Towards an improved estimation of the biological components of residual feed intake in growing cattle

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Outline

Motivation

Opening the black box

Objectives

Data available

Preliminary evidences

Phenotypic Models (PM)

Results PM

Genetic Models (GM)

Results GM

Conclusions

Motivation

Feed is expensive !

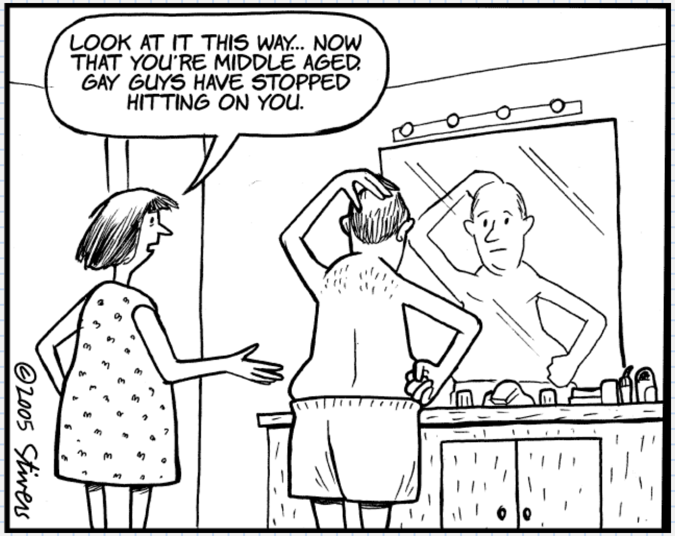
Environmental footprint …

Feed efficiency

Motivation

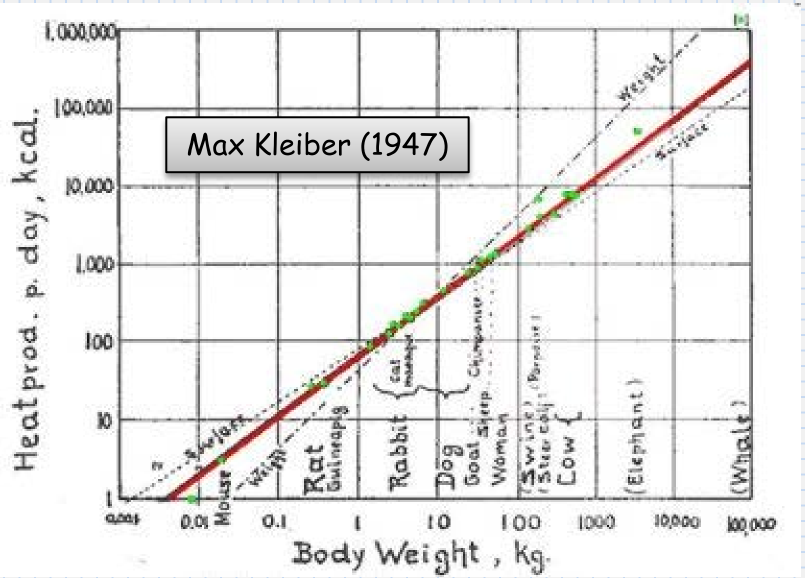
Many definitions…

…ratio & residual traits



Motivation

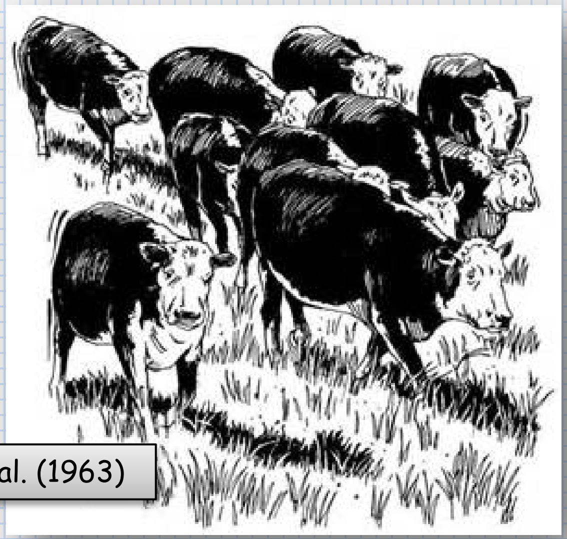
Feed conversion ratio
is easy and simple, but…


Max Kleiber (1947)

Motivation

Residual feed intake
has interesting properties, but…

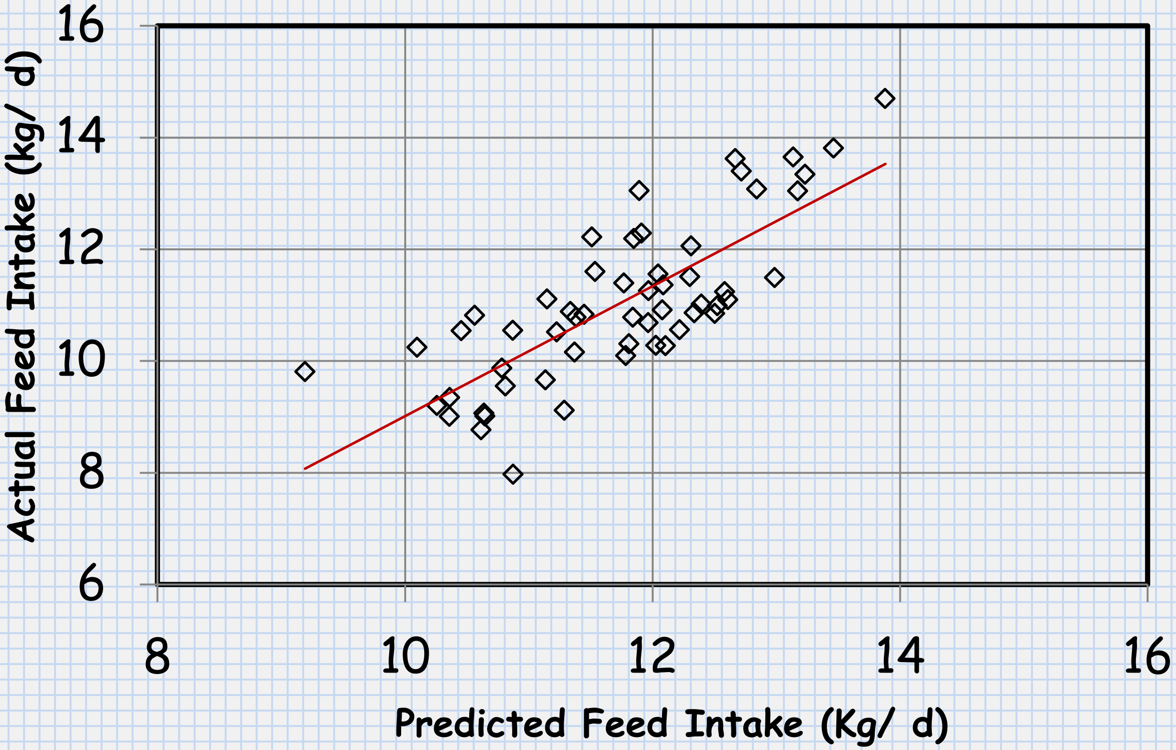
Byerly (1941)



Koch et al. (1963)

Opening the black box

$$FI_i = \mu + b_0 \cdot BW_i^{0.75} + b_1 \cdot ADG_i + e_i$$



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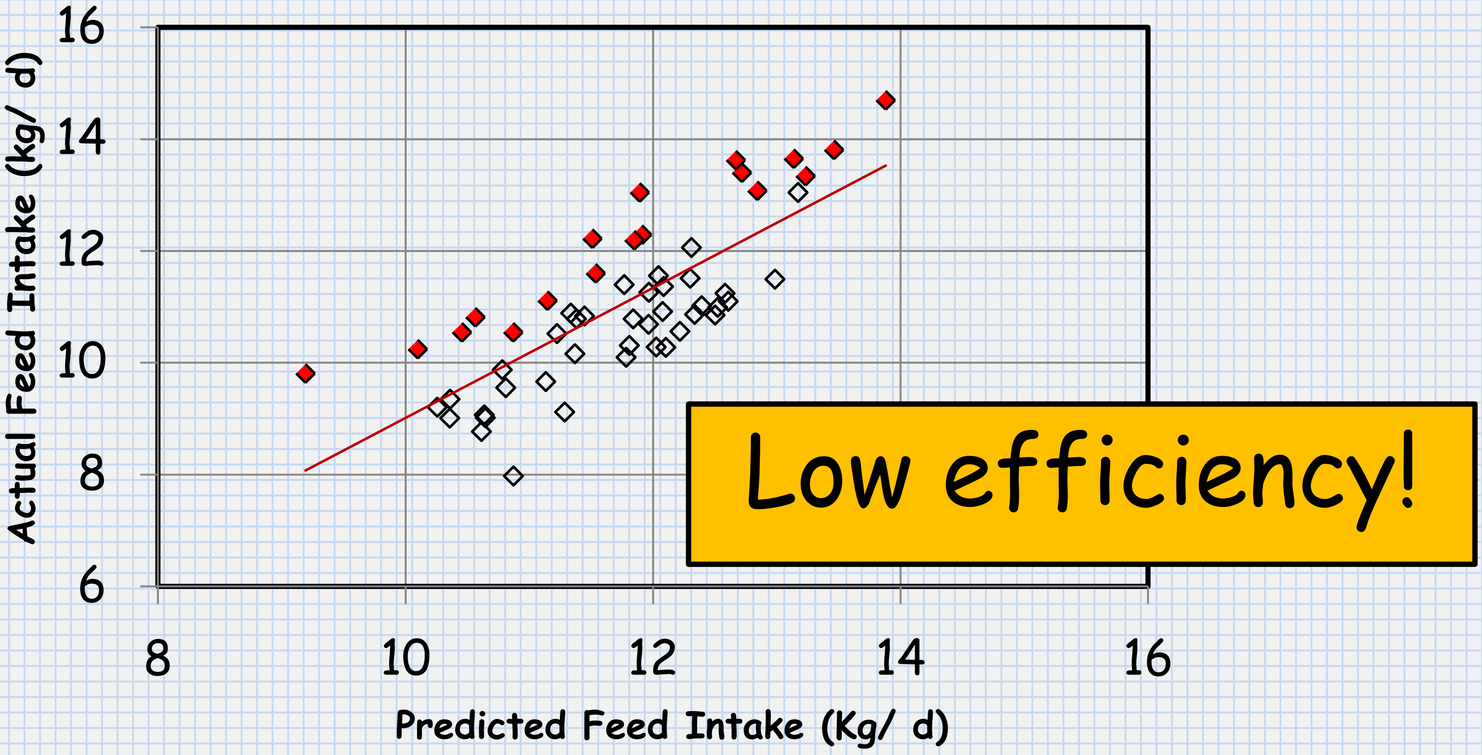

Low efficiency!

Opening the black box

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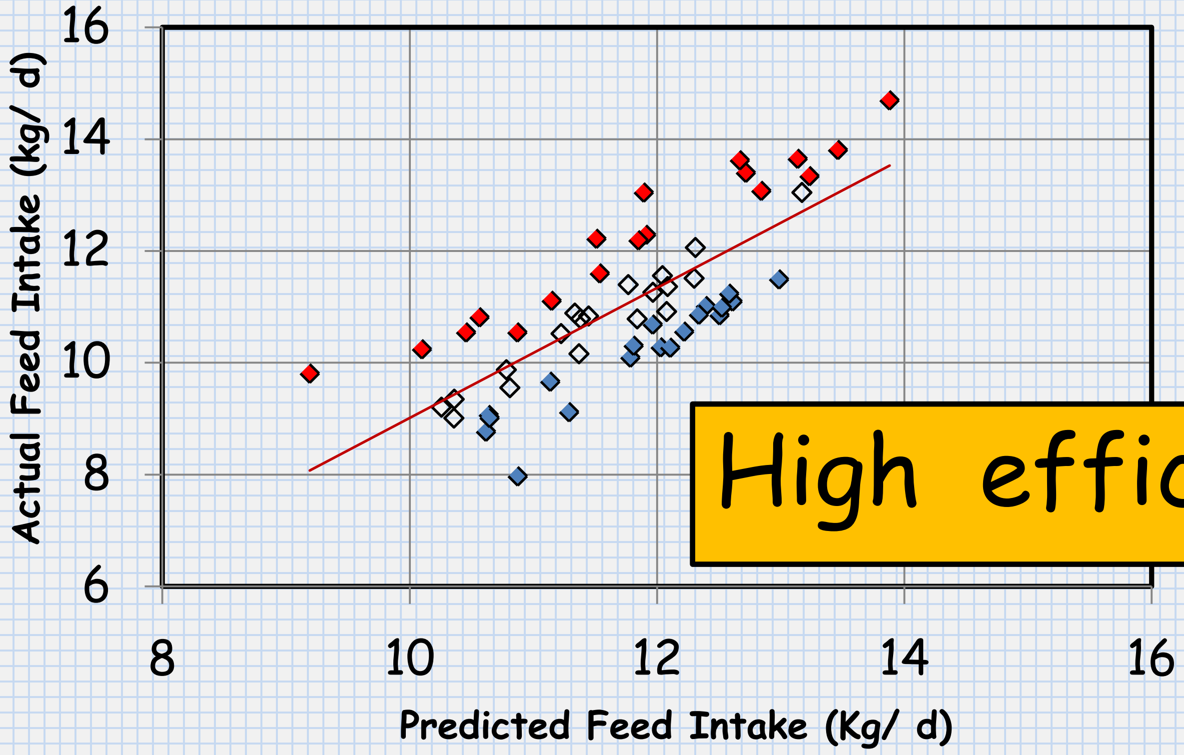
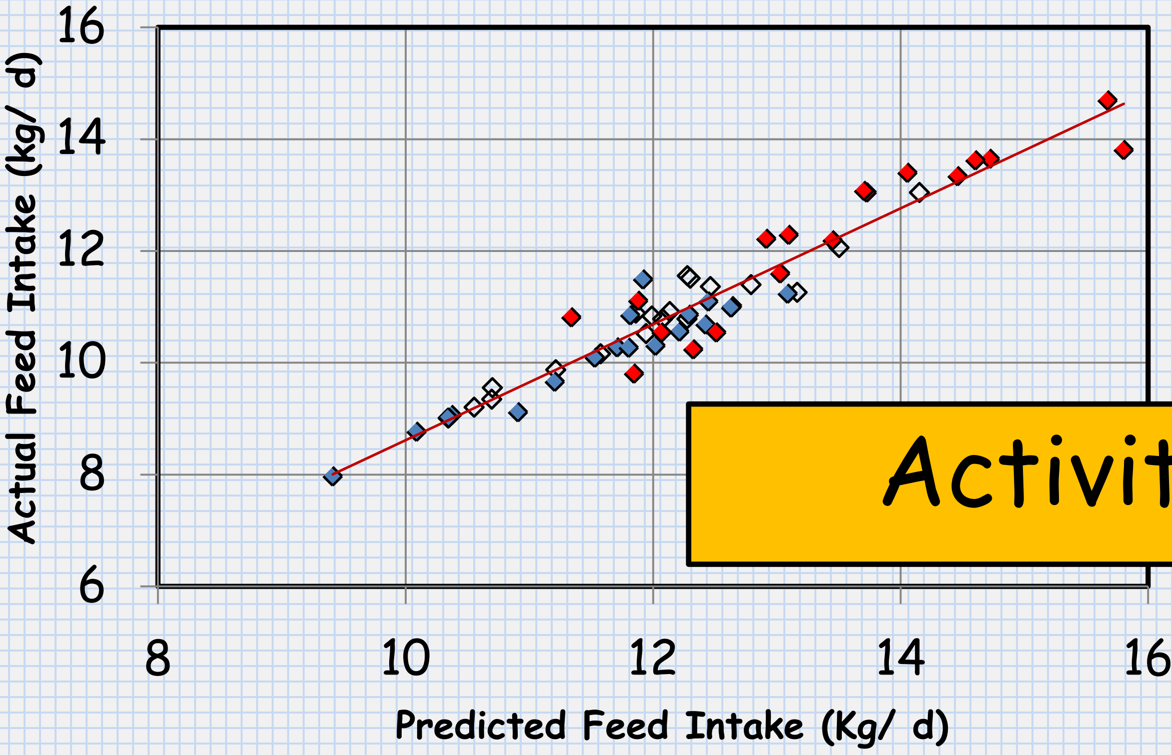


High efficiency!

Opening the black box

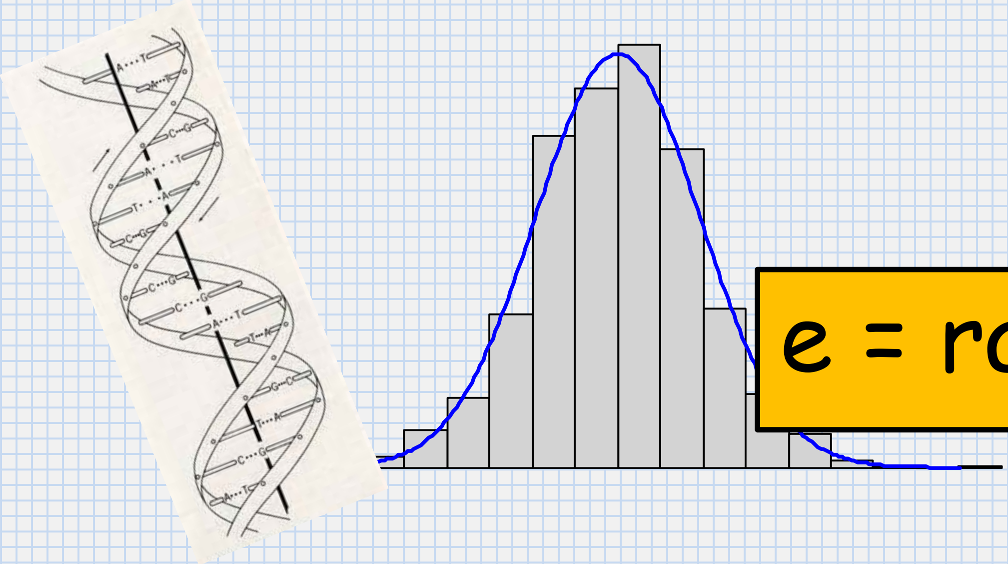
$$FI_i = \mu + b_0 \cdot BW_i^{0.75} + b_1 \cdot ADG_i + b_2 \cdot FAT_i + e_i$$



Activity?

Opening the black box

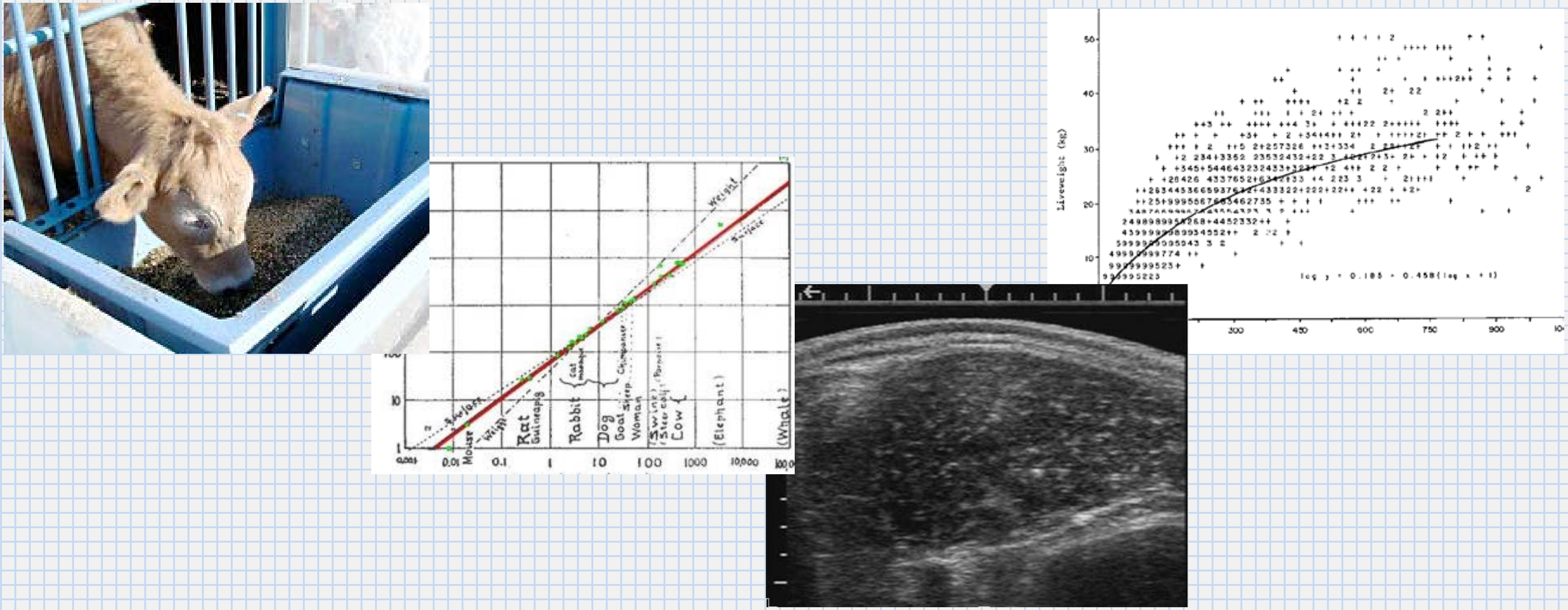
Correct model &
variables are error free



e = random noise

Objectives

Precise estimate feed intake from limited information

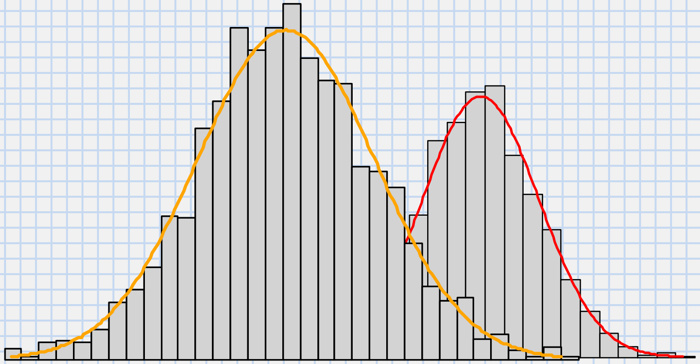


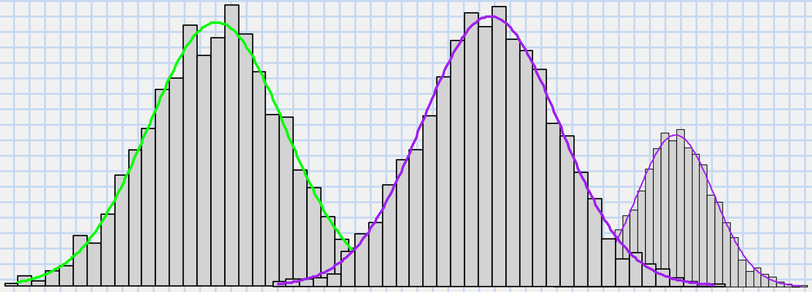
Objectives

Residuals are random noise

$$FI_i = \mu + (b_0 + b_{0a})\cdot BW_i^{0.75} + (b_1 + b_{1a})\cdot ADG_i + e_i$$

$$FI_i = \mu + b_0\cdot BW_i^{0.75} + b_1\cdot ADG_i + e_i$$





Data available

1,963 bulls

69 Contemporaneous Group

314 d old & 456 kg

70 d on test

CI, BW* and FAT

*MTW & ADG

Preliminary evidences

Table 1 - Summary statistics by breeds

Traits	AN n = 183	CH n = 485	HE n = 100	LI n = 821	SI n = 374
CI (kg/ d)	11.71^{c}	11.38^{b}	11.56^{bc}	10.19^{a}	12.24^{d}
MTW ($kg^{0.75}$)	108.4^{a}	117.2^{b}	107.8^{a}	108.3^{a}	118.1^{b}
ADG (kg/ d)	1.63^{a}	1.75^{b}	1.74^{b}	1.60^{a}	1.74^{b}
FAT (cm)	0.552^{c}	0.256^{a}	0.559^{c}	0.249^{a}	0.316^{b}
RFI (kg/ d)	0.332^{c}	-0.124^{ab}	0.025^{b}	-0.205^{a}	0.443^{c}

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Phenotypic Models (PM)

Basic models

[P1] $CI_i = b_0 \cdot MTW_i + e_i$

[P2] $CI_i = b_0 \cdot MTW_i + b_1 \cdot ADG_i + e_i$

[P3] $CI_i = b_0 \cdot MTW_i + b_1 \cdot ADG_i + b_2 \cdot FAT_i + e_i$

Phenotypic Models (PM)

No great expectations

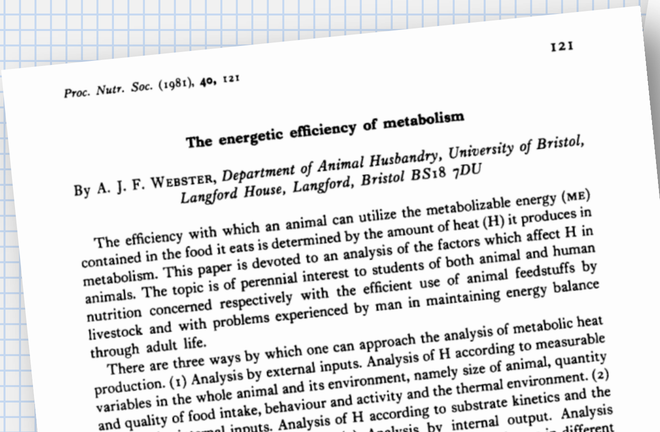
$$[P5]\ CI_i = [P3] + b_3 \cdot MTW \times ADG_i + e_i$$

$$MAYBE = \frac{YES}{NO} + \frac{NO}{YES}$$

Phenotypic Models (PM)

Composition affects maintenance

$$[P4]\ CI_i = [P3] + b_3 \cdot MTW{\times}FAT_i + e_i$$



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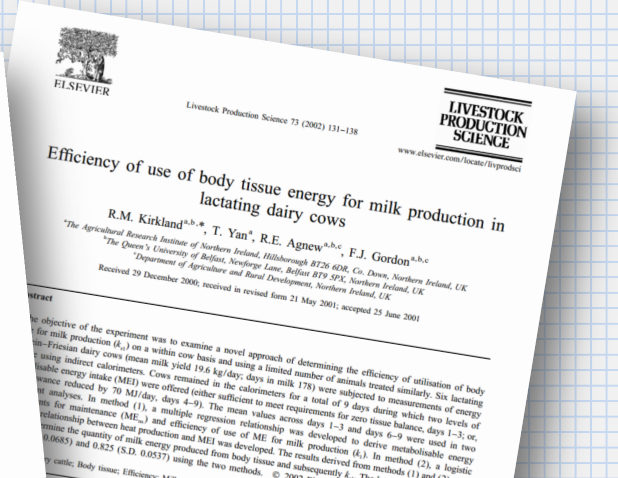
Proc. Nutr. Soc. (1981), 40, 121

The energetic efficiency of metabolism

By A. J. F. Webster, *Department of Animal Husbandry, University of Bristol, Langford House, Langford, Bristol BS18 7DU*

The efficiency with which an animal can utilize the metabolizable energy (ME) contained in the food it eats is determined by the amount of heat (H) it produces in metabolism. This paper is devoted to an analysis of the factors which affect H in animals. The topic is of perennial interest to students of both animal and human nutrition concerned respectively with the efficient use of animal feedstuffs by livestock and with problems experienced by man in maintaining energy balance through adult life.

There are three ways by which one can approach the analysis of metabolic heat production. (1) Analysis by external inputs. Analysis of H according to measurable variables in the whole animal and its environment, namely size of animal, quantity and quality of food intake, behaviour and activity and the thermal environment. (2) Analysis of H according to substrate kinetics and the internal output. Analysis



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Livestock Production Science 73 (2002) 131–138

LIVESTOCK PRODUCTION SCIENCE

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Efficiency of use of body tissue energy for milk production in lactating dairy cows

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[a] *The Agricultural Research Institute of Northern Ireland, Hillsborough BT26 6DR, Co. Down, Northern Ireland, UK*
[b] *The Queen's University of Belfast, Newforge Lane, Belfast BT9 5PX, Northern Ireland, UK*
[c] *Department of Agriculture and Rural Development, Northern Ireland, UK*

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stract

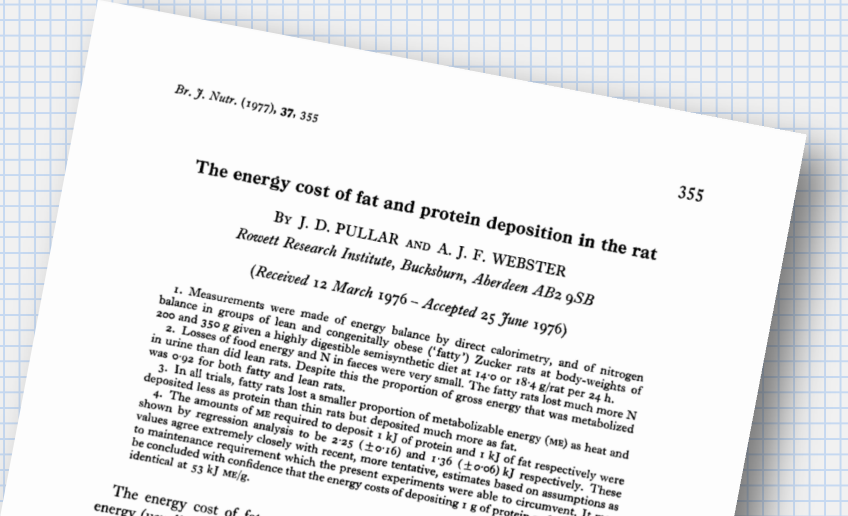
he objective of the experiment was to examine a novel approach of determining the efficiency of utilisation of body
for milk production (k_{t1}) on a within cow basis and using a limited number of animals treated similarly. Six lactating
ein–Friesian dairy cows (mean milk yield 19.6 kg/day; days in milk 178) were subjected to measurements of energy
using indirect calorimeters. Cows remained in the calorimeters for a total of 9 days during which two levels of
lisable energy intake (MEI) were offered (either sufficient to meet requirements for zero tissue balance, days 1–3; or,
wance reduced by 70 MJ/day, days 4–9). The mean values across days 1–3 and days 6–9 were used in two
nt analyses. In method (1), a multiple regression relationship was developed to derive metabolisable energy
nts for maintenance (ME_m) and efficiency of use of ME for milk production (k_1). In method (2), a logistic
relationship between heat production and MEI was developed. The results derived from methods (1) and (2)
rmine the quantity of milk energy produced from body tissue and subsequently
0.0685) and 0.825 (S.D. 0.0537) using the two methods.

y cattle; Body tissue; Efficiency

Phenotypic Models (PM)

Composition of gain has different cost

$$[P6]\quad CI_i = [P3] + b_3 \cdot ADG \times FAT_i + e_i$$



Br. J. Nutr. (1977), **37**, 355

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The energy cost of fat and protein deposition in the rat

BY J. D. PULLAR AND A. J. F. WEBSTER

Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB

(Received 12 March 1976 – Accepted 25 June 1976)

1. Measurements were made of energy balance by direct calorimetry, and of nitrogen balance in groups of lean and congenitally obese ('fatty') Zucker rats at body-weights of 200 and 350 g given a highly digestible semisynthetic diet at 14·0 or 18·4 g/rat per 24 h.

2. Losses of food energy and N in faeces were very small. The fatty rats lost much more N in urine than did lean rats. Despite this the proportion of gross energy that was metabolized was 0·92 for both fatty and lean rats.

3. In all trials, fatty rats lost a smaller proportion of metabolizable energy (ME) as heat and deposited less as protein than thin rats but deposited much more as fat.

4. The amounts of ME required to deposit 1 kJ of protein and 1 kJ of fat respectively were shown by regression analysis to be 2·25 (±0·16) and 1·36 (±0·06) kJ respectively. These values agree extremely closely with recent, more tentative, estimates based on assumptions as to maintenance requirement which the present experiments were able to circumvent. It may be concluded with confidence that the energy costs of depositing 1 g of protein identical at 53 kJ ME/g.

The energy cost of

energy

Results PM

Table 2 – Partial regression coefficients

Model	MTW	ADG	FAT	MTW×ADG	MTW×FAT	ADG×FAT	R^2
P1	0.093	.	.	.	.	.	0.691
P2	0.081	1.887	.	.	.	.	0.760
P3	0.080	1.899	1.132	.	.	.	0.764
P4	0.104	3.471	1.167	-0.014	.	.	0.765
P5	0.080	1.900	1.254^{NS}	.	-0.001^{NS}	.	0.764
P6	0.080	1.831	0.758^{NS}	.	.	0.213^{NS}	0.764

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Genetic Models (GM)

P3 was the base model

[G1] $CI_i = [P3] + a_i + e_i$

[G2] $CI_i = (b_0 + b_{0a}) \cdot MTW_i + \dots + a_i + e_i$

[G3] $CI_i = (b_1 + b_{1a}) \cdot ADG_i + \dots + a_i + e_i$

…

[G8] $CI_i = (b_0+b_{0a}) \cdot MTW_i + (b_1+b_{1a}) \cdot ADG_i + (b_2+b_{2a}) \cdot FAT_i + a_i + e_i$

Results GM

Table 3 – Additive and residual variances

Model	a_i	$b_{0a} \cdot MTW$	$b_{1a} \cdot ADG$	$b_{2a} \cdot FAT$	e_i	h^2	AIC
G1	0.317	.	.	.	0.315	0.50	1174.6
G2	0	0.00004	.	.	0.178	0.72	1137.3
G3	0.222	.	0.035	.	0.306	0.52	1172.8
G4	0.299	.	.	0.212	0.308	0.51	1175.2
G5	0	0.00004	0	.	0.178	0.72	1139.3
G6	0	0.00004	.	0.173	0.170	0.73	1138.1
G7	0.218	.	0.032	0.137	0.302	0.52	1174.2
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Conclusions

- Limited information limits modelling
  - Costs related to composition
    - Animals close to maturity
    - Dairy cows
- Random regression
  - Differences in CI related to MTW
    - Similar to findings on gene expression
    - Probably less complex to understand