Partitioning of Growth of Pigs into Protein and Lipid

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Otherwise Known As

what retired faculty do.

Background

- Indiana, corn, pigs
- Purdue, Cornell, Guelph
- Mixed models since 1950
- Random regression models, 1994, 4th order Legendre polynomials
- Statistical models/Animal Breeding

1970 Ithaca

Henderson

- MSc in Nutrition, 1935, Iowa St
- PhD in Animal Breeding, started in 1946
- Hired as Associate Prof at Cornell, 1948
- Full Professor in 1951.
- National Academy of Sciences (9 others)

Since Retirement

- History of Genetic Evaluation Methods in Dairy Cattle
- SAC for Genome Canada project on PRRS in swine
- Invited paper to WCGALP in Vancouver (on PRRS)
- Fiction novel (The Ferrari Affair)
- Meat and dairy sheep genetic evaluations (CEPOQ)
- Project in Atlantic salmon (sea lice) - genomics
- ELARES open journal, free, instant

Intro

Knowing the protein and lipid deposition rates of individual pigs would allow changing the feed ingredients during the course of the test station growth period, and thereby save money and keep pigs from getting too fat.

Test Periods

- 60 to 200 days of age
- Up to 120 kg BWT (or 140 kg)
- 3 and more weights (7 would be better)
- Daily feed intake, visits to feeders, duration at feeder.
- 1-3 backfat scans, towards the end.

References

Bridges, T. C. , Turner, L. W., Smith, E. M., Stahly, T. S., Loewer, O. J. 1986. A mathematical procedure for estimating animal growth and body composition. Trans. ASAE 29:1342.

Doeschl-Wilson, A. B. , Knap, P. W., Kinghorn, B. P., Van der Steen, H. A. M. 2007. Using mechanistic animal growth models to estimate genetic parameters of biological traits. Animal:1:489=499.

Knap, P. W. , Roehe, R., Kolstad, K., Pomar, C., Luiting, P. 2003. Characterization of pig genotypes for growth modeling. J. Anim. Sci. 81:E187-E195.

NRC 2012. Models for Estimating Nutrient Requirements of Pigs. Eleventh Revised Edition.

Refs

Schinkel, A. P. , de Lange, C. F. M. 1996. Characterization of growth parameters needed as inputs for pig growth models. J. Anim. Sci. 74:2021-2036.

Schinkel, A. P. , Einstein, M. E., Jungst, S., Booher, C., Newman, S. 2009. Evaluation of different mixed model nonlinear functions to describe the body weight growth of pigs of different sire and dam lines. The Professional Scientist 25:307-324.

Schaeffer, L. R. , de Lange, C. F. M. 2013. Method to partition growth of pigs on test into protein and lipid contributions. Elares:52.

Data

- 20,636 pigs with FI data and with pedigree info.
- Three breeds (YO, LA, DU).
- 2004 to 2012.
- Birth, start of test, end of test - minimum wts.
- Feed Intake: 14 consecutive days or more.

Procedure

1. Estimate daily body weights for each day
2. Estimate accumulated feed intake curve by day
3. Estimate daily protein and lipid deposition

Daily Body Weights

$$BWT_t = 1.5 + A \cdot [1.0 - \exp(-\exp(B) \cdot (t^C))]$$

- t = age in days.
- Birthweight of 1.5 kg assumed, unless known.
- Weights should be continuously increasing.
- A, B, and C estimated for each pig, then daily weights calculated over test period. (Differential Evolutionary Algorithms)

What are DE Algorithms?

- Start with a random group of 10 possible solutions.
- Define your Fitness function.
- Propose a challenger solution using Mutation and Recombination.
- If challenger has better Fitness than parent in group of 10, then replace parent.
- Iterate until group of 10 are identical.

Starting Solution

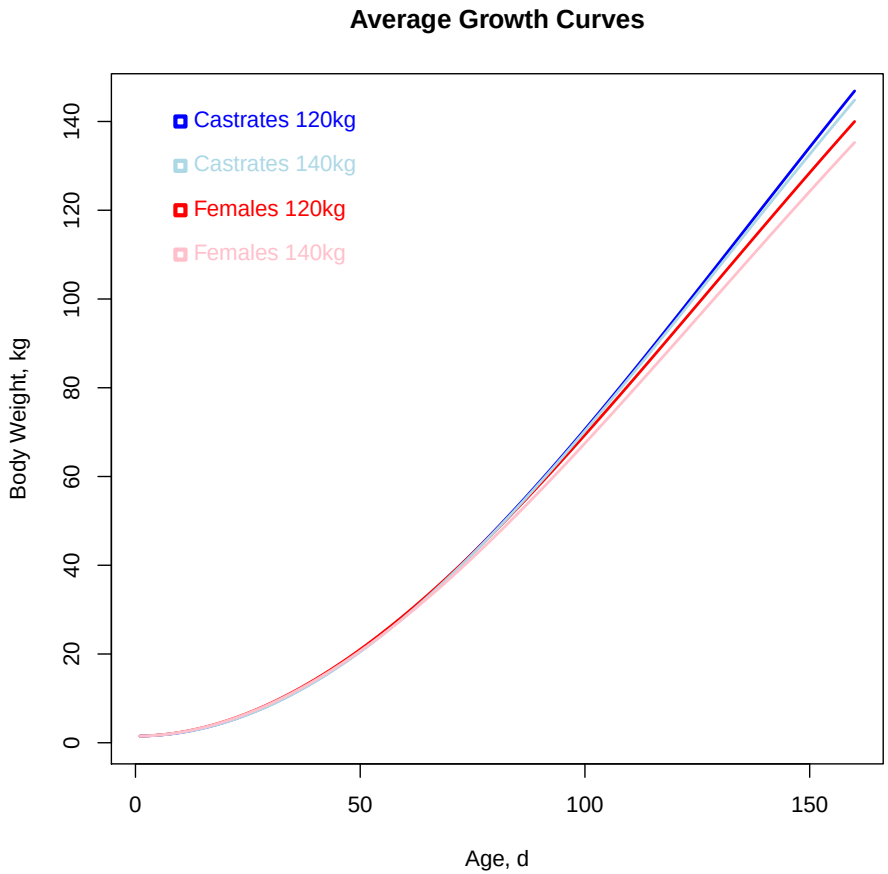
Starting solutions for growth curve of a pig.

Set	A	B	C	Fitness
1	268.5	-11.8	1.72	-1384.
2	272.3	-12.8	2.67	-1309.
3	268.7	-10.8	1.69	-1212.
4	263.6	-15.8	2.62	-1429.
5	259.8	-8.8	1.76	-1851.
6	264.9	-7.7	1.67	-1408.
7	266.1	-11.7	1.63	-1457.
8	270.4	-13.7	1.71	-1630.
9	259.1	-14.8	2.70	-1746.
10	261.0	-9.5	1.64	-1587.

Weight Curve Values

Gender	A	B	C
Castrated	270.4	-10.48923	2.01149
Females	253.6	-10.12786	1.93885

Graphs


Average Growth Curves
Castrates 120kg
Castrates 140kg
Females 120kg
Females 140kg
Body Weight, kg
0
20
40
60
80
100
120
140
0
50
100
150
Age, d

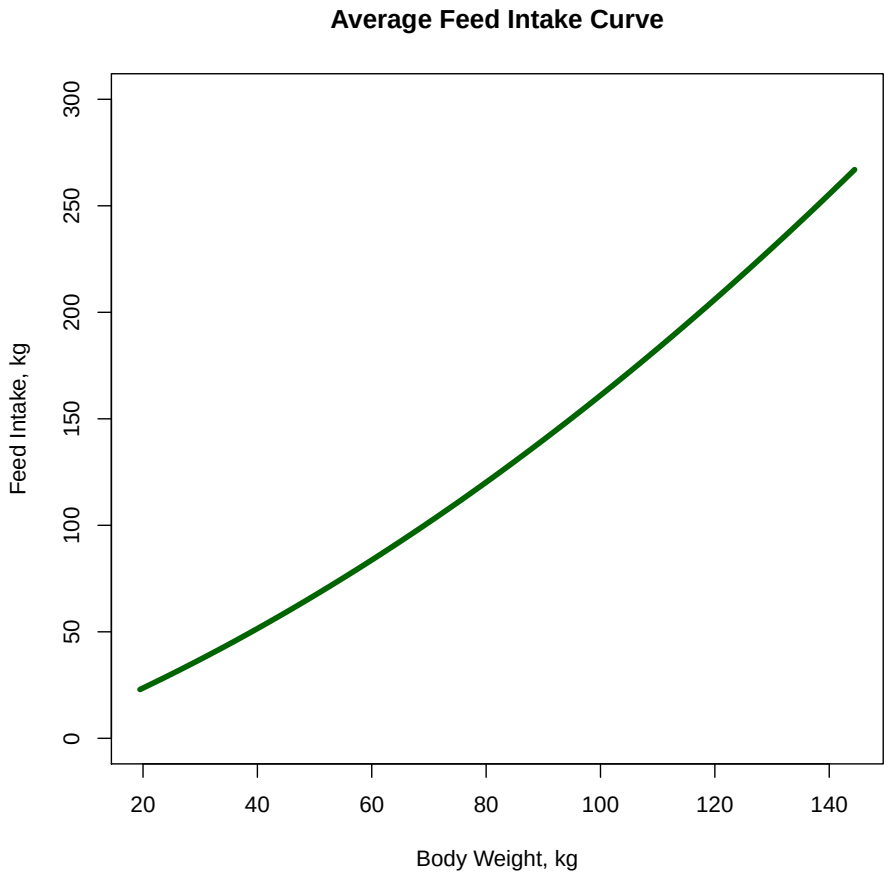
Accumulated Feed Intake Curve

$$acfi_t = b_0 + b_1 \cdot BWT_t + b_2 \cdot (BWT_t)^2$$

- $BWT = WT/(MaxWT)$ to give numbers from 0 to 1.
- *acfi* scaled to make all of them a positive number.
- Simple linear regression.

Gender	b_0	b_1	b_2
Castrated	-49.78	213.34	141.26
Females	-50.74	223.17	121.51

ACFI Curve


Average Feed Intake Curve
Feed Intake, kg
0
50
100
150
200
250
300
20
40
60
80
100
120
140
Body Weight, kg

Total Protein and Lipids

$$
\begin{aligned}
TL_t &= c_0 + c_1 \cdot acfi_t \\
TP_t &= d_0 + d_1 \cdot BWT_t
\end{aligned}
$$

and NRC formulas are 100% correct

DE Procedure I

1. Starting values for c_0, c_1, d_0, d_1.
2. Calculate TL and TP for all days on test.
3. Convert to daily lipid and protein values.
4. Determine $PDmax$.
5. Water content,

$$h2o = 4.322 + 0.0044 \cdot PDmax$$

6. Empty body weight

$$eBW1_t = BWT_t - 0.3043 \cdot (BWT_t)^{0.6}$$

and

$$eBW2_t = (1.189 \cdot TP_t + TL_t) + h2o \cdot (TP_t)^{0.855}$$

DE Procedure II

7. $$err_t \;=\; eBW1_t \;-\; eBW2_t$$

   and

   $$cfit \;=\; cfit - (err_t)^2$$

   over all t.

8. Metabolizable energy intake, (total end of test)

   $$MEi \;=\; 3250 \cdot \sum (DFI)_t$$

9. Maintenance energy is

   $$MEm \;=\; NRG \cdot \sum (BWT)_t^{0.6}$$

10. Difference is

    $$(MEi - MEm) \;=\; 12.5 \cdot (TL_{end} - TL_{60}) + 10.6 \cdot (TP_{end} - TP_{60}).$$

DE Procedure III

11. NRG, energy requirement of pig is

$$NRG = \frac{(MEi - 12.5 \cdot (TL_{end} - TL_{60}) - 10.6 \cdot (TP_{end} - TP_{60}}{(\sum (BWT)^{0.6})}$$

12. Lipid to Protein Ratio

$$LPR = \frac{TL_{end}}{TP_{end}}$$

13. Predicted backfat

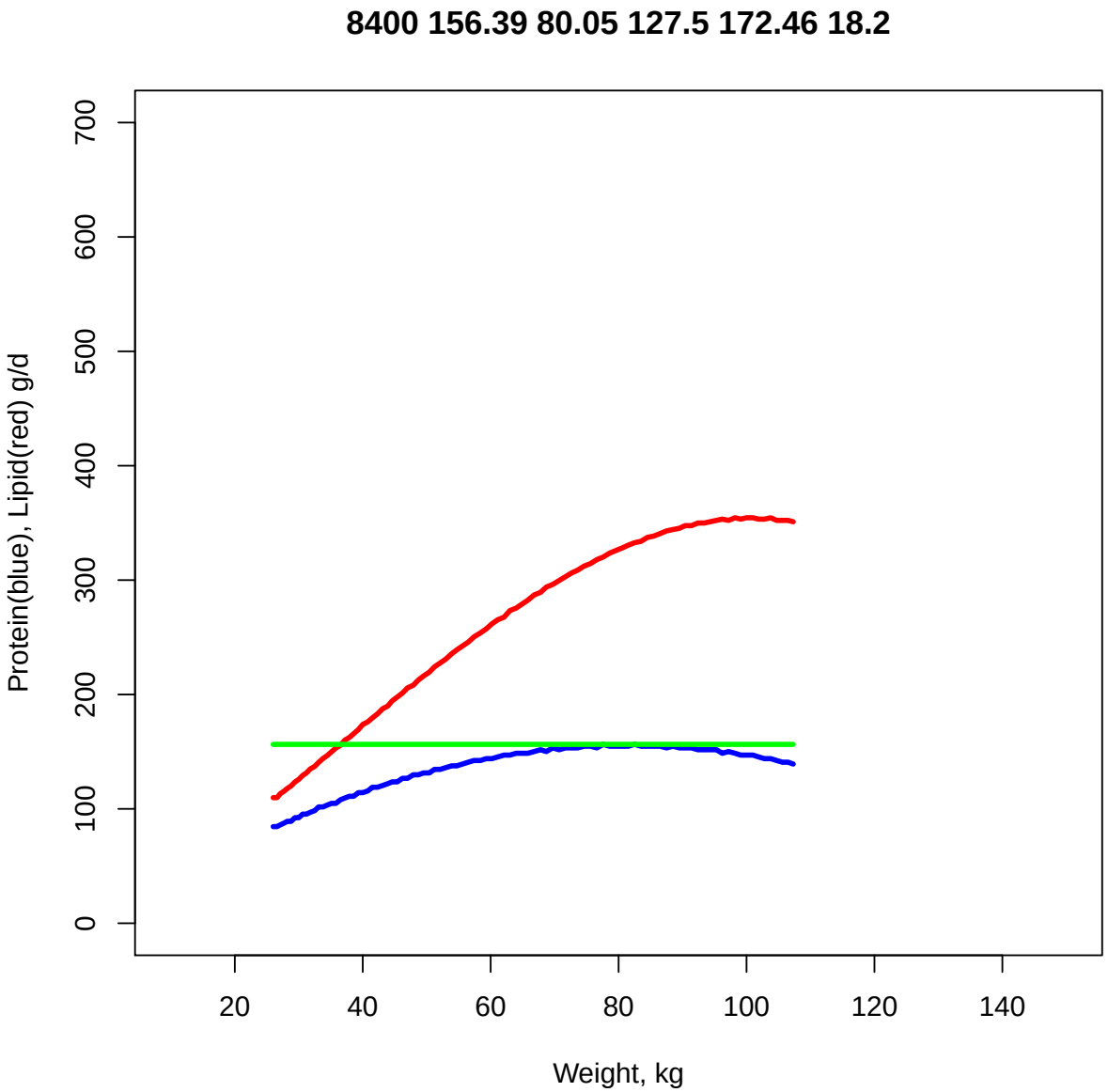
$$pBF = -5.0 + 12.3 \cdot LPR + 0.13 \cdot TP$$

14. Difference between pBF and actual BF minimized too.

Protein, Lipid Functions

Gender	c_0	c_1	d_0	d_1
Castrated	0.773	0.126	0.561	0.150
Females	0.655	0.117	0.377	0.158

Example Animal



Heavy Pigs Project

Item	Castrated		Females	
End Weight	$120kg$	$140kg$	$120kg$	$140kg$
ADG(60-130d)	1.02	1.02	0.96	0.96
Gain/Feed	0.41	0.41	0.43	0.43
PDmax	174.7	174.7	170.2	170.0
Wt at PDmax	97.3	97.3	93.3	93.3
NRG	198.9	198.4	184.9	184.9
L/P	1.75	1.75	1.51	1.51
P gain	10.8	10.8	10.8	10.7
L gain	22.1	22.2	18.8	18.8

The End

Questions, Comments
What more can or should be done?
www.aps.uoguelph.ca/~lrs/COWsite/