Partitioning genetic variance of metabolizable energy efficiency in dairy cows

Mehtiö, T., Negussie, E., Mäntysaari, P., Mäntysaari, E.A., Lidauer, M.H.*

Natural Resources Institute Finland (Luke)

EAAP – 67th Annual Meeting,
Belfast 2016

Luke
NATURAL RESOURCES INSTITUTE FINLAND

Motivation

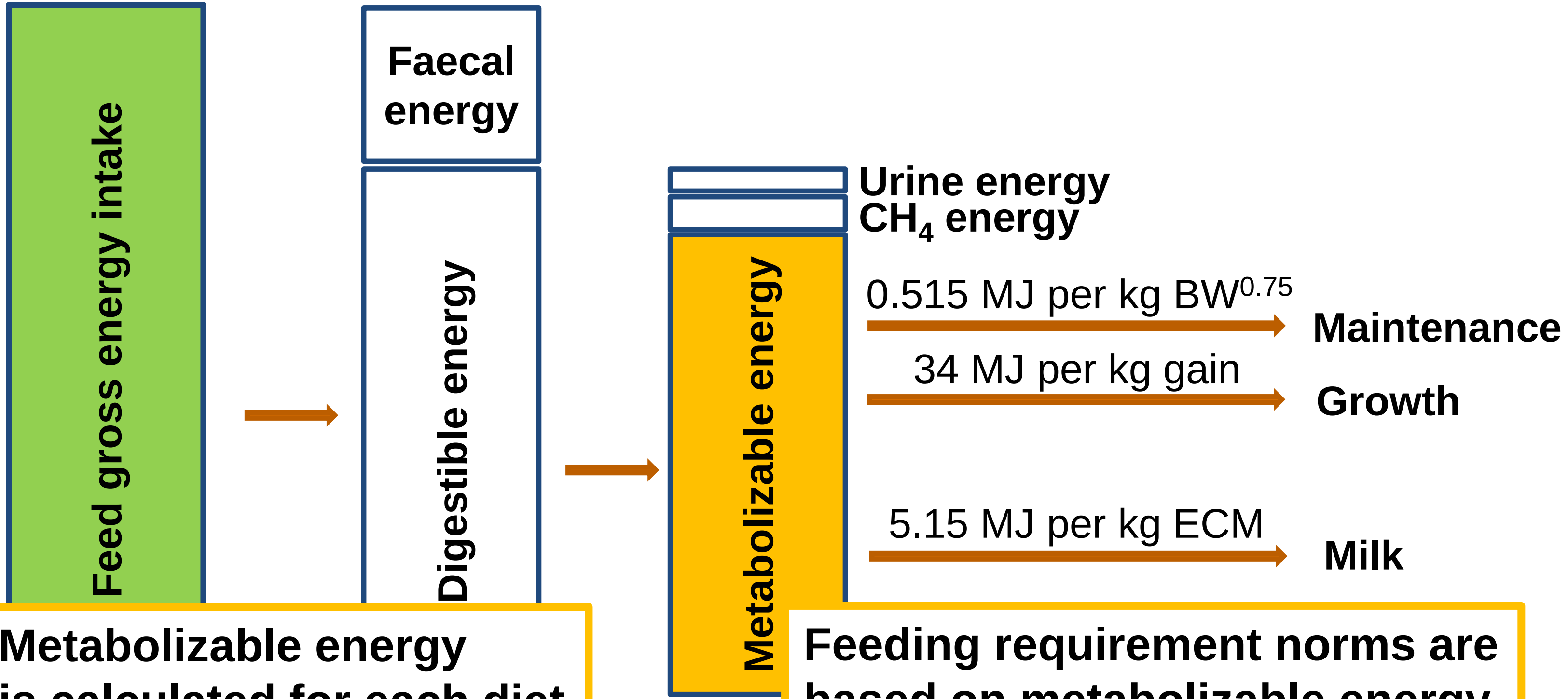
- A cow has different pathways of energy use
- Could we estimate partial efficiencies for different energy pathways?

  → it would increase understanding of cows' feed efficiency

  → supports defining of the breeding goal

  → breeding values for partial efficiencies

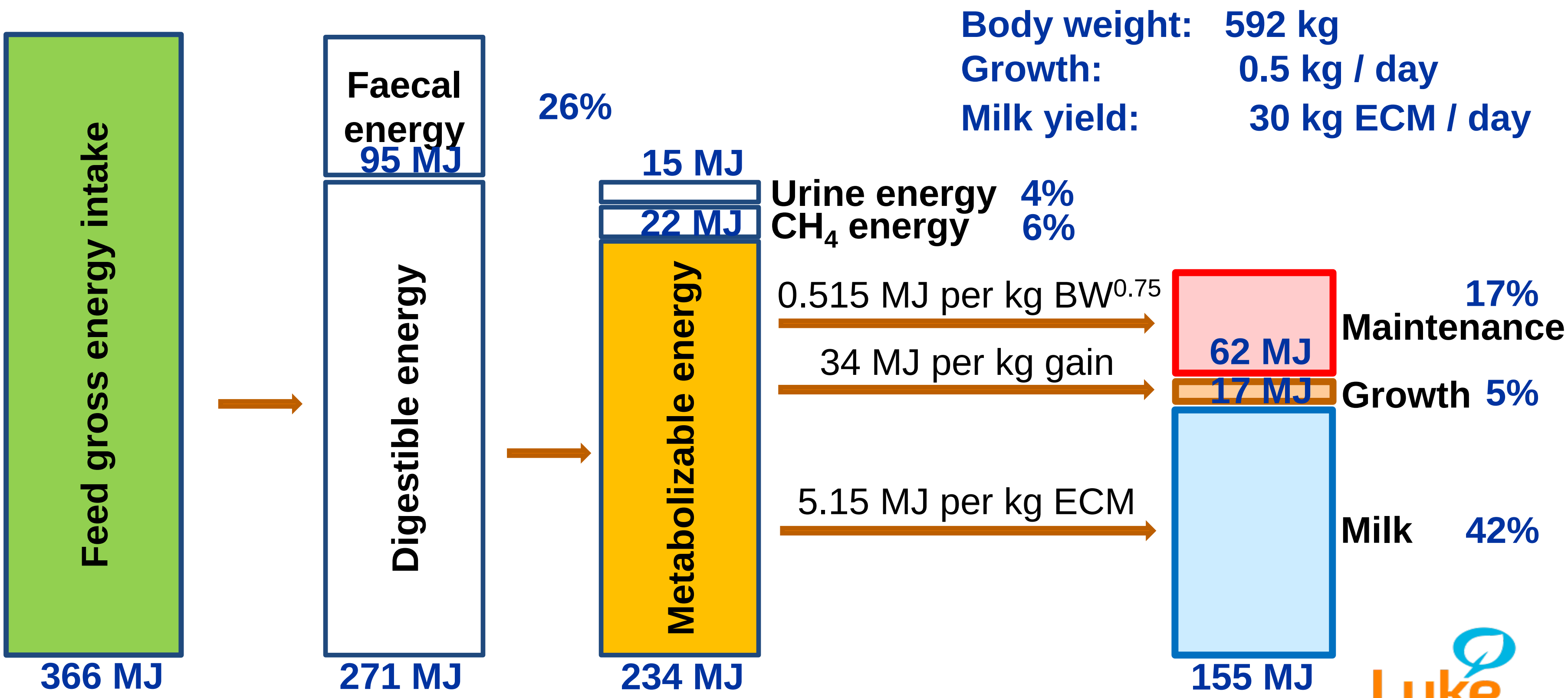
Finnish feeding is based on metabolizable energy



Metabolizable energy is calculated for each diet

Feeding requirement norms are based on metabolizable energy

Energy pathways of a lactating cow



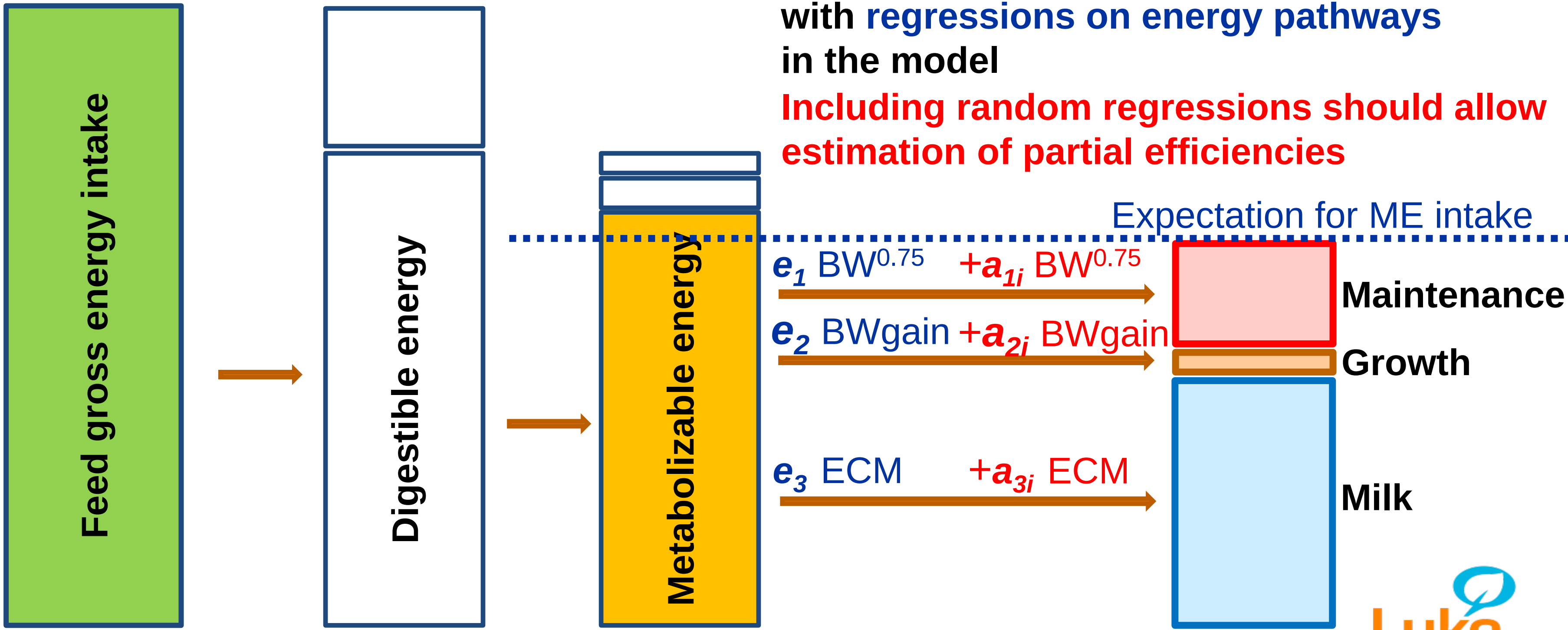
AIM

Assessing partial efficiencies for different energy pathways in dairy cows by random regression analyses

Metabolizable energy efficiency

Modelling metabolizable energy (ME) intake with regressions on energy pathways in the model

Including random regressions should allow estimation of partial efficiencies



Luke NATURAL RESOURCES INSTITUTE FINLAND

Used feed efficiency data

- From Luke’s research farms Rehtijärvi & Minkiö
- 495 primiparous Nordic Red dairy cows
- 12 350 weekly observations (averages of daily observations)
- Recorded from lactation week 2 to 40

Means for different variables by lactation weeks

Lactation weeks	Metabolizable energy intake (MJ)	Energy corrected milk (kg)	Metabolic body weight (kg)	Body weight gain (kg)	Body weight loss (kg)	Residual energy intake (MJ)
ALL	**208.7**	**28.5**	**119.1**	**0.3**	**-0.1**	**-3.6**
2-5	183.3	27.9	116.5	0.1	-0.5	-16.5
16-20	214.8	29.0	118.2	0.2	0.0	1.7
36-40	210.9	26.5	125.7	0.5	0.0	-7.8

Applied Statistical Models

1) Metabolizable Energy Efficiency (MEE)

- Repeatability animal model for metabolizable energy intake
- Expectation for intake modelled by regressions on energy pathways

$$\boldsymbol{MEI_{ijsl} = rym_i + lw_j +}$$
$$\boldsymbol{e_{1s}BW_{isl}^{0.75} \times lactcl_s + e_{2s}ECM_{isl} \times lactcl_s + e_{3s}BWG_{isl} \times lactcl_s + e_{4s}BWL_{isl} \times lactcl_s +}$$
$$\boldsymbol{a_l +}$$
$$\boldsymbol{pe_l +}$$
$$\boldsymbol{\epsilon_{ijsl}}$$

Applied Statistical Models

2) Partial Metabolizable Energy Efficiency (pMEE)

- Random regression animal model for metabolizable energy intake
- Expectation for intake modelled by regressions on energy pathways
- Random regressions for animal effects

$$\boldsymbol{MEI_{ijsl} = rym_i + lw_j +}$$
$$\boldsymbol{e_{1s}BW_{isl}^{0.75} \times lactcl_s + e_{2s}ECM_{isl} \times lactcl_s + e_{3s}BWG_{isl} \times lactcl_s + e_{4s}BWL_{isl} \times lactcl_s +}$$
$$\boldsymbol{a_{0l} + a_{1l}BW_{isl}^{0.75} + a_{2l}ECM_{isl} + a_{3l}BWG_{isl} + a_{4l}BWL_{isl} +}$$
$$\boldsymbol{pe_{0l} + pe_{1l}BW_{isl}^{0.75} + pe_{2l}ECM_{isl} + pe_{3l}BWG_{isl} + pe_{4l}BWL_{isl} +}$$
$$\boldsymbol{\epsilon_{ijsl}}$$

Applied Statistical Models

3) Residual Energy Intake (REI)

- Repeatability animal model for residual energy intake
- Served as reference analysis

$$\boldsymbol{REI_{ijl} = rym_i + lw_j + a_l + pe_l + \epsilon_{ijl}}$$

Analyses

- Restricted Maximum Likelihood analyses (AI-REML, EM-REML) [DMU package, Madsen & Jensen, 2013]
- Different random regression models were fitted
- Akaike's information criterion (AIC) for model comparison
- Heritabilities based on random regression models were calculated for a "*standard lactating cow*"

→ Metabolic body weight = 119.1 kg

→ Energy corrected milk yield = 28.5 kg / day

→ Body weight gain = 0.27 kg / day

Results

Variances and heritabilities

Model	Additive Genetic Animal Effects	σ^2_a	σ^2_{pe}	σ^2_e	h^2	$\eta^2_{Int.}$	η^2_{MBW}	η^2_{ECM}	η^2_{BWG}	η^2_{BWL}	AIC
REI	Intercept	188	116	266	0.33						81333
MEE	Intercept	137	149	247	0.26						80370
pMEE1	Intercept, MBW	159	137	246	0.29	0.00	0.29				80358
pMEE2	Intercept, ECM	343	28	246	0.56	0.00		0.56			80383
pMEE3	Intercept, MBW, ECM	132	169	221	0.25	0.00	0.04	0.04			79695
pMEE4	Intercept, MBW, ECM, BWG, BWL	98	205	182	0.20	0.00	0.10	0.09	0.00	0.00	78585
pMEE5	MBW, ECM	132	169	220	0.25		0.05	0.04			79686

Results

Correlations

Genetic (upper tr.) and permanent environmental (lower tr.) correlations between partial efficiencies and overall efficiency

	pMEE(MBW)	pMEE(ECM)	MEE(overall)
pMEE(MBW)		-0.49	0.55
pMEE(ECM)	-0.97		0.46
MEE(overall)	0.21	0.05	

Genetic standard deviations of partial regression coefficients

$\sigma_{a\,\mathrm{pMEE(MBW)}}$	$\sigma_{a\,\mathrm{pMEE(ECM)}}$	$\sigma_{a\,\mathrm{(overall)}}$
0.10 MJ / kg MBW / day	0.39 MJ / kg ECM / day	11.5 MJ /day

Conclusions

- Models for metabolizable energy efficiency resulted better fit
- Partial energy efficiencies can be modelled by random regressions
- Additive genetic variance was almost entirely explained by regressions on maintenance and milk yield
- Additional analyses are needed for verifying the genetic correlations between partial efficiencies

Thank you for your attention

Our gratitude to the co-funders of this study

mmm.fi
MINISTRY OF AGRICULTURE AND FORESTRY

Valio

faba