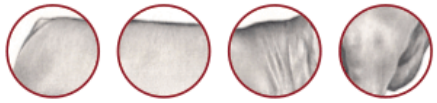


3 **Hips:** some palpable fat cover **Ribs & Spine:** ribs still individually identifiable but with rounded edges, some palpable fat along spine and over dorsal portion of ribs **Shoulder:** front of shoulder is slightly pointed **Brisket:** some palpable fat cover



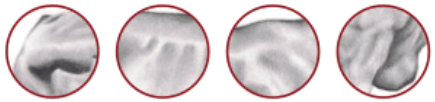
56 percent of BCS 3 cows became pregnant after 75-day breeding season. According to a study conducted, in part, by Ryon Walker, Ph.D., at Louisiana State University, the ideal body condition score for breeding cows is 5 or 6. The rate of pregnancy after a 75-day breeding season was 88 percent in cows with a BCS of 5 and 89 percent in cows with a BCS of 6. Rates dropped to 56 percent in cows with a BCS of 3.

7 **Hips:** very spongy fat cover, developing pones (fat pockets) **Ribs & Spine:** ribs and spine not visible, very spongy **Shoulder:** very spongy, hard to distinguish front of shoulder **Brisket:** very spongy



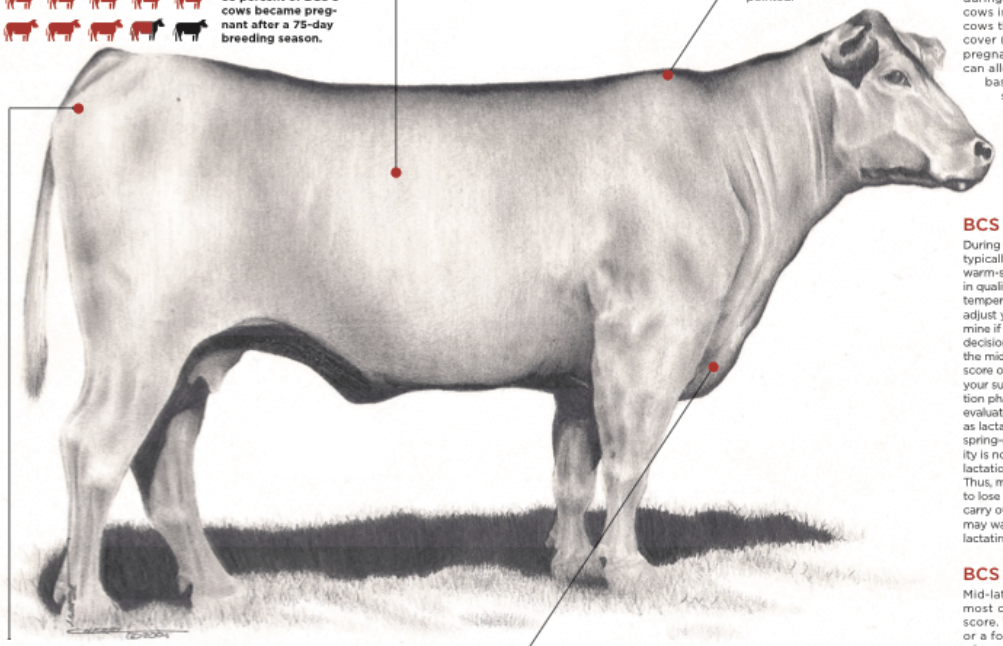
67 percent of BCS 7 cows became pregnant after a 75-day breeding season.

9 **Hips:** tail head and hips buried in fatty tissue, pones are protruding **Ribs & Spine:** excessively spongy along back and over ribs, no bones detectable **Shoulder:** excessively spongy, shoulder looks blocky **Brisket:** excessive amount of fat hanging between front legs



5 A BCS of 5 or 6 is the ideal body condition for breeding and calving. The large cow below shows a BCS of 5.

88 percent of BCS 5 cows became pregnant after a 75-day breeding season.



RIBS & SPINE

Developing a spongy feel over ribs and spine. Spine is not visible, but the last two ribs are still visible.

SHOULDER

Some palpable fat cover is developing. The front of the shoulder is rounded, not pointed.

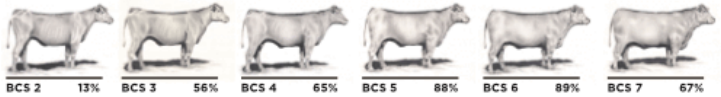
HIPS

Palpable fat cover is detected over hips with some signs of fat pockets developing around the tail head.

BRISKET

Starting to develop palpable fat cover in the brisket. Fat cover is smooth to the look with no developing fat pockets yet.

75-DAY BREEDING SEASON PREGNANCY RATES



Images provided by University of Minnesota Extension Beef Team

Source: Demeterco et al., 2017

When to Assess

The three most critical times of the year to assess body condition score are at calving, mid-lactation and mid-late gestation.

BCS AT CALVING

Many studies have correlated cow BCS at calving and the likelihood of getting pregnant during the breeding season. For example, cows in a BCS of 5 or greater have a better chance of getting bred early during the breeding season compared with cows in a BCS of less than 5. In addition, cows that have too much condition or fat cover (BCS greater than 7) can have lower pregnancy rates. This snapshot at calving can allow you to make adjustments in diet based on the time of year and calving season (spring or fall) to improve a cow's plane of nutrition and body condition prior to the breeding season. Young lactating females that are thin at calving will struggle to improve their body condition prior to breeding, unless they are on full feed.

BCS AT MID-LACTATION

During mid-lactation, the breeding season is typically wrapping up. For spring-calving cows, warm-season grasses are starting to decrease in quality because of lack of moisture and hot temperatures. This time of year will allow you to adjust your summer grazing strategy and determine if supplementation or other management decisions are needed. For fall-calving cows, it's the middle of winter. Based on the condition score of your cows, you may need to adjust your supplementation program. At this production phase, it is critical that condition scores be evaluated in younger producing females, such as lactating 2- and 3-year-olds. Oftentimes in spring-calving cows, warm-season forage quality is not sufficient to meet the requirements for lactation and growth of a lactating 2-year-old. Thus, most of those younger females will begin to lose body weight and condition, which will carry over into the next calving season. You may want to consider early weaning the young lactating females if this occurs.

BCS AT MID-LATE GESTATION

Mid-late gestation is the most critical and most convenient time to body condition score. This is typically done at weaning or a follow-up working after weaning where cows are palpated for pregnancy, dewormed and possibly vaccinated. At this stage, cows are approximately three to four months prior to calving, which allows the opportunity to adjust management so the majority of cows calve in a BCS range of 5 to 6. Cows can then be sorted into a fleshy and thin group using BCS, if pastures and resources allow. This prevents overfeeding or underfeeding certain groups, which ultimately saves money.

NOBLE RESEARCH INSTITUTE

Why is Body Reserves Important?

- ✓ To have a high probability of conception by approximately 80d post-calving, the estrus should occur approximately 40d postpartum.

BODY CONDITION RELATES TO INTERVAL FROM CALVING TO FIRST HEAT

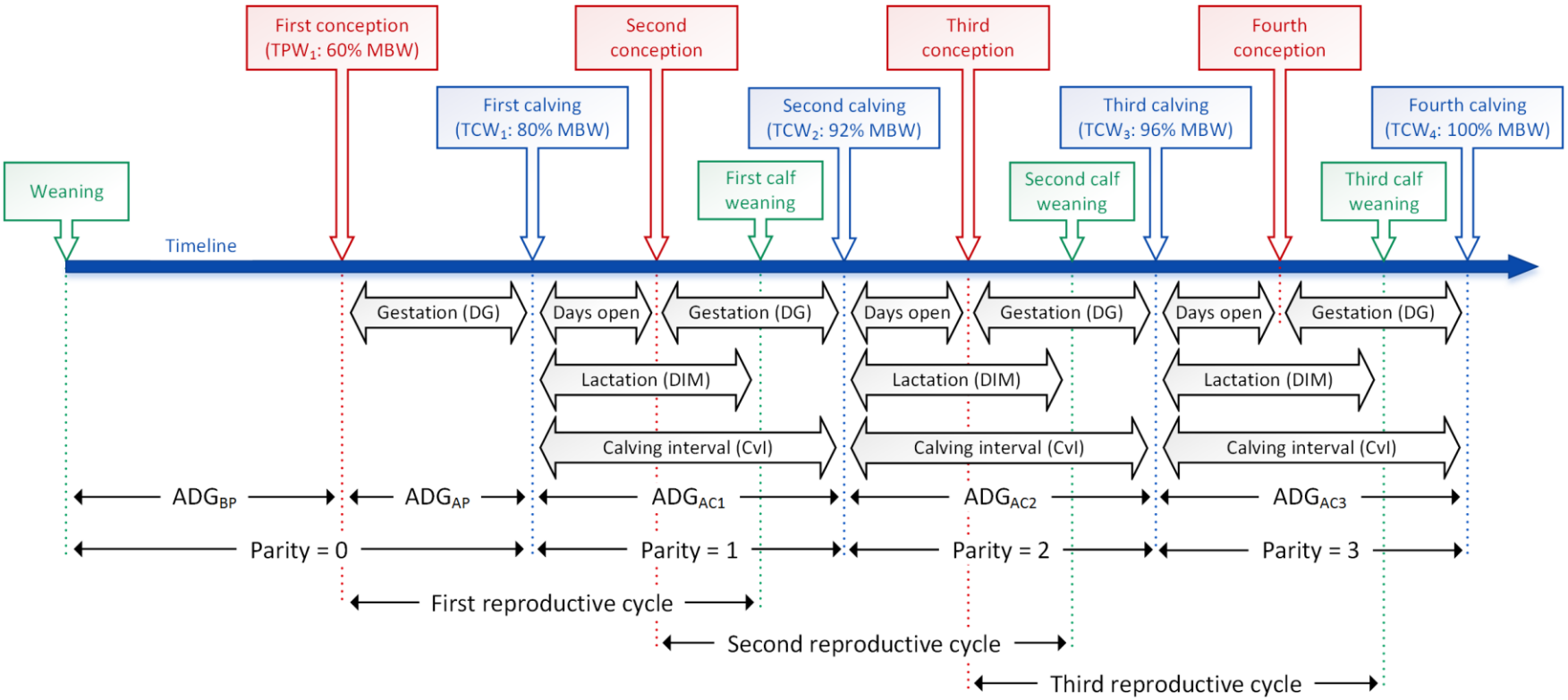
BCS	Post-Partum Interval (Days)	
3	89	80
4	70	
5	59	55
6	52	
7	31	

Why is Body Reserves Important?

- First calving at 24 months
  - Short calving interval
  - Wean one calf per year
  - Be productive for at least 5 years

- There is a positive correlation between BCS at calving and levels of insulin and IGF-1 and negative correlation between BCS at calving and NEFA and plasma urea-N (Soca et al., 2014)

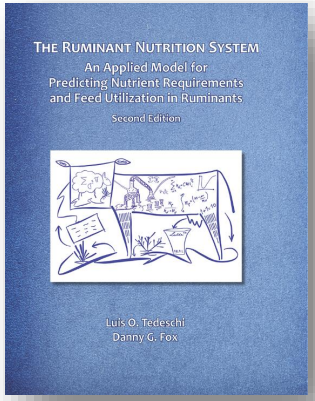
Planning the Cow Nutrition



First calving at 24 months:

- Short calving interval
- Wean one calf per year
- Be productive for 5 years

Are our cows in good nutritional condition?



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

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

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

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

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

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

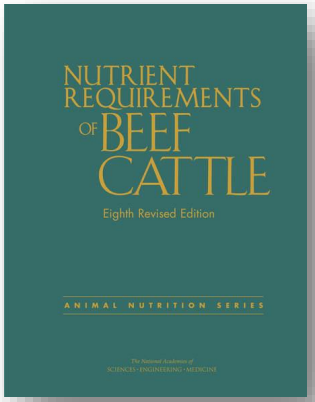
$$TCW_3 = MBW \times 0.96 \quad [15.36]$$

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

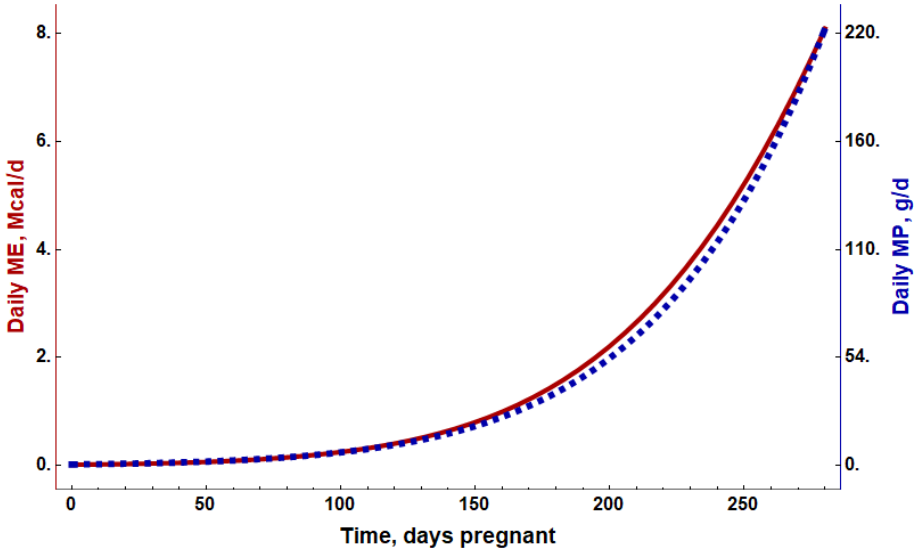
$$ADG_{ACx} = \begin{cases} \left(TCW_{x+1} - TCW_x\right)/CvI \mid x \geq 1 & \text{Ideal growth conditions} \\ \left(TCW_{x+1} - SBW\right)/\left(CvI - DIM\right) \mid x \geq 1 & \text{Current growth conditions} \end{cases} \quad [15.38]$$

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.

How Much Energy is Needed?



- Calving interval decreases as BCS at calving increases (Houghton et al., 1990)
- Thin mature cows at calving had extended calving interval but when they cycled, their fertility was high (Houghton et al., 1990)
- So, how much energy is needed to maintain an adequate BCS?



Body Condition Scoring Systems

- CSIRO (1990, 2007) and INRA (1989) adopted the 0 to 5 BCS system (Wright and Russel, 1984a,b)

- NRC and NASEM adopted the 1-to-9 scale system developed by the Research from Oklahoma State University and Colorado State University (Cantrell et al., 1982)

Do Not Despair…

$$BCS_{1-9} = 2 \times BCS_{1-5} - 1$$

$$BCS_{1-9} = \frac{8}{5} \times BCS_{0-5} + 1$$

$$BCS_{1-9} = \frac{8 \times BCS_{1-10} + 1}{9}$$

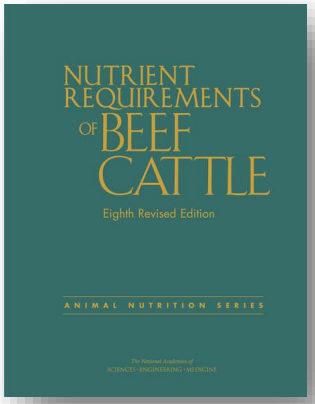
$$BCS_{1-9} = \frac{8 \times BCS_{1-8} - 1}{7}$$

Body Change per BCS?

- The CSIRO (1990, 2007) nutrient requirements assume 83 kg of BW change in BCS (1-to-5 scale)

- The NASEM (2016) adopted an adjustment factors of 7.105% change in SBW/BCS
  - Resulting in variable SBW/BCS of 28.4, 35.5, 42.6, 49.7 and 56.8 kg for 400-, 500-, 600-, 700-, 800-kg mature cows, respectively
  - Carcass fat, %: 3.77, 7.54, 11.30, 15.07, 18.84, 22.61, 26.38, 30.15, and 33.91 at 1-to-9 BCS scale

Energy Requirement



- NEm = 77 kcal/$BW^{0.75}$
  - Assuming 70% efficiency, leads to 110 kcal ME/$BW^{0.75}$

- MEm of lactating primiparous beef females ranged between 111.5 and 121.3 kcal/$BW^{0.75}$ (Graffam, 1992)

- More data needs to be validated, however, previous research suggest that the NEm requirement for primiparous beef females should be increased in 25% (97 kcal/$BW^{0.75}$)

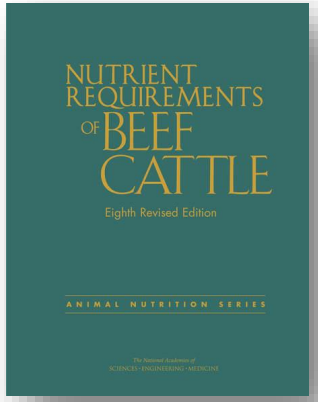
Modeling Body Reserves

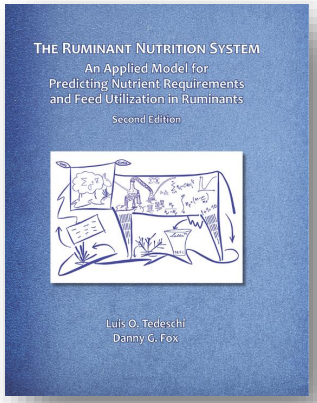
$$WAF_{BCS} = 1 - 0.07105 \times (5 - BCS); \quad \text{(Eq. 13-5)}$$

$$SBW_5 = SBW/WAF_{BCS}, \quad \text{(Eq. 13-6)}$$

where

WAF_{BCS} is the weight adjustment factor at BCS;
BCS is the current body condition score (1 to 9);
SBW_5 is the shrunk body weight at BCS 5, kg; and
SBW is the current shrunk body weight, kg.





$$WAF = 1 - 0.0743 \times (5 - BCS_{[1-9]}) \quad [16.22]$$

$$EBW_{[1-9]} = (0.8513 \times EBW_{BCS5}) \times WAF \quad [16.23]$$

Where *EBW* is the empty body weight at a given BCS; EBW_{BCS5} is the EBW at BCS 5; and *WAF* is the weight adjustment factor for BCS 1-to-9 scale.

Body Composition x BCS
(NRC, 1996, 2000, NASEM, 2016)

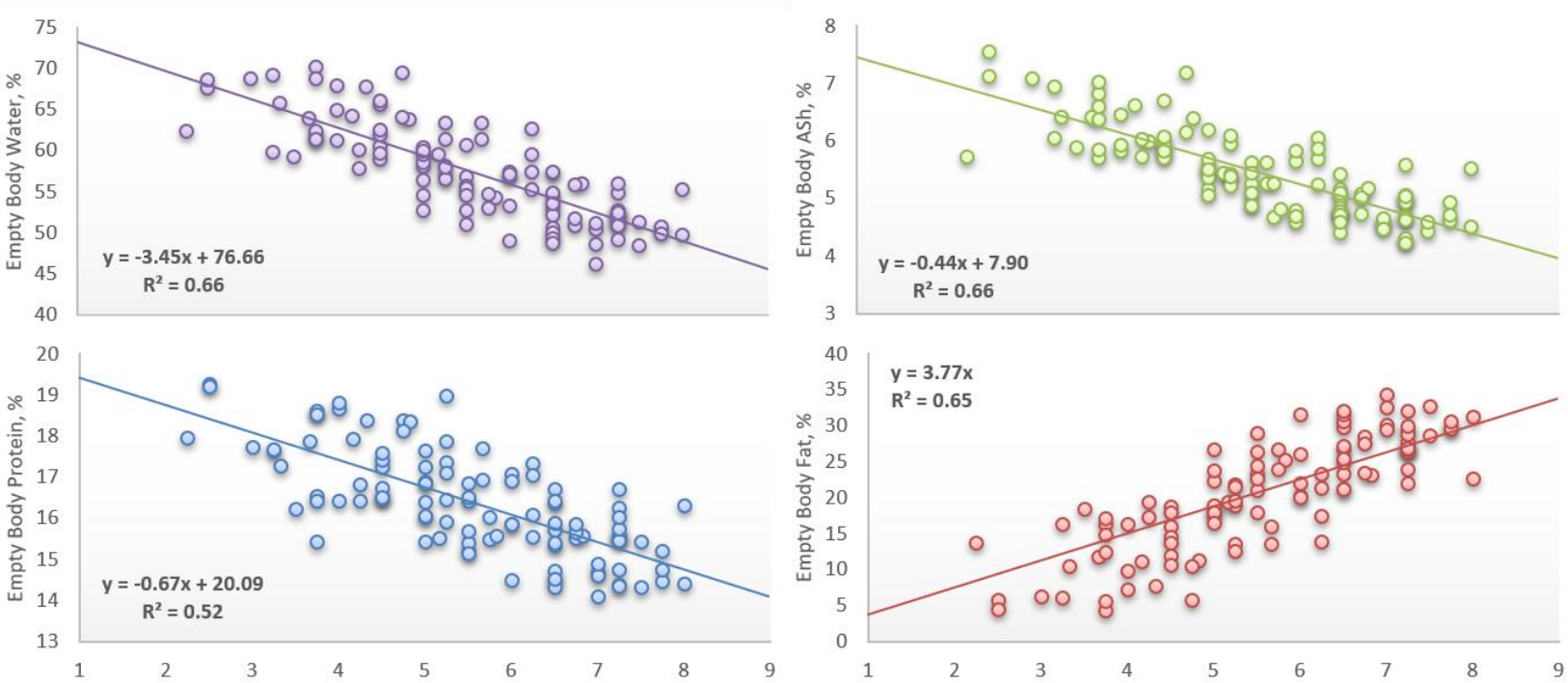
U.S. MARC (Clay Center, NE)

Development dataset:

- 105 mature cows
- EBW = 0.851 × SBW
- mean EBW = 546 (302 to 757) kg
- % empty body fat = 19.3% (4.03 to 31.2)
- % empty body protein = 15.3% (13.2 to 18.0)
- BCS = 5.56 (2.25 to 8.0)

Evaluation dataset:

- 65 mature cows



Body Energy Reserves

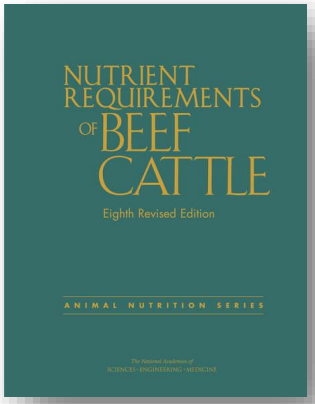


TABLE 13-4 Estimated Body Energy Reserves for Cows Differing in Body Condition Score (BCS) and Weight

	Empty Body Composition[a]		Mature Cow Empty Body Energy Reserves, Mcal						
BCS	Fat, %[b]	Protein, %[c]	400 kg	500 kg	600 kg	700 kg	800 kg	Mcal/kg EBW gain[d]	Mcal/kg EBW loss[e]
1	3.77	19.42	356	445	534	623	712	4.22	3.69
2	7.54	18.75	476	595	714	833	952	4.76	4.22
3	11.30	18.09	611	764	917	1,070	1,223	5.30	4.76
4	15.07	17.42	762	952	1,143	1,333	1,524	5.84	5.30
5	18.84	16.75	928	1,160	1,392	1,624	1,856	6.38	5.84
6	22.61	16.08	1,109	1,386	1,664	1,941	2,218	6.91	6.38
7	26.38	15.42	1,306	1,632	1,958	2,285	2,611	7.45	6.91
8	30.15	14.75	1,517	1,897	2,276	2,655	3,035	7.99	7.45
9	33.91	14.08	1,744	2,181	2,617	3,053	3,489		7.99

Mature cows of different breeds might have different body composition due to different rates of deposition or mobilization of body tissues (Laurenz et al., 1992)

Some breeds may deposit more internal fat than others, and this internal fat reserve is not evident when estimating BCS

Energy Reserves/BCS

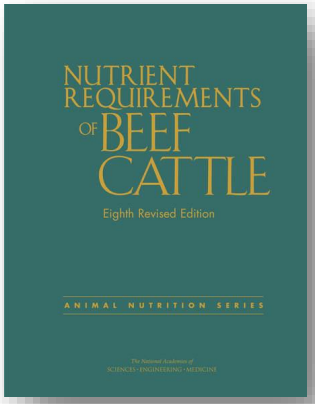
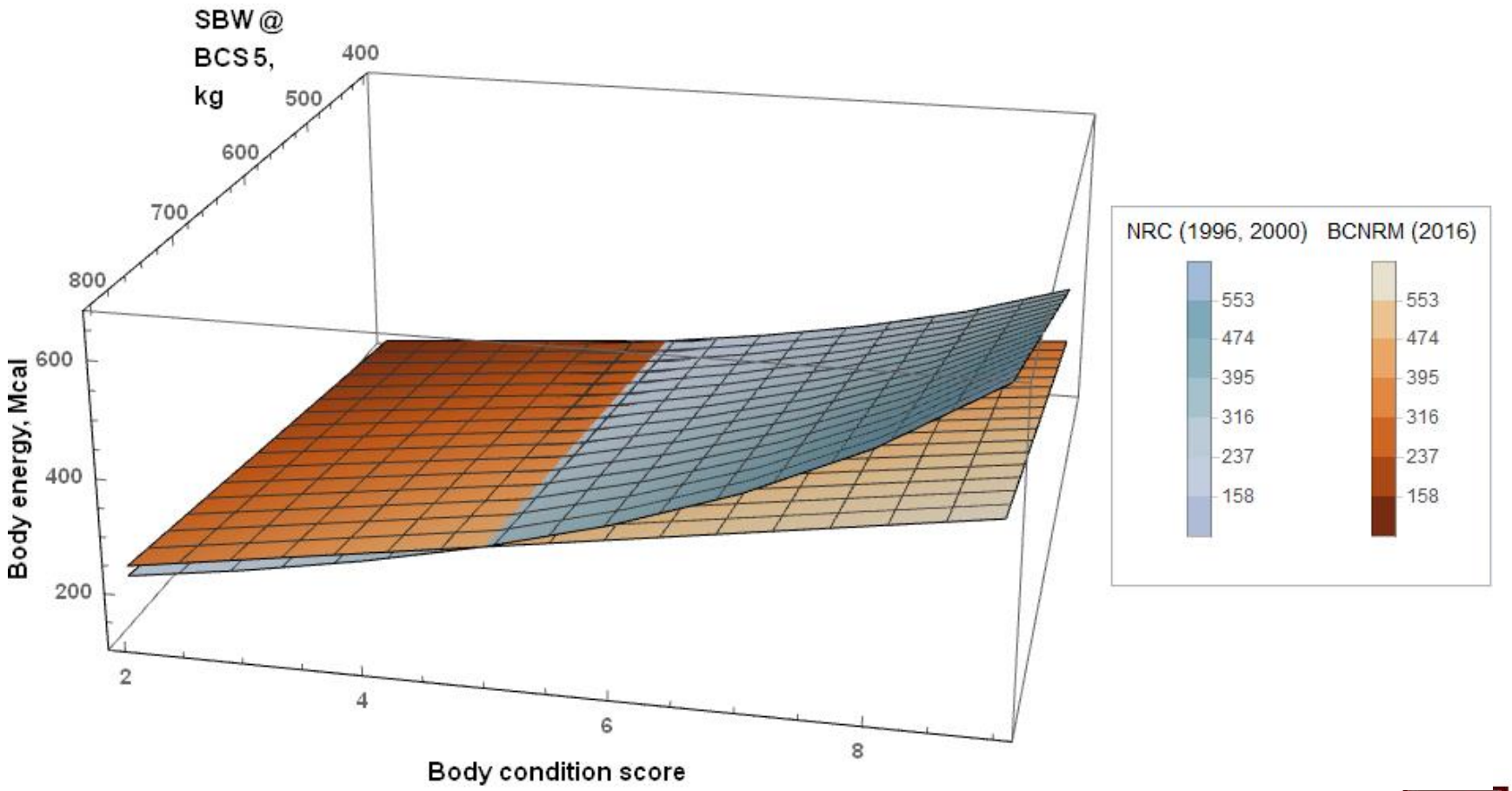


TABLE 13-5 Energy Reserves (Mcal) for Cows with Different Body Weights and Condition Scores to Change One Body Condition Score[a]

BCS		Current SBW at BCS 5, kg								
Gain	Lose	400	450	500	550	600	650	700	750	800
1 → 2	2 → 1	120	135	150	165	180	195	210	225	240
2 → 3	3 → 2	135	152	169	186	203	220	237	254	271
3 → 4	4 → 3	151	169	188	207	226	245	264	282	301
4 → 5	5 → 4	166	187	207	228	249	270	290	311	332
5 → 6	6 → 5	181	204	226	249	272	294	317	340	362
6 → 7	7 → 6	196	221	246	270	295	319	344	368	393
7 → 8	8 → 7	212	238	265	291	318	344	371	397	424
8 → 9	9 → 8	227	255	284	312	341	369	397	426	454

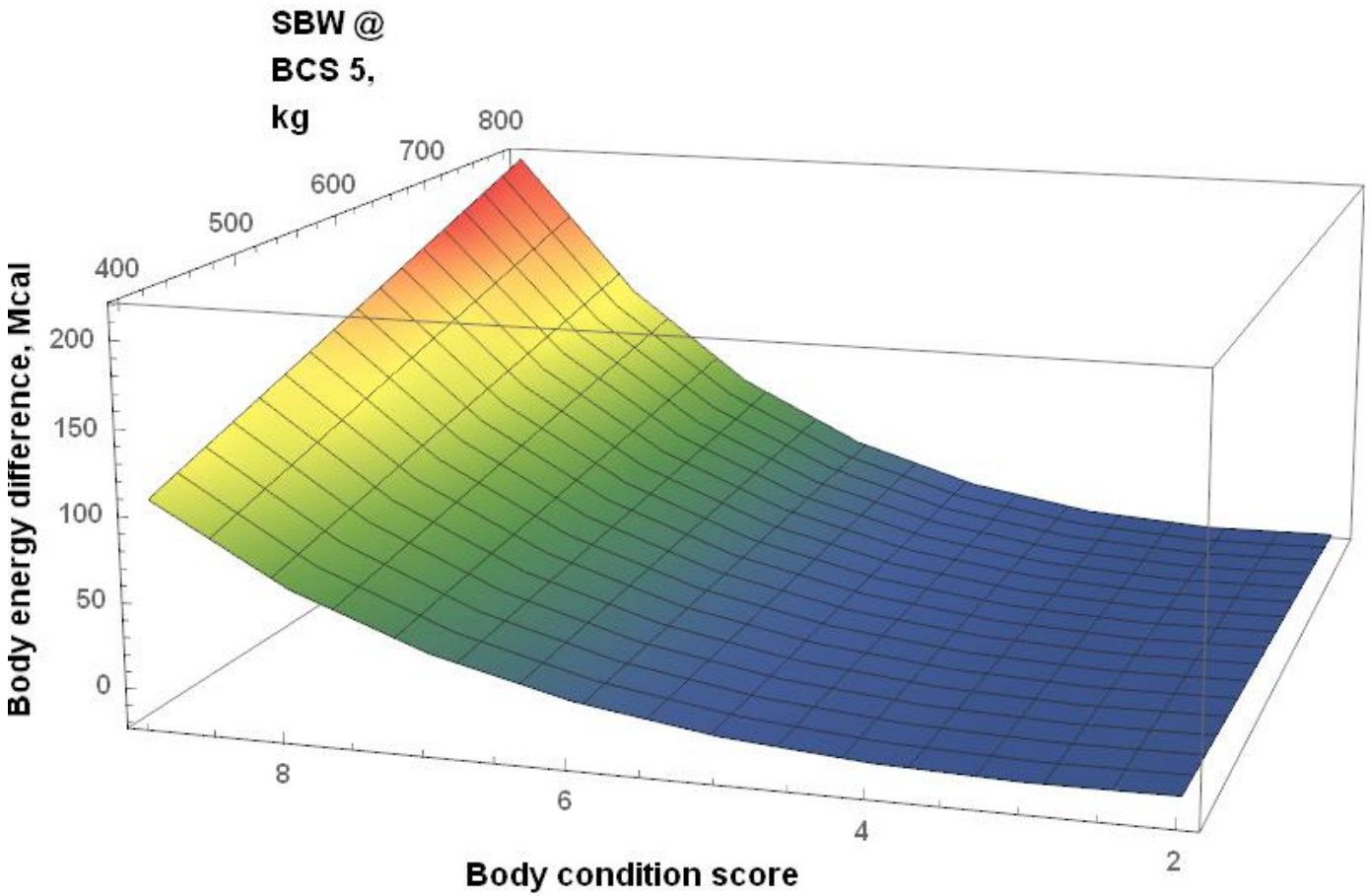
[a]Example: It takes 228 Mcal of body energy reserves for a 550-kg SBW cow to change from a BCS 4 to 5 and to change from a BCS 5 to 4.

Body Reserves:
NRC (1996, 2000) x NASEM (2016)

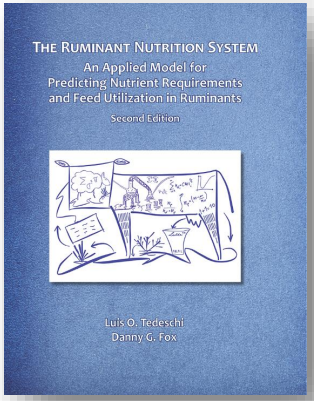


Body Reserves:

NRC (1996, 2000) – BCNRM (NASEM, 2016)



NRC (1996, 2000) predicted greater body energy than BCNRM (2016)



A Revised Body Reserves

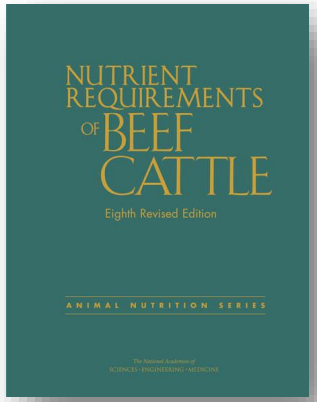


Table 16.4. Empty body composition of mature cows at different body condition scores

BCS	RNS Equations					NRC (1996) Equations				
	Protein	Ash	Fat	Water	% of SBW at BCS 5 [1]	Protein	Ash	Fat	Water	% of SBW at BCS 5 [1]
	% EBW					% EBW				
1	20.99	6.50	0.62	71.96	78.1	19.42	7.46	3.77	73.21	76.5
2	20.10	6.15	5.30	68.51	82.7	18.75	7.02	7.54	69.76	81.3
3	19.21	5.79	9.98	65.06	87.7	18.09	6.58	11.30	66.31	86.7
4	18.32	5.44	14.67	61.61	93.5	17.42	6.15	15.07	62.86	92.9
5	17.43	5.08	19.35	58.16	100.0	16.75	5.71	18.84	59.41	100.0
6	16.54	4.73	24.03	54.71	107.5	16.08	5.27	22.61	55.96	108.3
7	15.65	4.37	28.71	51.26	116.3	15.42	4.83	26.38	52.51	118.1
8	14.76	4.02	33.39	47.80	126.5	14.75	4.39	30.15	49.06	129.9
9	13.87	3.66	38.07	44.35	138.8	14.08	3.96	33.91	45.61	144.3

[1] These values were computed assuming constant body ash amount divided by the proportion of empty body ash for each BCS. The shrunk body weight (SBW) change from BCS 5 weight can be estimated from the difference between BCS 5 weight and BCS 5 weight × percentage of BCS 5 weight for the BCS in question. Note the sum of protein, ash, fat, and water is not 100% for the NRC (1996) calculations.

Energy Reserves/BCS

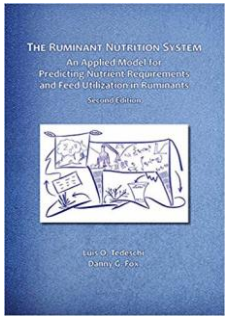


Table 16.7. Net energy required or provided (Mcal) for changes in the body condition score (BCS) of mature cows at different shrunk body weight (SBW) at mid-BCS considering a variable amount of energy per BW change and fixed BW change per unit of BCS change [1]

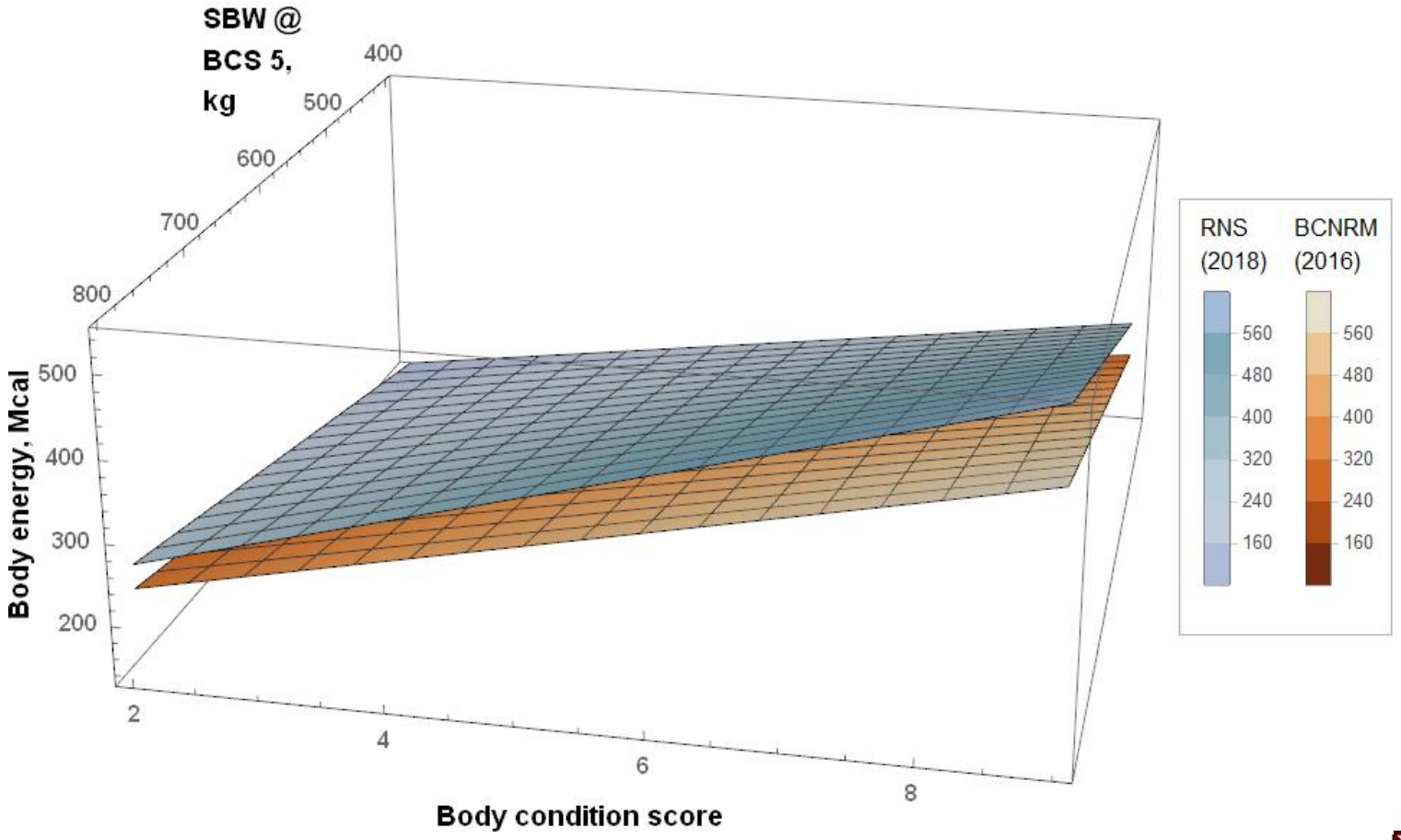
BCS change (ΔBCS)		Mature SBW at BCS 5								
Dairy	Beef	400	450	500	550	600	650	700	750	800
1.0 ↔ 1.5	1 ↔ 2	135	152	168	185	202	219	236	253	270
1.5 ↔ 2.0	2 ↔ 3	154	174	193	212	232	251	270	290	309
2.0 ↔ 2.5	3 ↔ 4	174	196	218	239	261	283	305	327	348
2.5 ↔ 3.0	4 ↔ 5	194	218	242	267	291	315	339	364	388
3.0 ↔ 3.5	5 ↔ 6	214	240	267	294	320	347	374	400	427
3.5 ↔ 4.0	6 ↔ 7	233	262	292	321	350	379	408	437	467
4.0 ↔ 4.5	7 ↔ 8	253	285	316	348	379	411	443	474	506
4.5 ↔ 5.0	8 ↔ 9	273	307	341	375	409	443	477	511	545
ΔSBW/ΔBCS		30	33	37	41	45	48	52	56	59
$\lvert NE\ BCS_{i \leftrightarrow i+1} - NE\ BCS_{i+1 \leftrightarrow i+2} \rvert$ [2]		20	22	25	27	30	32	34	37	39

[1] Represents the energy mobilized or replenished in changing from/to an adjacent BCS. The energy content of each change in SBW varies, but the ΔSBW/ΔBCS was constant within a given mature SBW at BCS 5.

[2] For $1 \leq i \leq 7$, assuming the 1-to-9 scale (beef).

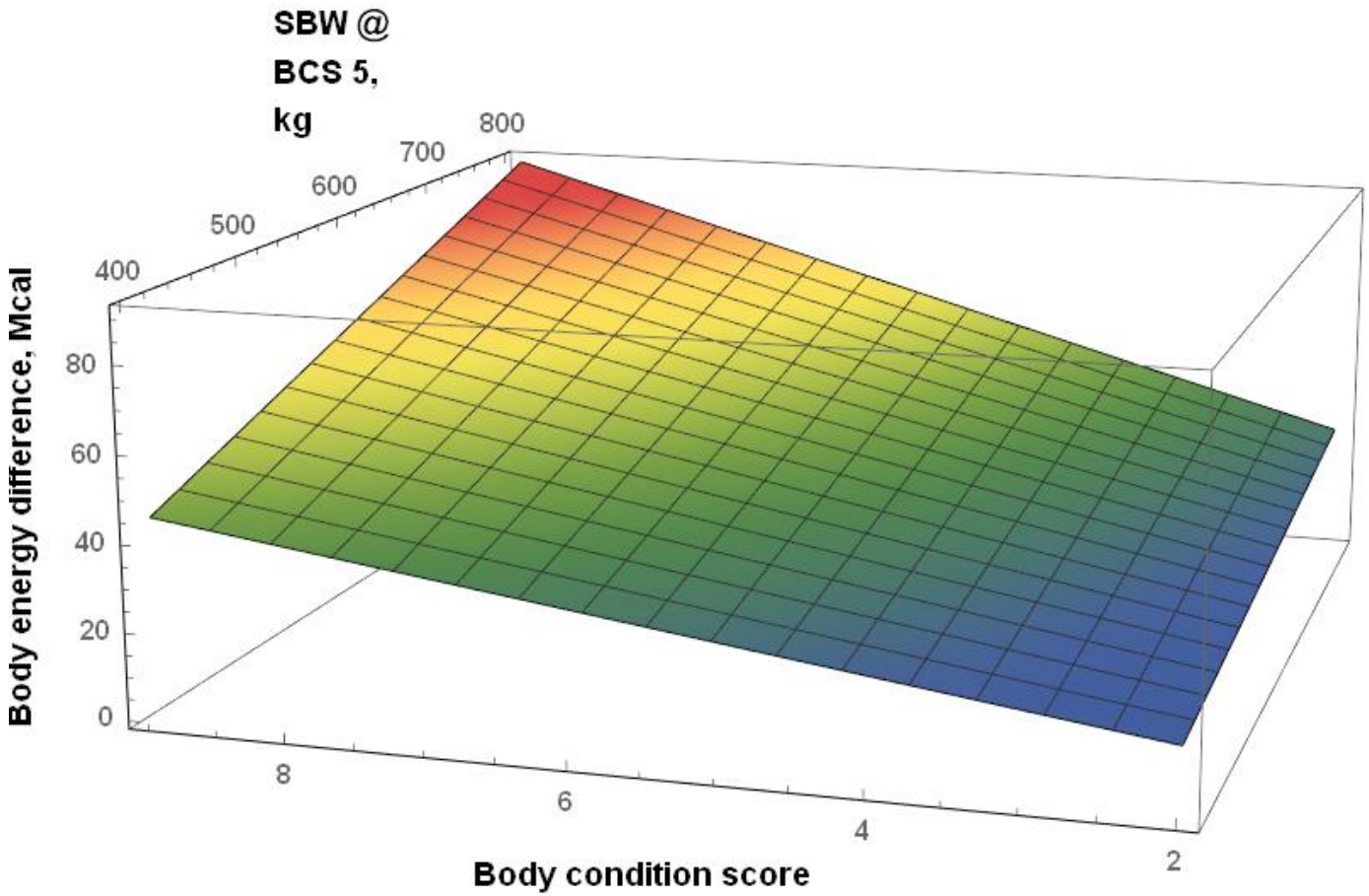
Body Reserves:

RNS (Tedeschi and Fox, 2018) x BCNRM (NASEM, 2016)

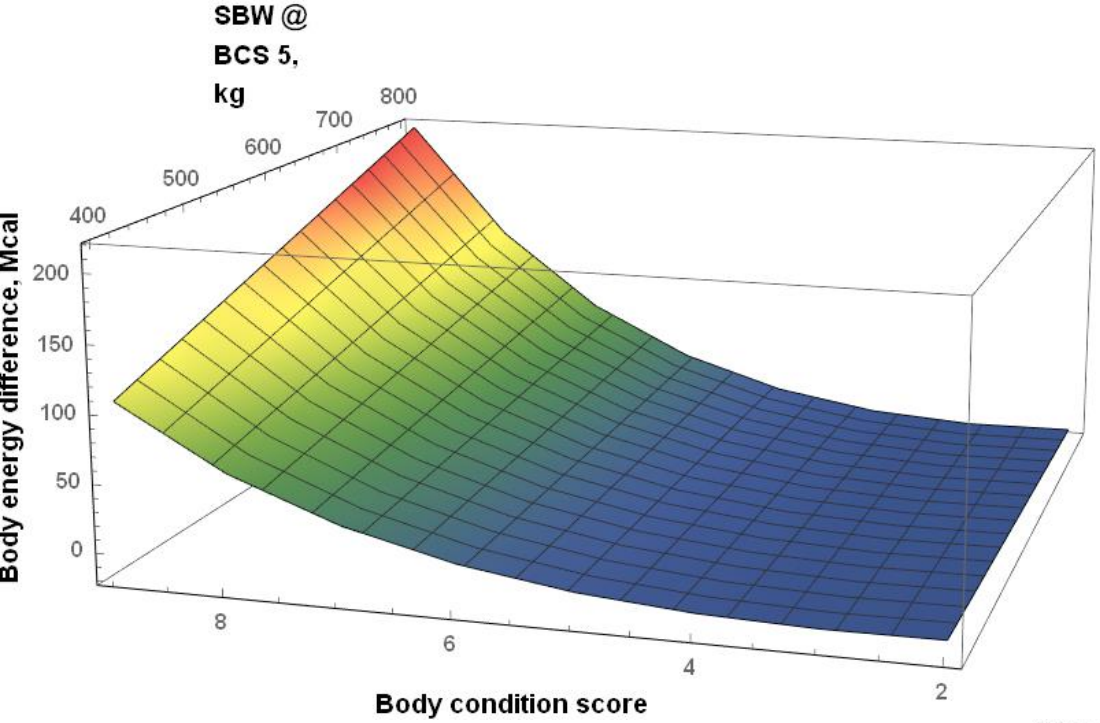


Body Reserves:

RNS (Tedeschi and Fox, 2018) – BCNRM (NASEM, 2016)

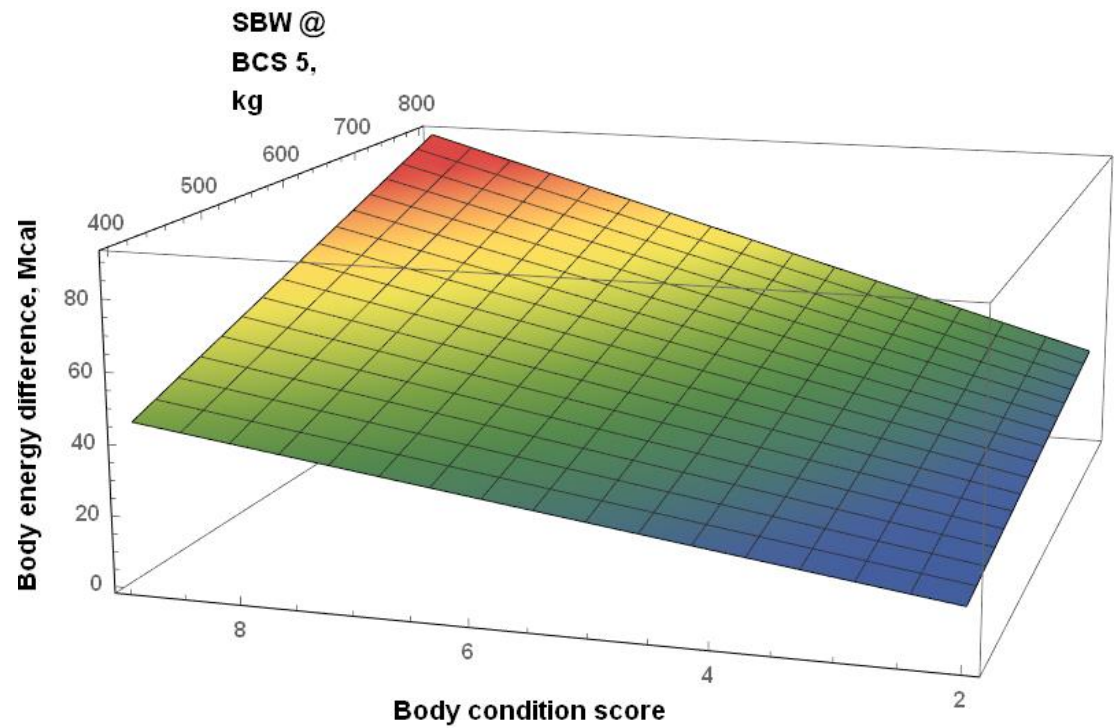


RNS (2018) predicted greater body energy than BCNRM (2016)

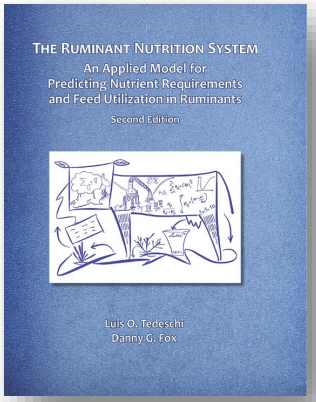


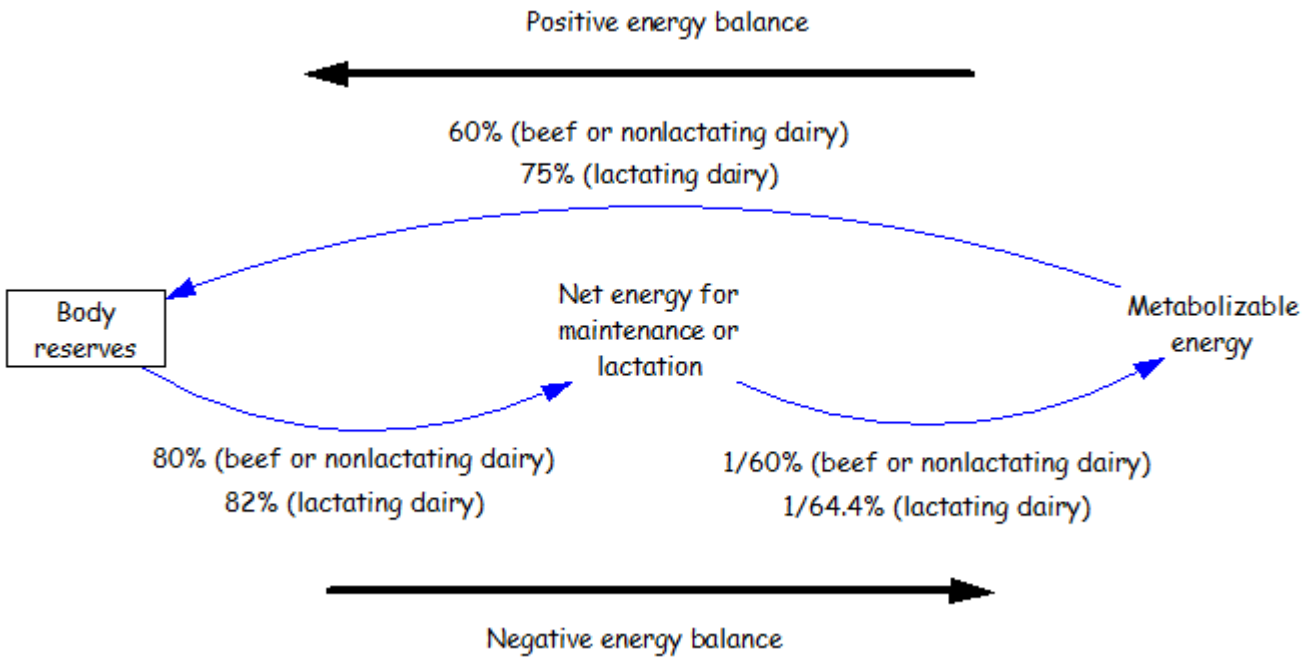
NRC (1996, 2000) – BCNRM (NASEM, 2016)

RNS (Tedeschi and Fox, 2018) – BCNRM (NASEM, 2016)



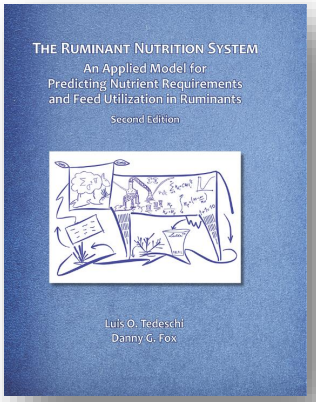
Efficiency of Use of Body Reserves: Energy

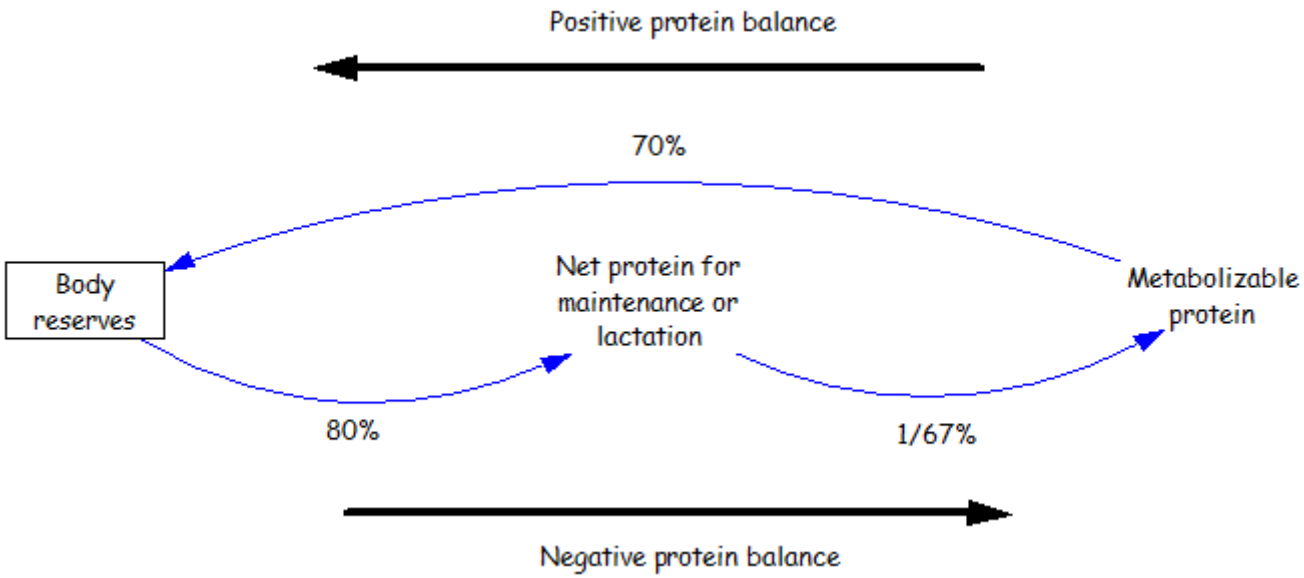




Efficiency of use of NEr for maintenance or milk production is about 77% to 84% (NASEM, 2016)

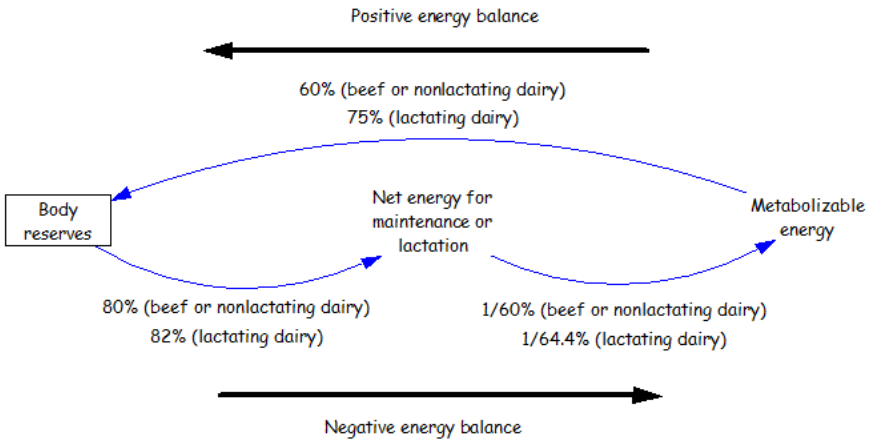
Efficiency of Use of Body Reserves: Protein





Scarce information regarding the efficiency with which mobilized AA are utilized for milk production or maintenance (Tedeschi and Fox, 2018)

Example BCS

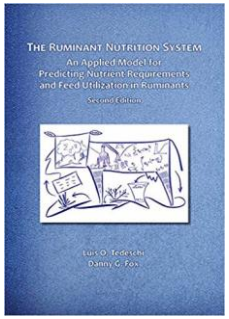


- A 600-kg lactating beef cow at BCS 5

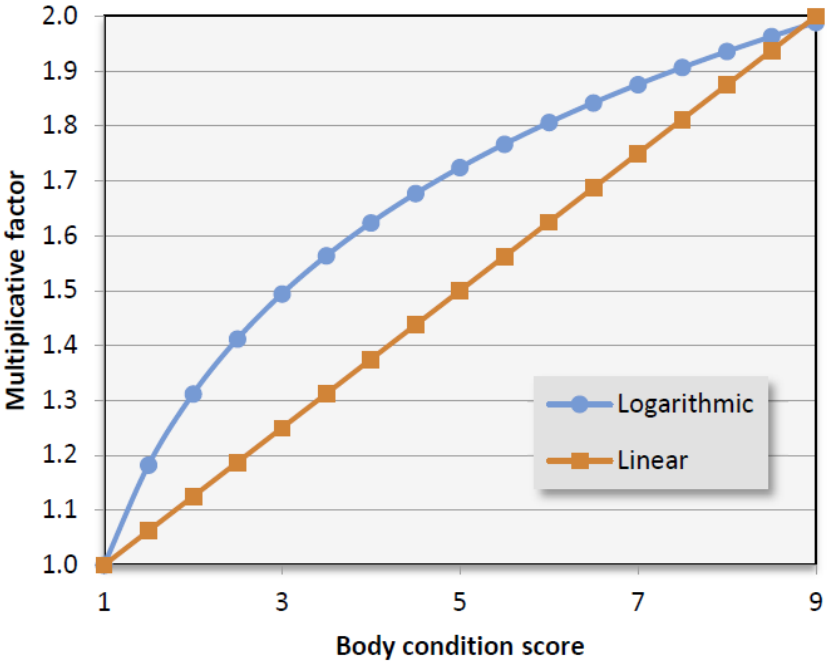
- Negative energy balance of 3 Mcal NEm/d
  Mobilizes 291 Mcal NEr (BCS 5 to 4) in 78 days
  291×0.8/3 = 78 days

- Positive energy balance of 3 Mcal NEm/d
  Requires 97 days to reach BCS 5 from BCS 4 (555 kg)
  291/3 = 97 days

Future Research on Body Reserves

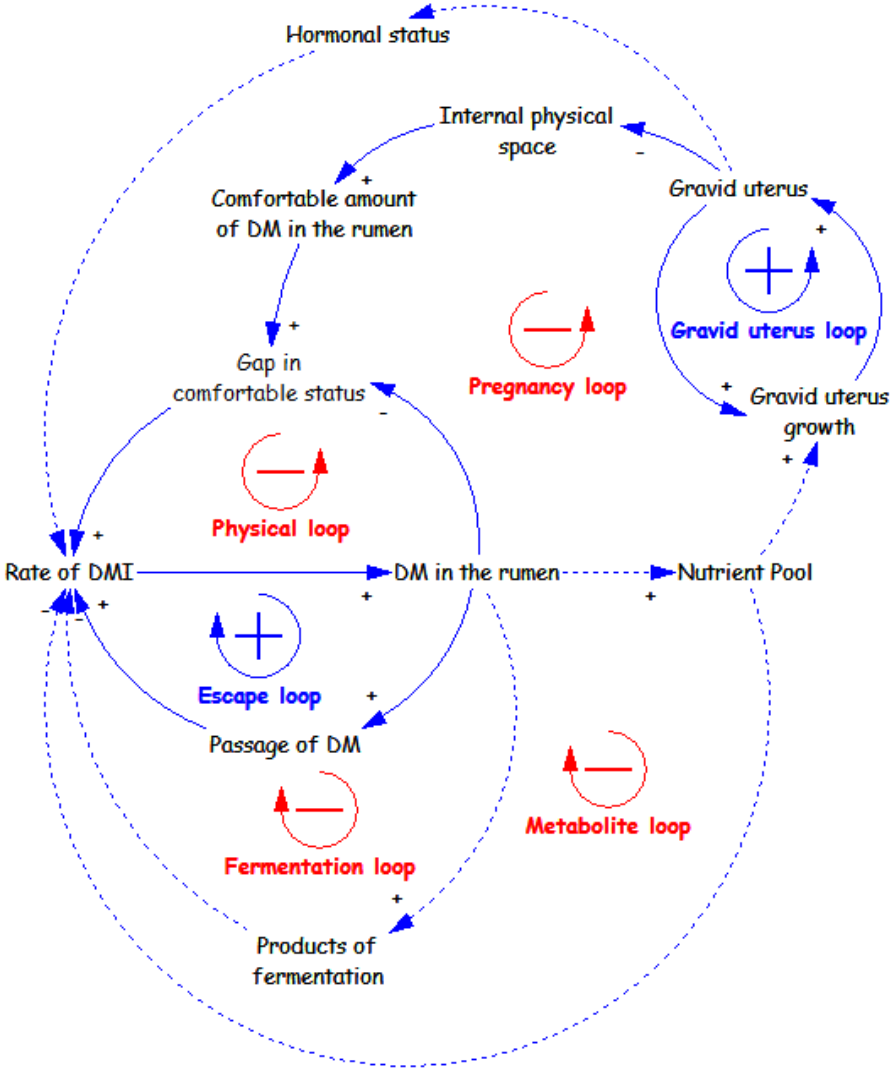


- The impact of nutritional environment and breeds
- A different approach for the BCS scaling system



Future Research on Body Reserves

- The impact of nutritional environment and breeds
- A different approach for the BCS scaling system
- The development of dynamic and mechanistic routines



Case Study 1

- 48 months of age
- 2nd lactation
- 380 kg with BCS 3 (1-9)
- *B. brizantha* without supplement

Texas A&M University
Department of Animal Science
230 Kleberg Animal and Food Science Center
College Station, TX 77843-2471
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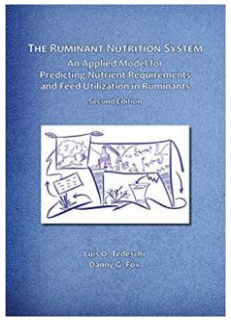
Solution
Level 2



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)	3.000	Body condition score (BCS2)	4.000
Empty body weight (EBW1), kg	310.4	Empty body weight (EBW2), kg	337.5
Body fat (BF1), %	9.98	Body fat (BF2), %	14.67
Body protein (BP1), %	19.21	Body protein (BP2), %	18.32
Body ash (BA1), %	5.79	Body ash (BA2), %	5.44
Body water (BWt1), %	65.01	Body water (BWt2), %	61.58
Body fat, kg	30.99	Body fat, kg	49.50
Body protein, kg	59.64	Body protein, kg	61.84
Body ash, kg	17.98	Body ash, kg	18.35
Body water, kg	201.83	Body water, kg	207.84
Body energy, Mcal	631.27	Body energy, Mcal	817.78

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

Net energy: BCS1 -> BCS2, Mcal	186.5
Net protein: BCS1 -> BCS2, g	2202.6
Dietary ME balance, Mcal/d	3.98
Dietary NE balance, Mcal/d	2.39
ME to NE efficiency, %	60.00
Time to gain 1 BCS, days	78
Empty weight gain, kg/d	0.347
Shrunk weight gain, kg/d	0.408
Full weight gain, kg/d	0.425

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	256.26	1.59	53.79	321.54	0.00
2.000	1.500	0.625	283.35	15.02	56.95	465.85	144.32
3.000	2.000	1.250	310.44	30.99	59.64	631.27	165.42
4.000	2.500	1.875	337.54	49.50	61.84	817.78	186.51
5.000	3.000	2.500	364.63	70.54	63.56	1025.40	207.61
6.000	3.500	3.125	391.72	94.12	64.80	1254.10	228.71
7.000	4.000	3.750	418.81	120.24	65.56	1503.91	249.80
8.000	4.500	4.375	445.90	148.89	65.83	1774.81	270.90
9.000	5.000	5.000	473.00	180.08	65.62	2066.81	292.00

- Energy Needed
  - BCS 3 to 4: 186.51 Mcal of NE
  - BCS 4 to 5: 207.61 Mcal of NE
  - Total = 394.12 Mcal of NE
- Efficiency of use: 60%
  - Total = 656.85 Mcal of ME
- Assuming this cow is at BCS 5 in 60 days:
  - Forage provides 3.98 Mcal of ME/d (238.80 Mcal in 60 days)
  - Supplement needs to provide 656.85 – 238.80 = 418.05 Mcal ME
  - Corn has 3.2 Mcal of ME/kg
  - **Hence, 2.18 kg of corn /d (?)**

Case Study 2

- 48 months of age
- 2nd lactation
- 420 kg with BCS 4 (1-9)
- *B. brizantha* without supplement

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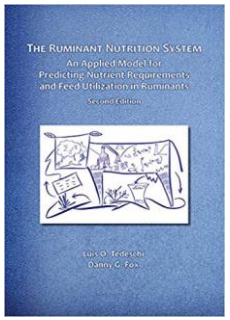
Solution
Level 2



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)	4.000	Body condition score (BCS2)	5.000
Empty body weight (EBW1), kg	343.1	Empty body weight (EBW2), kg	370.7
Body fat (BF1), %	14.67	Body fat (BF2), %	19.35
Body protein (BP1), %	18.32	Body protein (BP2), %	17.43
Body ash (BA1), %	5.44	Body ash (BA2), %	5.08
Body water (BWt1), %	61.58	Body water (BWt2), %	58.14
Body fat, kg	50.32	Body fat, kg	71.71
Body protein, kg	62.86	Body protein, kg	64.61
Body ash, kg	18.66	Body ash, kg	18.84
Body water, kg	211.28	Body water, kg	215.50
Body energy, Mcal	831.32	Body energy, Mcal	1042.37

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

Net energy: BCS1 -> BCS2, Mcal	211.0
Net protein: BCS1 -> BCS2, g	1749.2
Dietary ME balance, Mcal/d	4.69
Dietary NE balance, Mcal/d	2.82
ME to NE efficiency, %	60.00
Time to gain 1 BCS, days	75
Empty weight gain, kg/d	0.368
Shrunk weight gain, kg/d	0.432
Full weight gain, kg/d	0.450

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	260.50	1.62	54.68	326.86	0.00
2.000	1.500	0.625	288.04	15.27	57.89	473.57	146.71
3.000	2.000	1.250	315.58	31.51	60.62	641.72	168.15
4.000	2.500	1.875	343.12	50.32	62.86	831.32	189.60
5.000	3.000	2.500	370.66	71.71	64.61	1042.37	211.05
6.000	3.500	3.125	398.20	95.68	65.87	1274.86	232.49
7.000	4.000	3.750	425.74	122.23	66.64	1528.80	253.94
8.000	4.500	4.375	453.28	151.36	66.92	1804.18	275.39
9.000	5.000	5.000	480.82	183.06	66.71	2101.02	296.83

- Needed Energy
  - BCS 4 to 5: 211.05 Mcal of NE
- Efficiency of use: 60%
  - Total = 351.6 Mcal of ME
- Assuming this cow is at BCS 5 in 60 days:
  - Forage provides 4.69 Mcal of ME/d (281.4 Mcal in 60 days)
  - Supplement needs to provide 351.6 – 281.39 = 70.2 Mcal ME
  - Corn has 3.2 Mcal of ME/kg
  - **Hence, 0.36 kg of corn /d (!)**

Acknowledgements

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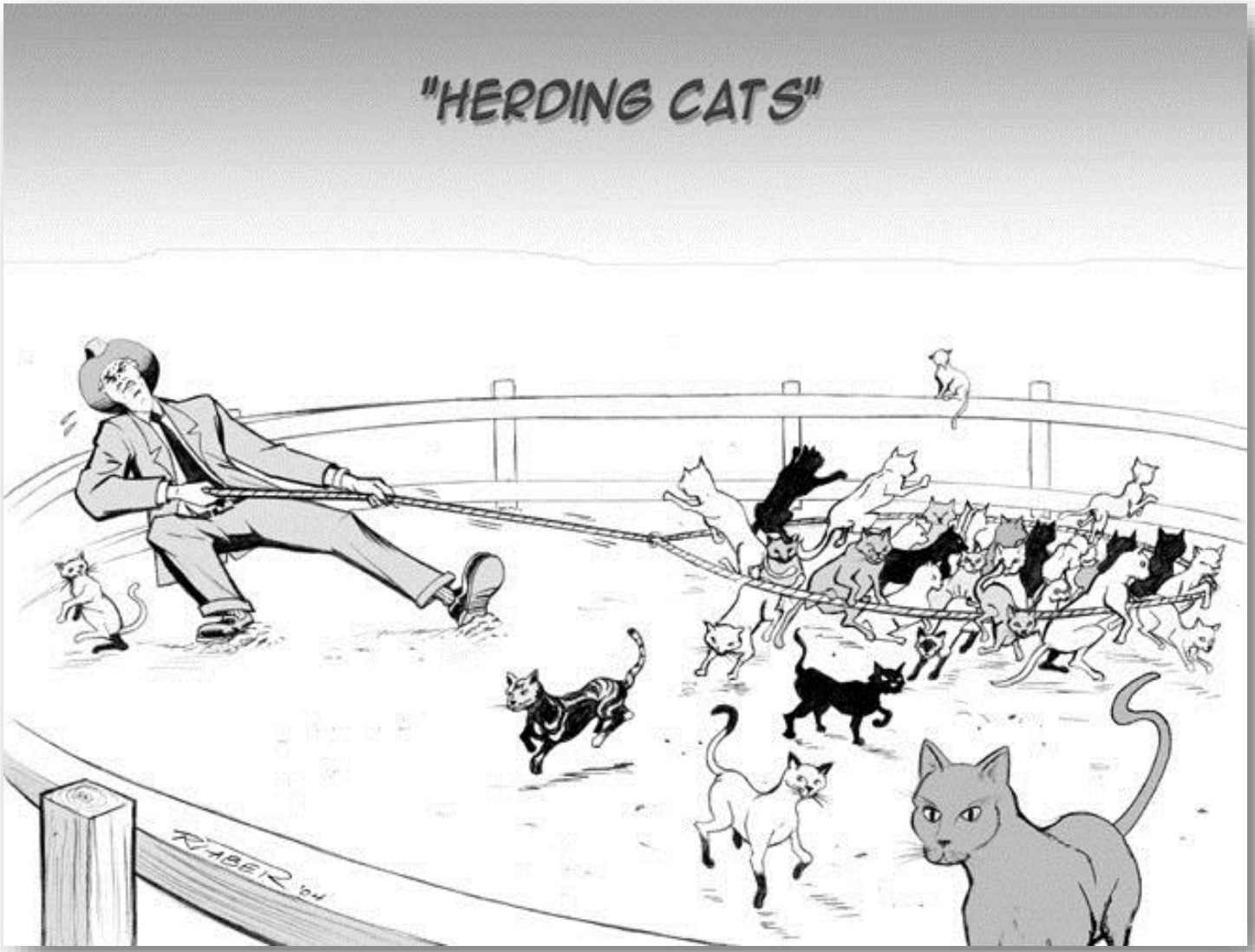
"Justin"



Thank you