Development and Evaluation of a Model to Assist Individual Cattle Management

Luis O. Tedeschi* and Dan G. Fox#

* Texas A&M University
# Cornell University

Mathematical Models

- Cornell Net Carbohydrate and Protein System - CNCPS
  - Nutritional model that simulates ruminal fermentation and animal requirement
- Cornell/Cattle Value Discovery System - CVDS
  - Growing and finishing cattle
  - Beef cow and calf systems

Introduction

- Individual management and marketing
  - Predict the rate and cost of gain to market individual animals at their most profitable endpoint
  - Determine days on feed based on animal characteristics and diet information
  - Reduce variability within a pen
- Genetic selection for feed efficiency

Growth Models

- Different objectives of growth models:
  - Predict retained energy and growth rate
  - Use growth rates and animal characteristics
  - Use DNA accretion curves and protein to DNA ratio to compute potential growth
  - Compute growth and body composition using simple biochemistry pathways and physiological mechanisms

Objectives of the CVDS

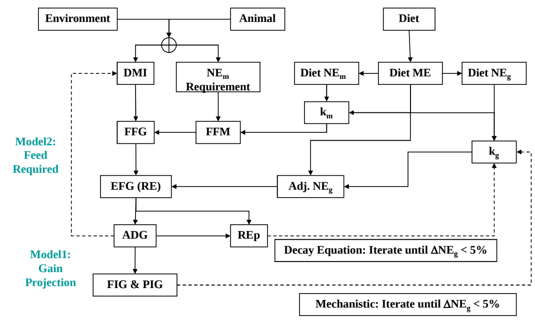
- Development and evaluation of a dynamic iterative mechanistic (DIM) growth model
- Based on known relationship of energy for growth, body and gain compositions, and feed intake
- Dynamic model (day step)

CVDS for Feedlot Operations

The DIM Model Options

- Projection
  - Predicts DMI and/or ADG
  - Different end points (Select, low Choice)
  - Requires animal, diet, and environment information
- Feed required
  - Predicts dry matter required (DMR) for a known gain
  - Requires animal, diet, and environment information
  - Four different methods of calculation
    - Mean body weight
    - Dynamic growth with and without adjustment for composition of gain (decay and mechanistic)

Flowchart of the DIM model



Equivalent Body Weight

- EqBW = (FBW/SRW)×SBW
- FBW is BW @ target composition (e.g. 28% EBF)
- Estimating FBW:
  - During growth: frame size, ultrasound, or visual appraisal
  - After harvest: HCW, BF, REA, and QG (Guiroy et al. 2001)

Relationship EBF x QG

N	QG	EBF, %	Score	%UAtbl
45	Std	21.1[a]	5.3	40
470	Select	26.2[b]	5.6	13
461	-Choice	28.6[c]	5.8	8
206	Choice	29.9[d]	6.2	0
90	+Choice	31.0[de]	--	--
51	-Prime	31.9[e]	--	--
32	Prime	32.5[e]	--	--

Guiroy et al. (2001)

Predicting Gain

- Garrett (1980)
  - $k_g = (0.0122\times ME^3 - 0.174\times ME^2 + 1.42\times ME - 1.65)/ME$
- Does not account for effect of gain composition on partial efficiency for gain…

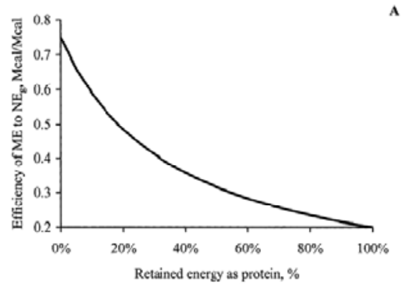
Predicting Gain

- ME for fat deposition has a higher efficiency than for protein
- Using a mean value for k_g:
  - ↑ proportion of protein in the gain ➔ overestimates energy in the gain
- Therefore, the effect of gain composition on k_g has to be accounted for

Adjusting k_g for gain composition

- Retained energy partitioning:
  - $ME = RE_{Fat}/k_{Fat} + RE_{Prot}/k_{Prot} = RE/k_g$
  - $REp = RE_{Prot}/RE$
  - $RE_{Fat} = (1 – REp) \times RE$
- Solving these equations:
  - $k_g = (k_{Fat} \times k_{Prot})/(k_{Prot} + REp \times (k_{Fat} – k_{Prot}))$
- Assuming k_{Fat} is 75% and k_{Prot} is 20%:
  - $k_g = 3/(4 + 11 \times REp)$

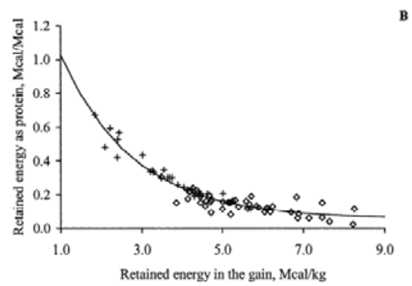
Partial Efficiency of ME to NEg



How REp is computed?

- Two options:
  - A decay equation:
    - $REp = 0.0554 + 1.6939 \times e^{(-0.5573 \times RE/EWG)}$
  - A mechanistic approach:
    - Compute PIG from RE and EWG (NRC, 2000)
    - Then compute the REp

Decay Equation

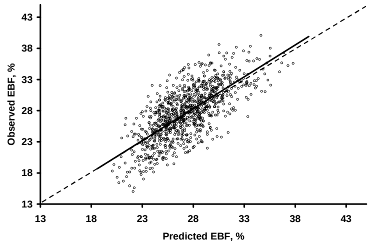


Model Application

Summary of Inputs

GROUP	INDIVIDUAL
Pen DMI	Breed, sex, implants…
Ration formula	Initial and final SBW
Ingredient analysis - DM, NDF, CP, Lignin…	Days on feed
Pen size	ADG
Pen environment	Carcass traits - HCW, BF, REA, QG

Predicting Empty Body Fat



Guiroy et al. (2001)

Dynamic Model Steps

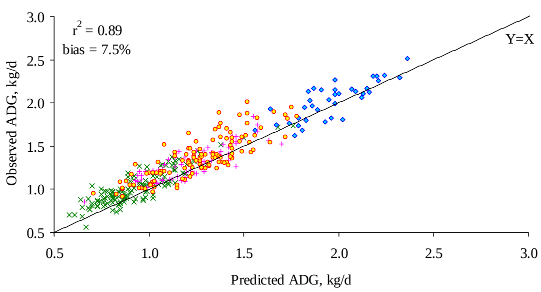
1. Predict daily DMI (based on current SBW, diet energy, environmental conditions, and 28% EBF BW)
2. Predict feed required for maintenance (FFM)
   - FFM = NEm required / diet NEm
3. Predict NE available for gain (NEFG)
   - NEFG = (DMI – FFM) × diet NEg
4. Predict Shrunk Weight Gain (SWG) from NEFG
5. Compute the new SBW (initial SBW + SWG)
6. Repeat above steps for each additional day to 28% EBF BW
7. Adjust predicted DMI until actual and predicted ADG match

Model Evaluation

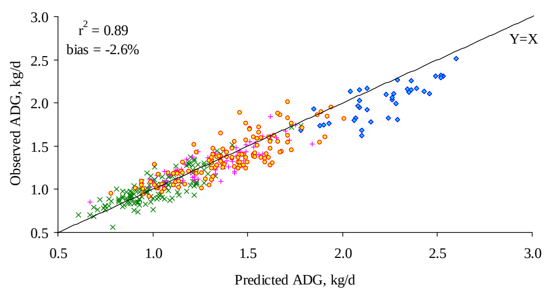
Evaluation Database

- Four studies
- 362 steers
  - 240 steers in individual stalls
  - 122 steers in Calan Broadbrent pen
- Four levels of dietary ME
- Two housing types
- Nine groups were created based on housing, dietary ME, and study

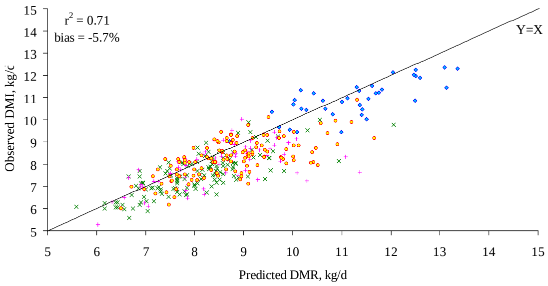
Predicting ADG without kg adjustment



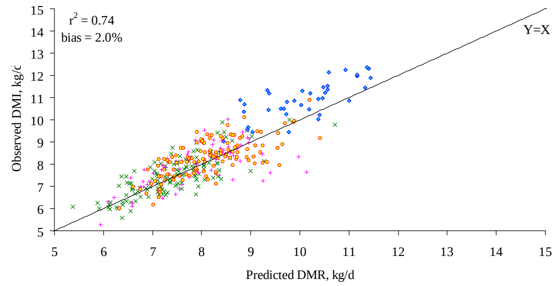
Predicting ADG with kg adjustment



Predicting DMR without kg adjustment



Predicting DMR with kg adjustment

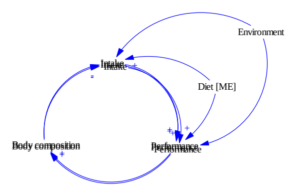


Summary

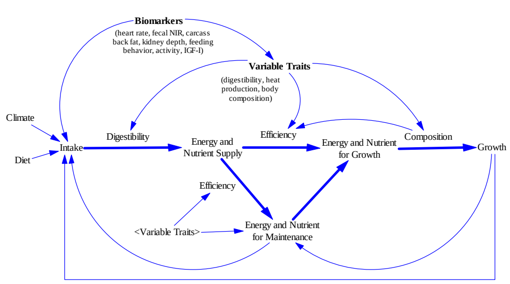
- Use post-weaning growth model to compute
  - ADG and SBW when DMI is known
  - DMR and EBF when ADG is known
- Applications of the model
  - From a group-fed animals, we can estimate their probable individual intake to:
    - Genetically select animals for high feed efficiency
    - Feed allocation when mixed ownership
    - Predict days on feed required to maximize the profit

Next Generation of Models

- Improving individual DMI predictions
  - Combination of various predictions



How to account for individuality?



Tedeschi et al. (unpublished)

Summary

- Use post-weaning growth model to compute
  - ADG and SBW when DMI is known
  - DMR and EBF when ADG is known
- Applications of the model
  - From a group-fed animals, we can estimate their probable individual intake to:
    - Genetically select animals for high feed efficiency
    - Feed allocation when mixed ownership

CVDS for

Cow/Calf Operations

Model application

- Identify the best combination of beef cow mature size and milk potential for given resource
- Strategic supplementation to enhance profitability (e.g. weaning weight)
- Provide inputs for genetic selection for cow efficiency

Current situation of US?

- Beef cow production is still perceived as an inefficient process…
  - About 50% of the total energy in beef production is used by the cow
  - It is related to the energy expenditure for maintenance of the cow

Improving the situation?

- Reproduction indexes
  - Calving frequency, age at 1st calving, calving interval
- Applying nutrition concepts
  - Strategic supplementation, forage mgt
- Genetic selection
  - Bull selection, crossbreeding

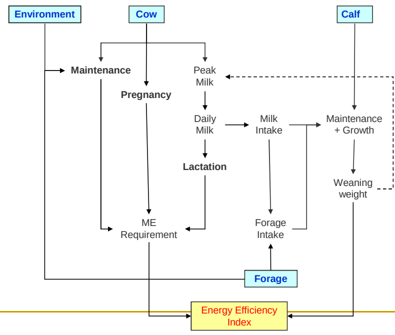
Selecting efficient animals

- Ideally, efficient beef cows use less resource to obtain the same outcome in a sustainable environment
- Indexes are based on retaining beef cows that routinely produce a weaned calf with fewer inputs
- Evaluation of biological efficiency must be expressed relative to some measure of input (e.g. energy/output) (Jenkins and Ferrell, 2002)

Model description

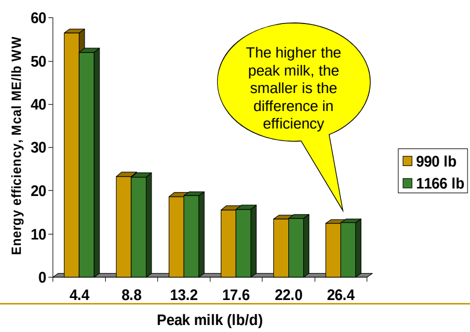
- Model computes energy requirements for maintenance, pregnancy, lactation, and tissue mobilization
- Computes an energy efficiency index (EEI) as the ratio of required ME to calf weaning weight ➔ energy/output
- Provides information to rank efficient cows

Flowchart of the Model



Model Evaluation

Energy efficiency at 6 peak milk levels for 2 cow sizes



How can we apply this model to identify efficient cows?

Identification approaches

- Iterate peak milk
  - Calf weaning weight
  - Cow body weight
  - Forage quality (ME)
- Risk analysis
  - Mean, variance, and distribution of
    - Cow body weight
    - Peak milk
    - Forage quality (ME)

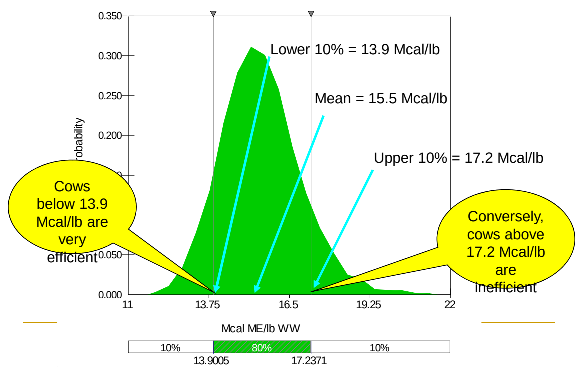
Iterative Approach

Bell Ranch summary

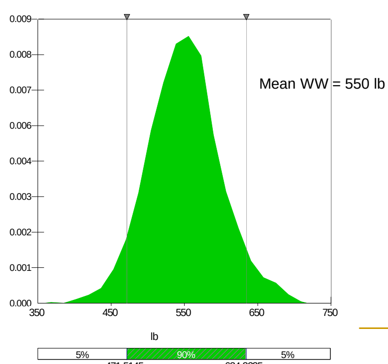
- There was a small correlation between frame size and/or age with EEI
- Model correctly identified cows that were judged to be efficient by the management team
- Model was able to accurately identify the cows that had been deemed inefficient and culled

Risk Analysis Approach

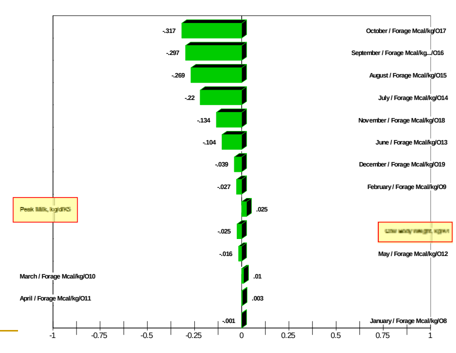
Distribution of Cow Efficiency



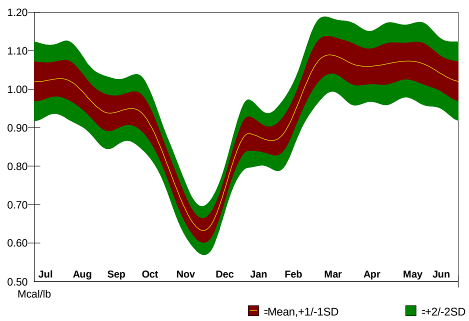
Distribution of Weaning Weight



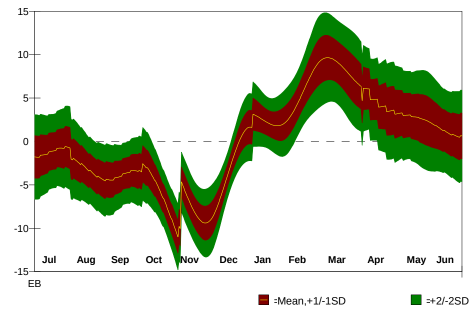
Sensitivity Analysis of Efficiency



Forage Energy Content



Energy Balance



Summary

- Optimization of herd production
  - Simulation of energy balance and nadir
  - Supplementation strategies
- Based on specific farm variations
- Selection of cows based on energy efficiency, e.g. Mcal ME/WW, that are most efficient on specific farms