


Teagasc Research:
Feed efficiency in beef cattle

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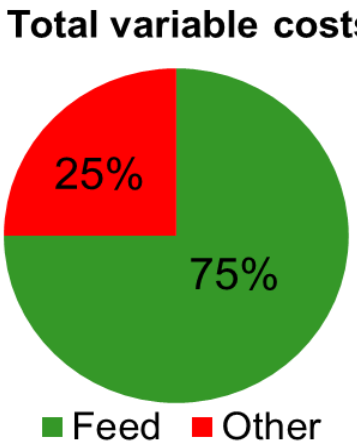
Agriculture and Food Development Authority

CURRENT RESEARCH: Feed Efficiency

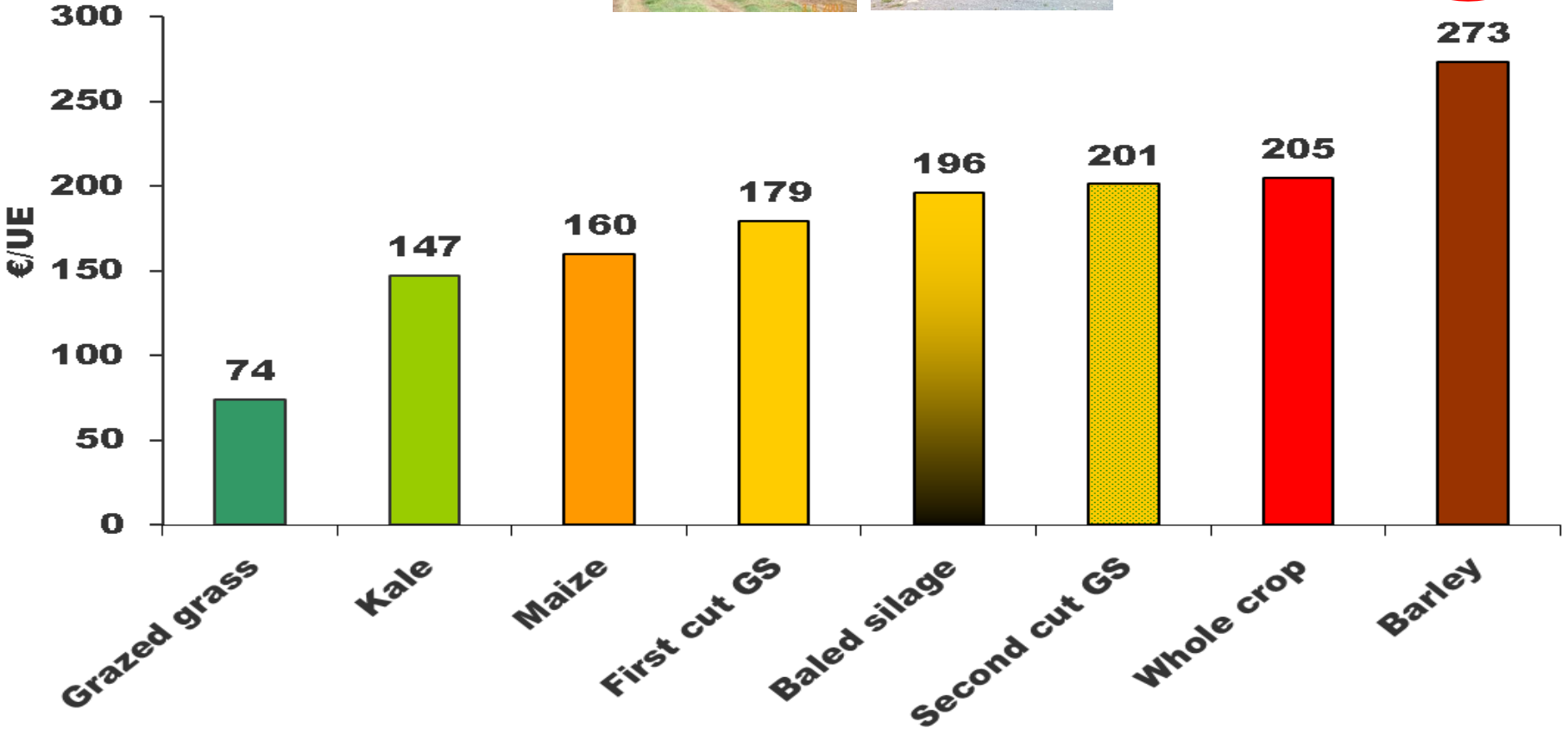
- Beef production: Conversion of feed to animal product as (cost) efficiently as possible.

- Feed provision: Single largest variable cost in beef production.



- Major factor determining cost competitiveness + environmental footprint & sustainability.

Total feed costs – Net energy basis



Source: Finneran et al. (2013)

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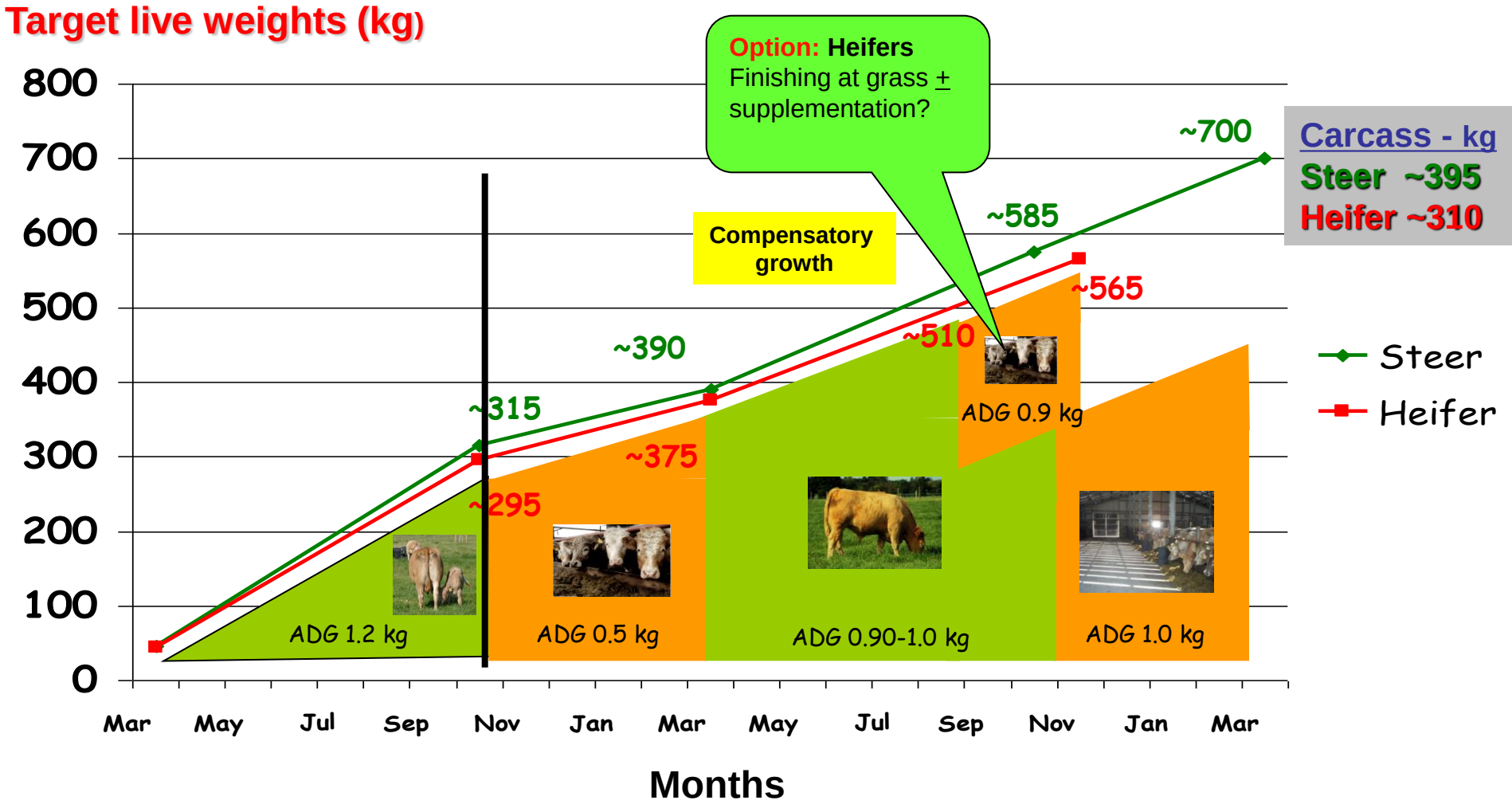
Suckler Beef Production System: *"Blueprint"*

Steers 24 mths + Heifers 20 mths



Source: McGee et al. – Teagasc Grange

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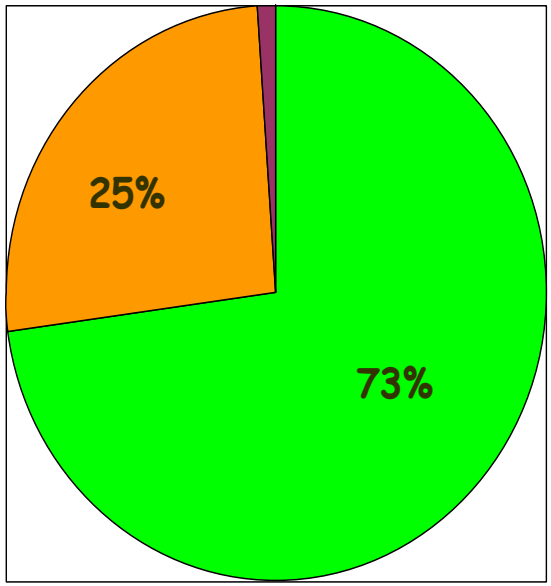
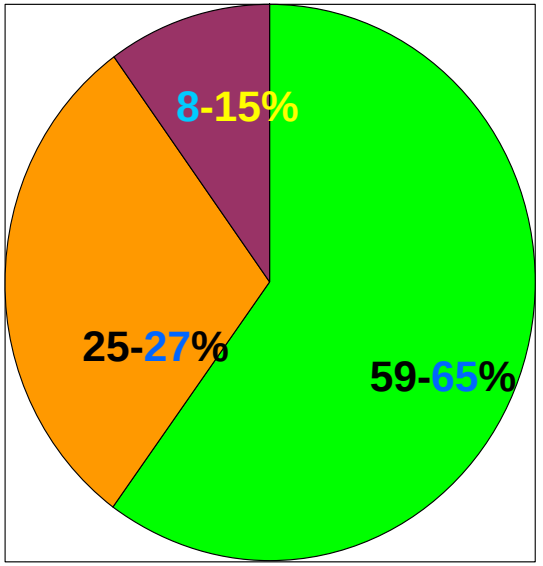
Annual Feed Budgets

(DM intake / cow unit)

Calf-to-Weaning



Calf-to-Beef



Source: McGee et al. – Teagasc Grange

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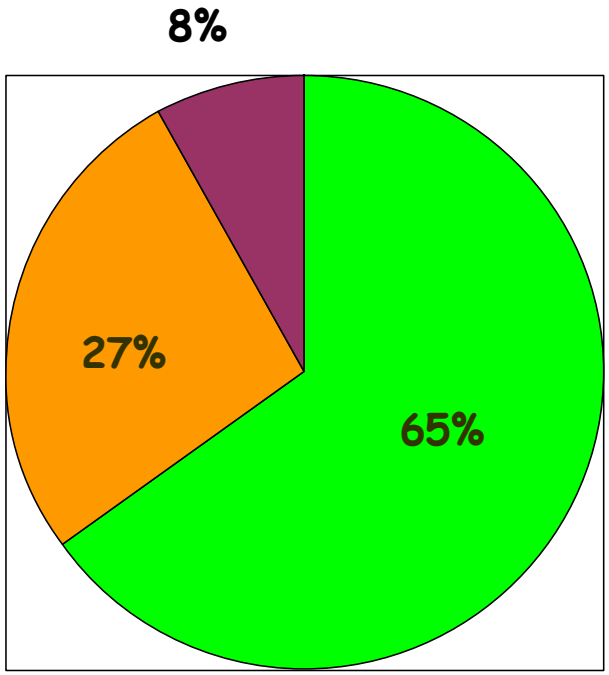
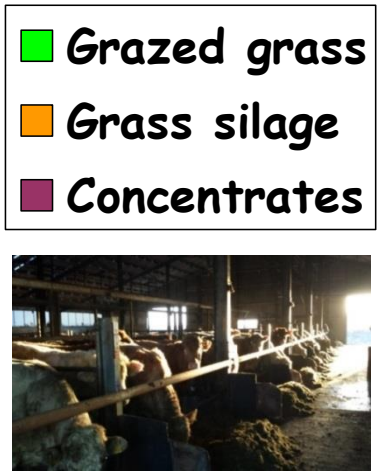
Annual Feed Budgets (/cow unit)

Suckler calf-to-Beef: 24 mth steer/20 mth heifer

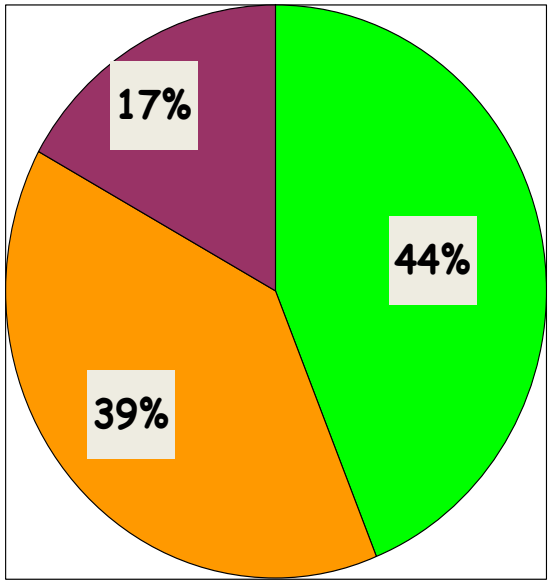
Feed DM Intake





Feed €

(incl. land charge)



Optimising the contribution of grazed grass
to the lifetime intake of feed
+
Provide silage & concentrates as efficiently and
at as low as cost as feasible

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Feed efficiency

- Traditionally, expressed

  FCR = feed intake : weight gain

- Selection for FCR (**or** FCE, gain:intake)
  - Similar to selection for growth rate
  - Improves FCR in growing animal

BUT

↳ Increase in **COW SIZE**

↳ Increase in **Maintenance** **requirements**

↳ Increase 'costs': **€** & **Environment**

Improve the efficiency of growth / finishing phase

BUT not necessarily the entire production system

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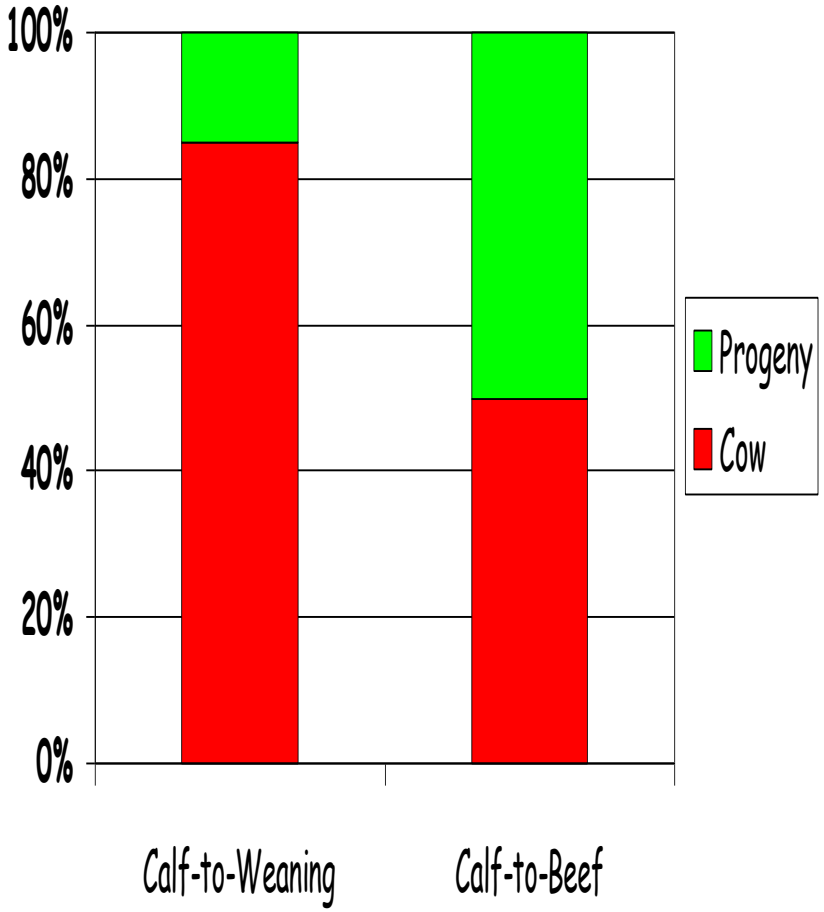
Residual Feed Intake (RFI)

- RFI is **moderately heritable** ($h^2 \approx 0.35$) & **genetically independent** of growth and mature size
- RFI can be improved through selection without affecting ADG or mature size
- Addition of appropriate body energy sinks to reduce 'residual'/unknown portion e.g. body composition, activity….

Beef cow feed consumption within grass-based systems



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Residual Feed Intake (RFI)

<u>Independent</u> of growth and body size

Expected requirements for maintenance & growth **+…….?**

RFI = animals actual intake - predicted intake

Negative or lower values desirable

Cattle with better feed efficiency (**Low** RFI) **<u>eat less</u>** than expected for their size and growth rate + …….?

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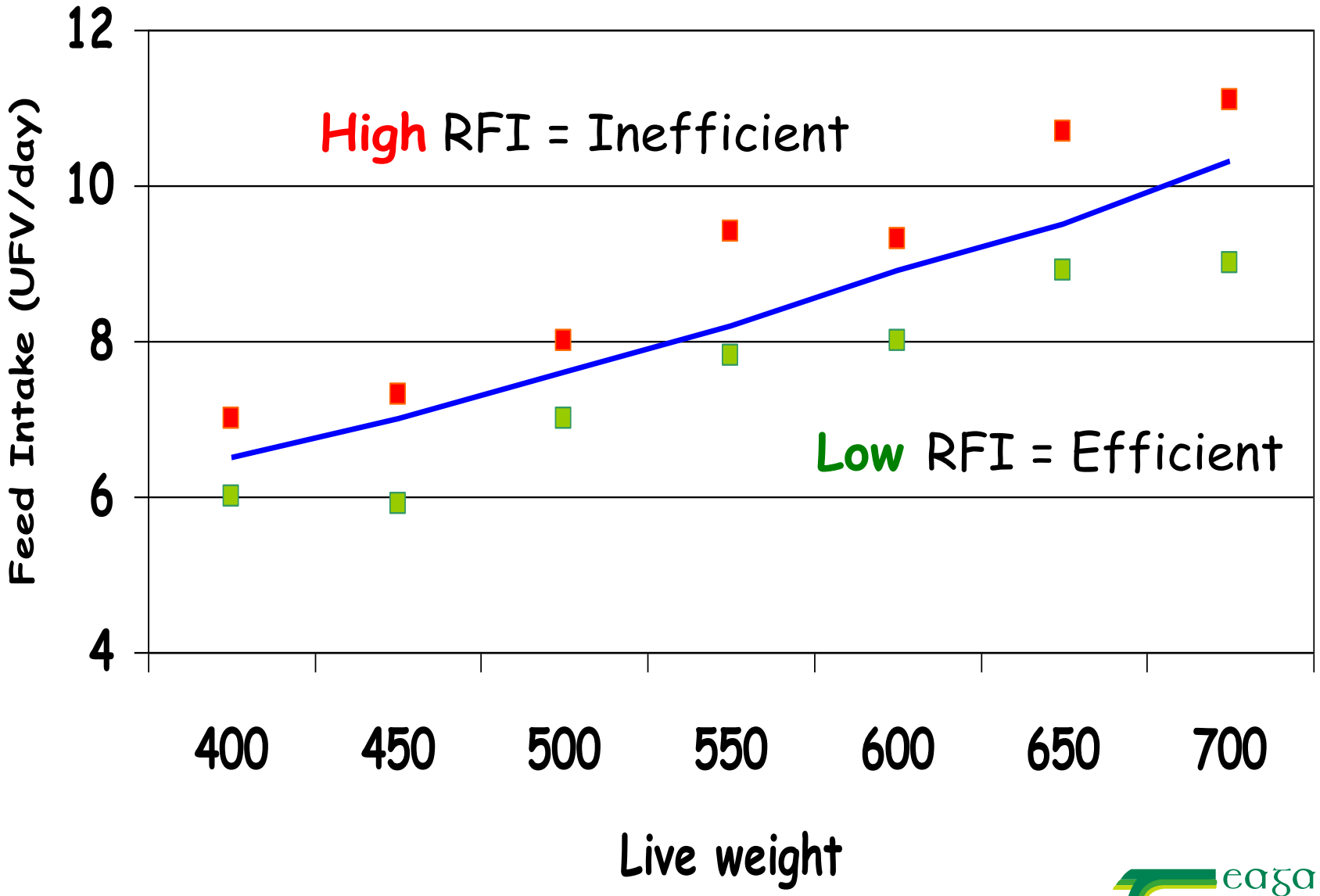
Residual Feed Intake



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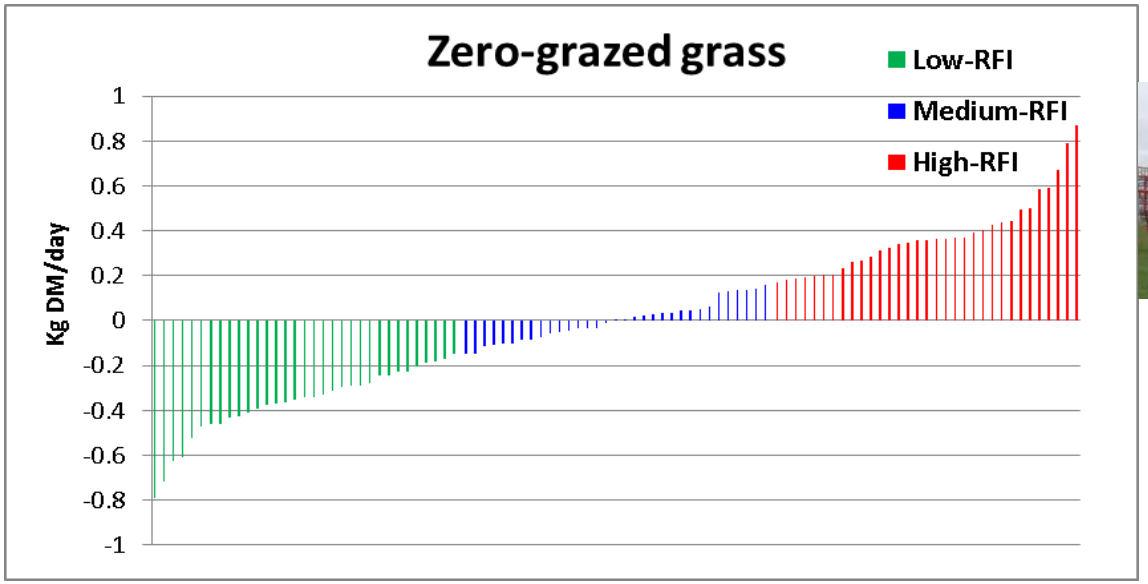
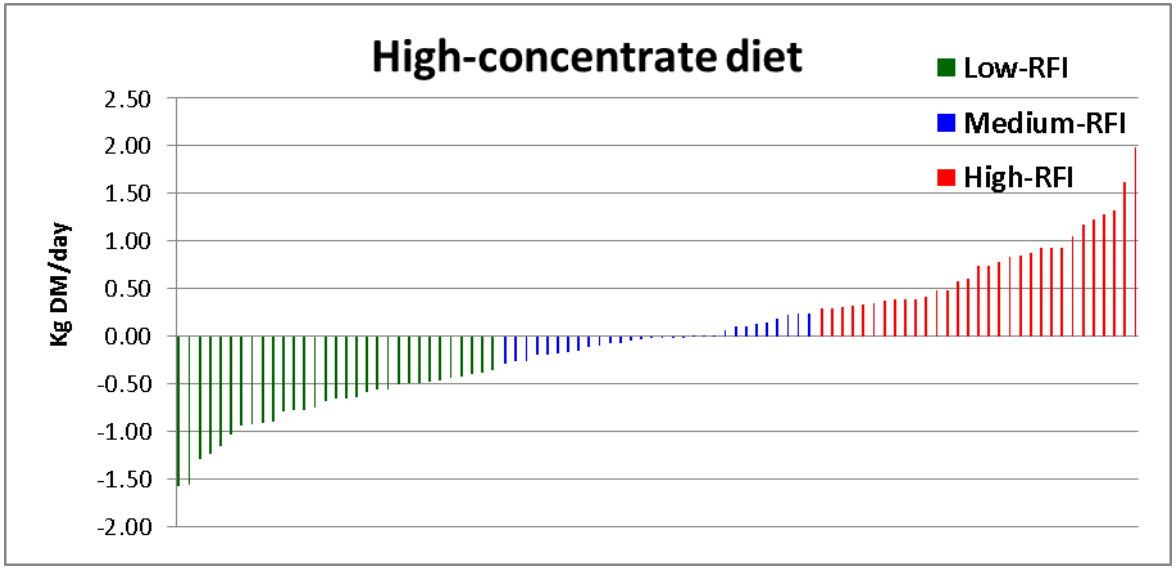
Phenotypic RFI in suckler-bred Charolais steers



- **MOST published 'RFI-studies'**
  - INDOORS
  - GROWING cattle
  - ENERGY-dense diets

RFI 'Test period' = >70d (following adaptation)
- **70d = ADG**
- **30-40d = DMI**



Source: McGee et al. (2019)

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Growing heifers (‘store period’): Grass silage + concentrates

Table 2 *Characterisation of intake, growth and energetic efficiency traits in beef heifers with high, medium and low RFI*

Trait	RFI group[a] High	Medium	Low	s.e.[b]	*P*-value
Winter indoor period					
No. of animals	27	32	26	–	–
RFI (kg DM/day)	0.48[a]	−0.02[b]	−0.50[c]	0.037	0.001
Feed conversion ratio (kg of DM/kg of LW gain)	12.07	11.13	9.81	0.834	0.13
DMI (kg DM/day)					
Silage DMI	4.59[a]	4.22[b]	3.77[c]	0.127	0.001
Total DMI	6.31[a]	5.94[b]	5.49[c]	0.127	0.001
NE intake (UFL/day)					
Silage NE	3.87[a]	3.56[b]	3.17[c]	0.108	0.001
Total NE	5.81[a]	5.50[b]	5.12[c]	0.107	0.001
Metabolic LW ($kg^{0.75}$)	75	77	77	1.6	0.27
ADG (kg/day)	0.60	0.61	0.60	0.028	0.92
Initial LW (kg)	292	302	304	8.7	0.19
Final LW (kg)	340	351	355	9.8	0.14

P. Lawrence[1,2], D. A. Kenny[2,3], B. Earley[3] and M. McGee[1†]

Animal (2012), **6:10**, pp 1648–1661 © The Animal Consortium 2012
doi:10.1017/S1751731112000559

15% DMI ***

ADG = NS

LW = NS

Beef Heifers: Maize silage + concentrates TMR

Table 2. Characterization of intake, performance, and energetic efficiency traits in growing beef heifers with high, medium, and low residual feed intake (RFI)

	RFI group[1]				
Trait	High	Medium	Low	SE[2]	*P*-value
No. of animals	23	42	21		
Residual feed intake, kg/d	0.52[a]	0.00[b]	−0.63[c]	0.05	<0.0001
Feed conversion ratio, kg of DM/kg of BW gain	4.86[a]	4.61[b]	4.04[c]	0.10	<0.0001
DMI, kg/d	7.34[a]	6.75[b]	6.17[c]	0.17	<0.0001
ME intake, kcal/(kg$^{0.75}$·d)	304.1[a]	280.2[b]	258.0[c]	3.22	<0.0001
Relative growth rate	0.26	0.25	0.26	0.01	0.36
Kleiber ratio	0.02	0.02	0.02	0.00	0.15
Metabolic BW, kg$^{0.75}$	63.47	63.53	62.84	1.24	0.90
ADG, kg/d	1.52	1.49	1.54	0.03	0.41
Initial BW, kg	194	197	192	6.44	0.81
Final BW, kg	314	313	312	7.01	0.97

19% DMI ***

ADG = NS

LW = NS

A. K. Kelly,* M. McGee,† D. H. Crews Jr.,‡ A. G. Fahey,* A. R. Wylie,§ and D. A. Kenny*[2]

J. Anim. Sci. 2010. 88:109–123
doi:10.2527/jas.2009-2196

‘Finishing’ Bulls: High-concentrate diet

Table 2 *Feed intake, feed efficiency and growth traits of beef bulls ranked as high, medium and low RFI*

	RFI group[a]				*P*-value[b]
Traits	High	Medium	Low	s.e.[c]	RFI
No. of animals	22	23	22	–	–
DMI (kg DM/day)	10.24[a]	9.59[b]	9.00[c]	0.145	0.001
RFI (kg DM/day)	0.61[a]	–0.03[b]	–0.45[c]	0.079	0.001
Mid-test metabolic BW ($kg^{0.75}$)	107	108	108	1.8	0.84
Initial BW (kg)	435	437	433	11.4	0.75
Final BW (kg)	608	608	590	12.7	0.76
ADG (kg)	1.66	1.63	1.55	0.076	0.51

14% DMI ***

LW = NS

ADG = NS

C. Fitzsimons[1,2], D. A. Kenny[3] and M. McGee[1†]

Animal (2014), **8:6**, pp 949–959 © The Animal Consortium 2014
doi:10.1017/S1751731114000652

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Suckler cows: Late pregnancy – Grass silage (a)

Table 2. Characterization of intake, growth, energetic efficiency traits, calf birth weight, and calving difficulty score in pregnant beef heifers with high, medium, and low residual feed intake (RFI)

	RFI group[1]				
Trait	High	Medium	Low	SEM	*P*-value
No. of animals	24	25	24	—	—
DMI, kg of DM/d	8.73[a]	7.96[b]	7.24[c]	0.14	<0.001
Residual feed intake, kg of DM/d	0.75[a]	0.04[b]	−0.78[c]	0.08	<0.001
Feed conversion ratio, kg of DM/kg of BW gain	18.52	18.24	17.52	2.125	0.86
Metabolic BW, $kg^{0.75}$	116	116	117	1.7	0.85
Conceptus-adjusted metabolic BW, $kg^{0.75}$	112	111	112	1.75	0.75
Initial BW, kg	547	544	551	11.41	0.81
Conceptus-adjusted initial BW, kg	532	530	538	11.4	0.74
Final BW, kg	590	585	590	11.54	0.86
Conceptus-adjusted final BW, kg	543	540	548	11.44	0.77
Mean BW, kg	569	564	571	11.33	0.85
Conceptus-adjusted mean BW, kg	538	535	543	11.28	0.74
ADG, kg/d	0.52	0.49	0.46	0.04	0.38
Conceptus-adjusted ADG, kg/d	0.13	0.12	0.11	0.04	0.96

21% DMI ***

LW = NS

ADG = NS

P. Lawrence,*†[2] D. A. Kenny,†‡ B. Earley,‡ D. H. Crews Jr.,§ and M. McGee*[3]

J. Anim. Sci. 2011. 89:3248–3261
doi:10.2527/jas.2010-3774

Suckler cows: Late pregnancy – Grass silage (b)

Table 2. Feed intake, feed efficiency, and performance of pregnant beef cows of high, medium, and low residual feed intake (RFI)

	RFI group[1]				
Trait	High	Medium	Low	SEM	*P*-value
No. of animals	15	17	15	—	—
DMI, kg DM/d	9.50[a]	8.78[b]	7.59[c]	0.178	<0.001
Residual feed intake, kg DM/d	0.90[a]	0.10[b]	−1.00[c]	0.106	<0.001
Metabolic BW, $kg^{0.75}$	133	132	133	2.8	0.99
Conceptus-adjusted metabolic BW, $kg^{0.75}$	127	127	128	2.8	0.98
Initial BW, kg	663	659	667	18.5	0.95
Conceptus-adjusted initial BW, kg	646	642	652	18.5	0.92
Final BW, kg	690	693	690	19.2	0.99
Conceptus-adjusted final BW, kg	638	641	642	19.2	0.99
Mean BW, kg	676	676	679	18.7	0.99
Conceptus-adjusted mean BW, kg	642	642	647	18.6	0.97
ADG, kg/d	0.68	0.89	0.56	0.130	0.16
Conceptus-adjusted ADG, kg/d	−0.12	−0.01	−0.12	0.100	0.50

25% DMI ***

LW = NS

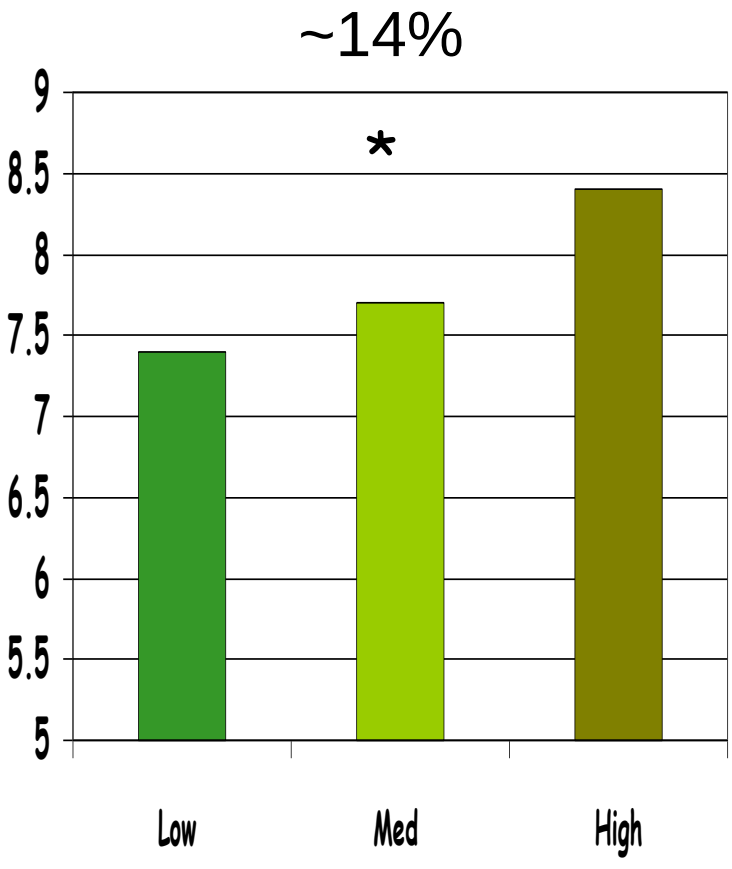
ADG = NS

C. Fitzsimons,*[,2,†] D. A. Kenny,[‡] A. G. Fahey,[†] and M. McGee*[3]

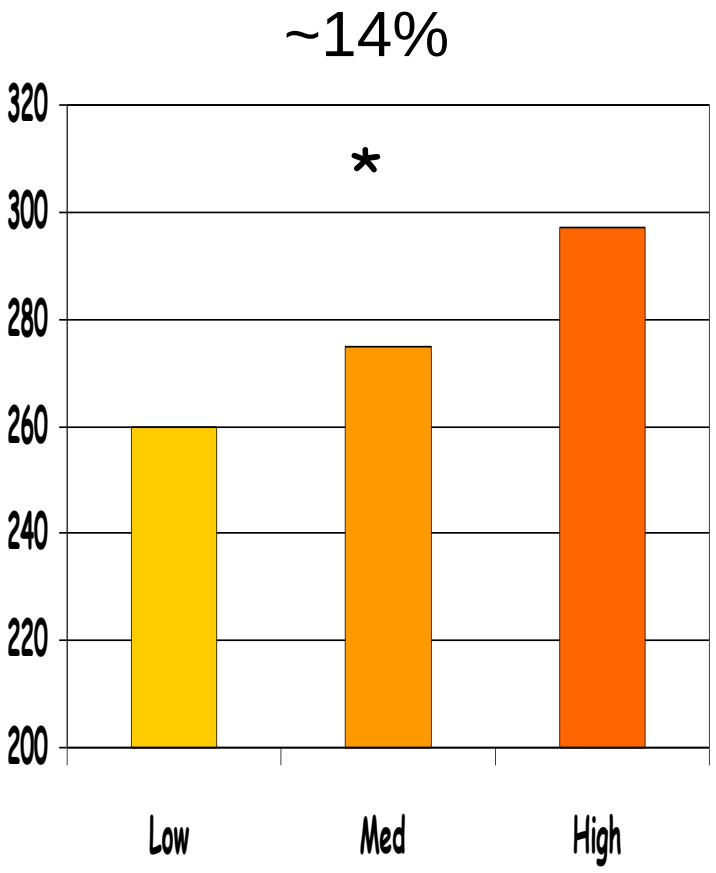
J. Anim. Sci. 2014.92:2170–2181
doi:10.2527/jas2013-7438

RFI & Methane production: Growing heifers

Dry matter intake (kg/day)



Methane (g/day)



Source: Fitzsimons et al. (2013) – Teagasc Grange

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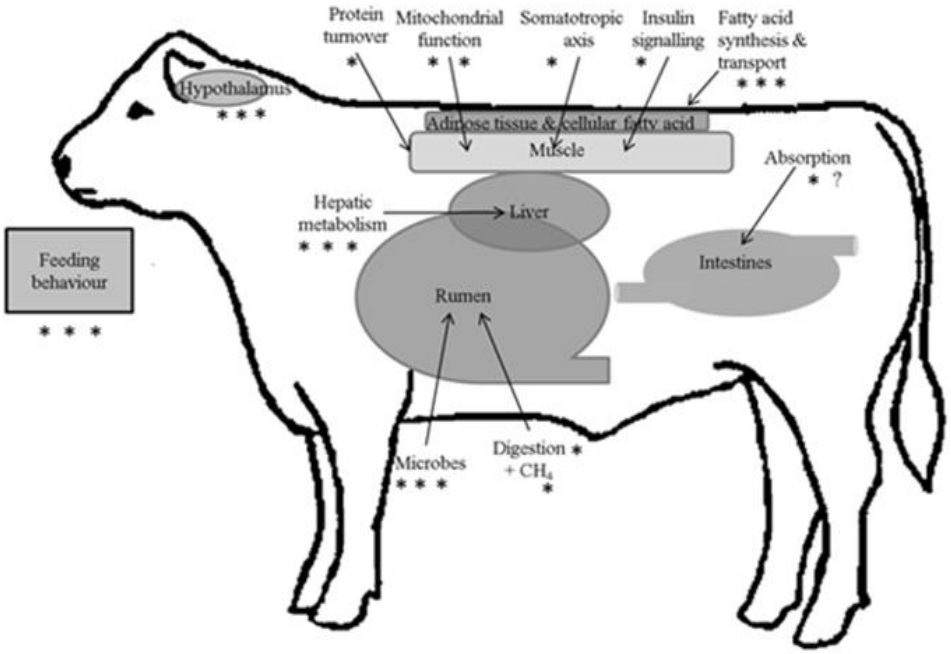
Suggested relative contribution of various biological processes underlying variation in feed efficiency of beef cattle ?



*** Likely a highly important role
** Likely a moderate role
* Likely a minor role
? Potentially important role

Source: Fitzsimons et al. (2017)

Feed efficiency is a multifactorial and complex trait *…… and* ***inter-animal variation*** *stems from the* ***interaction of many biological processes****, influenced, in turn, by* ***physiological status and management regimen***

Source: Kenny et al. (2018)

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‘Repeatability’ of feed efficiency?

- **Do cattle identified as feed efficient early in life remain so as they get older?**

- **Do cattle re-rank for feed efficiency when fed different diets sequentially?** i.e. genotype x environment (diet) interactions?

- **Implication:**
  - Generation of ‘Breeding Values’ for feed efficiency?

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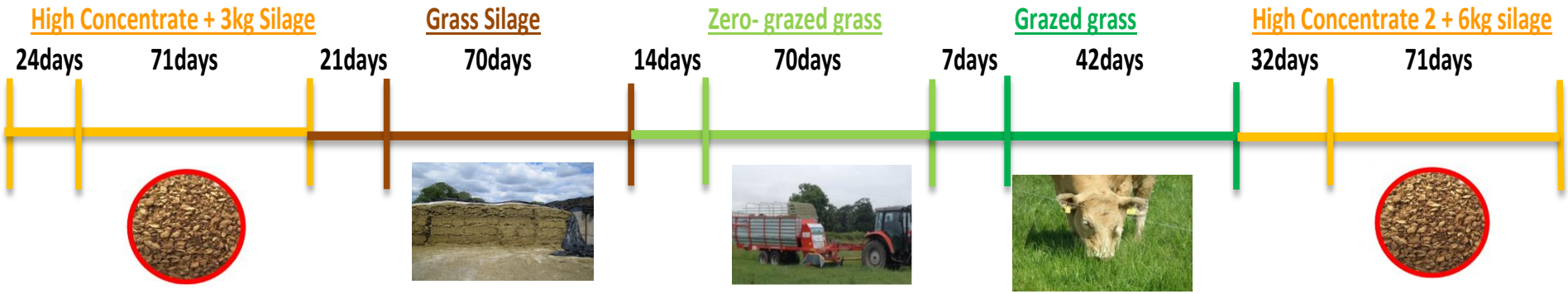
Experimental Approach: animal 'model'

Animals: (n=200)

Breeds: Holstein-Friesian (**HF**) + ≥3/4 Charolais (suckler-bred) (**CH**) steers

Spring-born: purchased @8-9 mths old

Diets:



Measurements:

- Intake, digestion, body composition, blood, carcass traits, organs.....

- **Biopsies:** muscle & liver

[Extremes RFI within Breed: 'High' & 'Low']

.....**DNA-based biomarkers?**

Source: McGee et al. (2019)

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Variation in DMI: Residual Feed Intake (RFI)

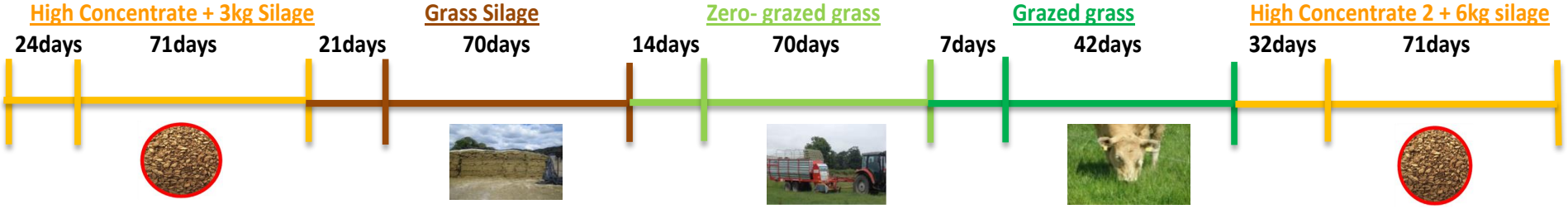
	Phase 1 High-Concentrate				Phase 2 Grass silage				Phase 3 Zero-grazed grass				Phase 5 High-Concentrate			
Breed	CH		HF		CH		HF		CH		HF		CH		HF	
RFI (Thirds)	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
DMI (kg/d)	9.1	7.8	9.3	8.3	6.9	6.1	7.6	6.5	9.4	8.7	9.9	8.9	12.3	10.8	13.7	11.6
BW (Kg)	446	435	340	350	498	497	409	413	563	565	476	480	727	724	663	665
ADG (kg)	1.32	1.27	1.40	1.38	0.37	0.38	0.48	0.44	1.30	1.30	1.25	1.26	1.44	1.39	1.30	1.29
DMI High v. Low RFI	17%		12%		13%		17%		8%		11%		14%		18%	

- **Within each dietary phase, high-RFI animals (i.e. inefficient 'third') had higher daily DMI (P<0.001) compared their low-RFI counterparts, despite having the same weight & ADG.**

Source: McGee et al. (2019)

‘Repeatability’ - Feed efficiency traits: Correlation coefficients

Breeds - steers: Holstein-Friesian (**HF**) (n=100)
>3/4 Charolais (**CH**) (n=100)



‘Yearling’ vs. ‘2-year-old’ High-concentrate diet

Trait	CH	HF
ADG	0.21	0.22†
DMI	0.63**	0.56**
G:F	0.07	0.08
RFI	0.35***	0.29*

Source: Coyle et al. (2016a)

Grass silage vs. Zero-grazed grass

Trait	CH	HF
ADG	0.13	-0.03
DMI	0.70***	0.51***
G:F	0.07	0.04
RFI	0.40***	0.30*

Source: Coyle et al. (2016b)

Zero-grazed grass vs. High-concentrate diet

Trait	CH	HF
ADG	-0.01	0.05
DMI	0.52***	0.45***
G:F	-0.07	-0.02
RFI	0.18†	0.19†

Source: Coyle et al. (2017)

Conclusion: DMI and, to a lesser extent, RFI are ‘repeatable’ traits, whereas G:F is not.

Based on terciles: ~45-50% unchanged; ~40% re-ranked 1 position;10-15% re-ranked 2 positions
(L, M, H) for RFI ~40-45% unchanged; ~40% re-ranked 1 position; ~20% re-ranked 2 positions

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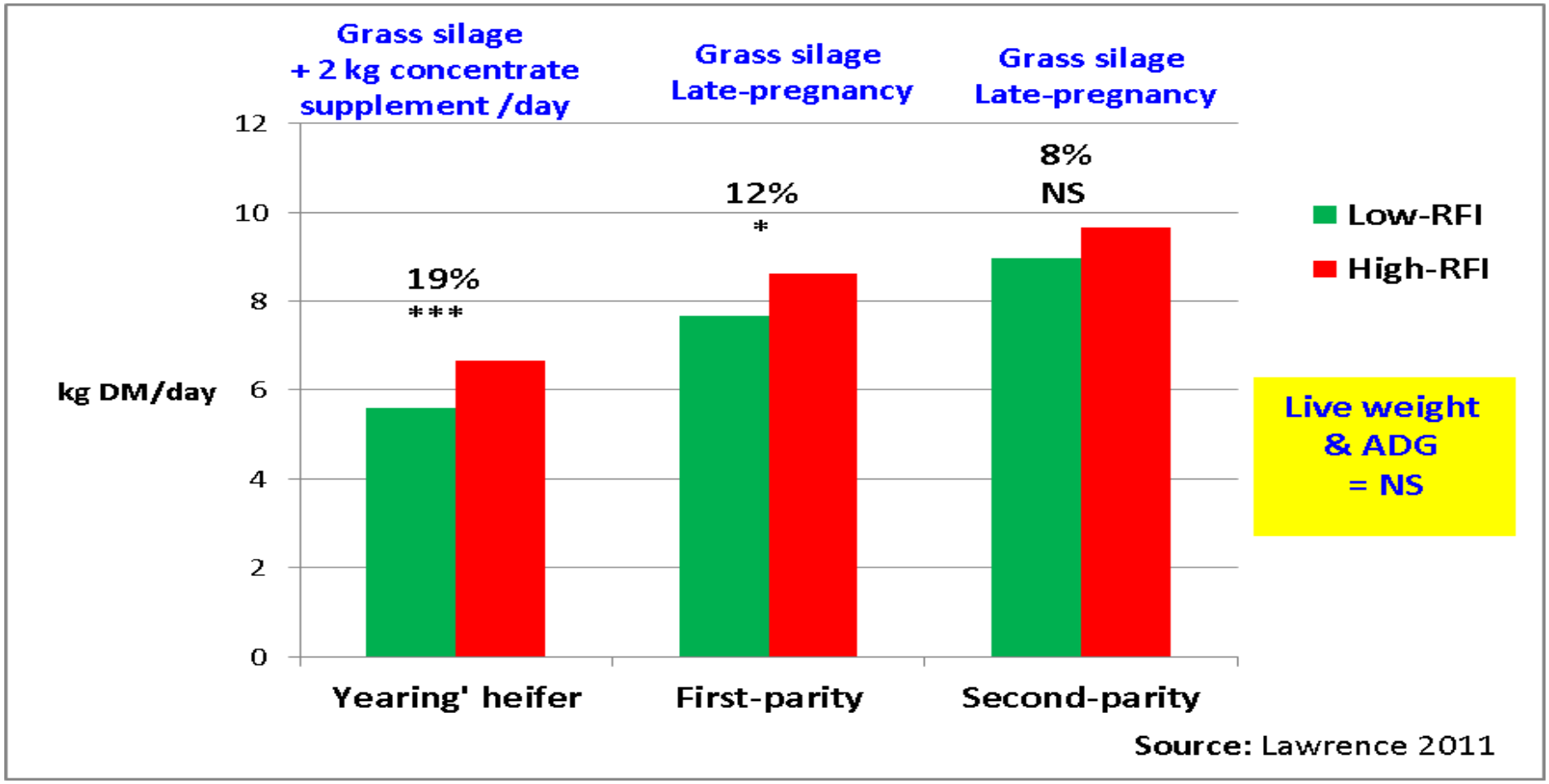
RFI "Repeatability": Breeding Heifers → Pregnant Suckler cows?

Effect of Heifer RFI classification on grass silage DMI as first- and second-parity Cows (late pregnancy)



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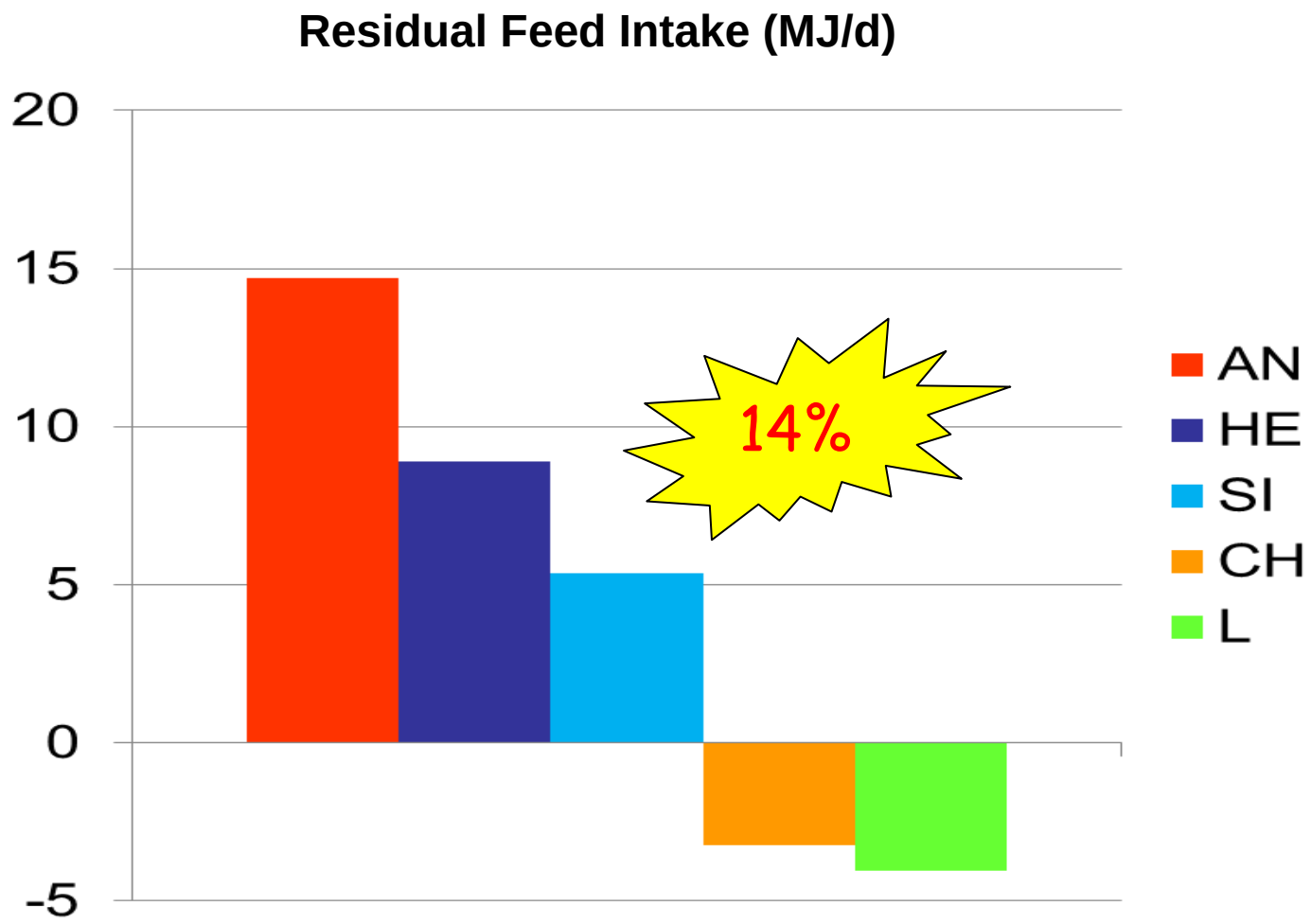
Breeds! - Performance Test Station Data - Ireland



Source: Crowley et al. 2010

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Intake, live weight gain and feed efficiency of suckler-bred Charolais and dairy-origin Holstein-Friesian steers offered zero-grazed grass

	Charolais	Holstein-Friesian	s.e.m.	P-value
Age – initial (days)	465	489	1.4	***
Daily grass DM intake (kg)	9.07	9.47	0.058	***
(g/kg live weight)	16.2	19.7	0.12	***
Live weight, mid-test (kg)	562	482	4.0	***
ADG (kg)	1.34	1.27	0.022	*
FCE (kg live weight gain/kg DM intake)	0.147	0.134	0.0023	***
RFI (kg DM/day)	-0.27	0.29	0.051	***

CONCLUSION: The proportionately 0.14 lighter and 0.05 slower-growing **Holstein-Friesian** steers consumed 0.04 more grass DM resulting in an inferior FCE and RFI compared to **Charolais**.

Source: McGee et al. (2018a) – Teagasc Grange

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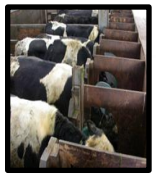
Intake and feed efficiency of suckler-bred Charolais and dairy-origin Holstein-Friesian steers offered a high-concentrate 'finishing' diet

		Charolais	Holstein-Friesian	P-value	Difference in favour of HF
Age – initial (days)		654	678	***	+24 d
Daily DM Intake	(kg)	11.5	12.6	***	+10%
	(g/kg live weight)	15.9	19.1	***	+20%
ADG (kg)		1.37	1.28	P=0.07	-7%
FCE (kg live weight gain/kg DMI)		0.12	0.10	***	-17%
Live weight, mid-test (kg)		725	659	***	-9%
Carcass weight (kg)		446	362	***	-19%
Rumen weight empty (kg)		12.6	13.3	**	+6%
Liver weight (kg)		8.4	9.6	***	+14%
Kill-out proportion (g/kg)		580	519	***	-11%
Carcass conformation (1-15)		10.3	4.5	***	-56%
Carcass fat score (1-15)		10.0	9.9	NS	~

Source: McGee et al. (2018b), Teagasc Grange

CONCLUSION: The lighter, slower-growing **Holstein-Friesian** steers consumed 0.10 more feed DM resulting in a **substantially inferior feed efficiency** compared to **Charolais**.

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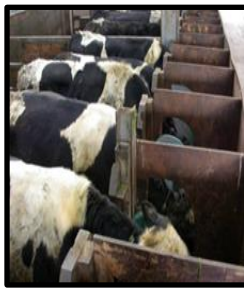
Intake and feed efficiency of Charolais and Holstein-Friesian steers offered a high-concentrate 'finishing' diet



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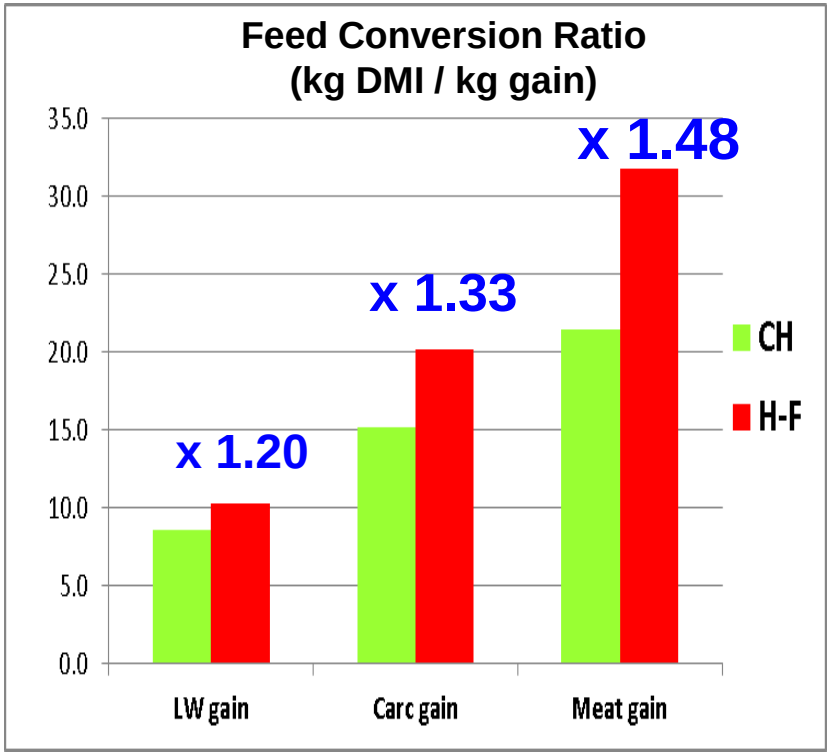

CONCLUSION: The lighter, slower-growing **Holstein-Friesian** steers had a **substantially inferior feed efficiency** compared to **Charolais**.

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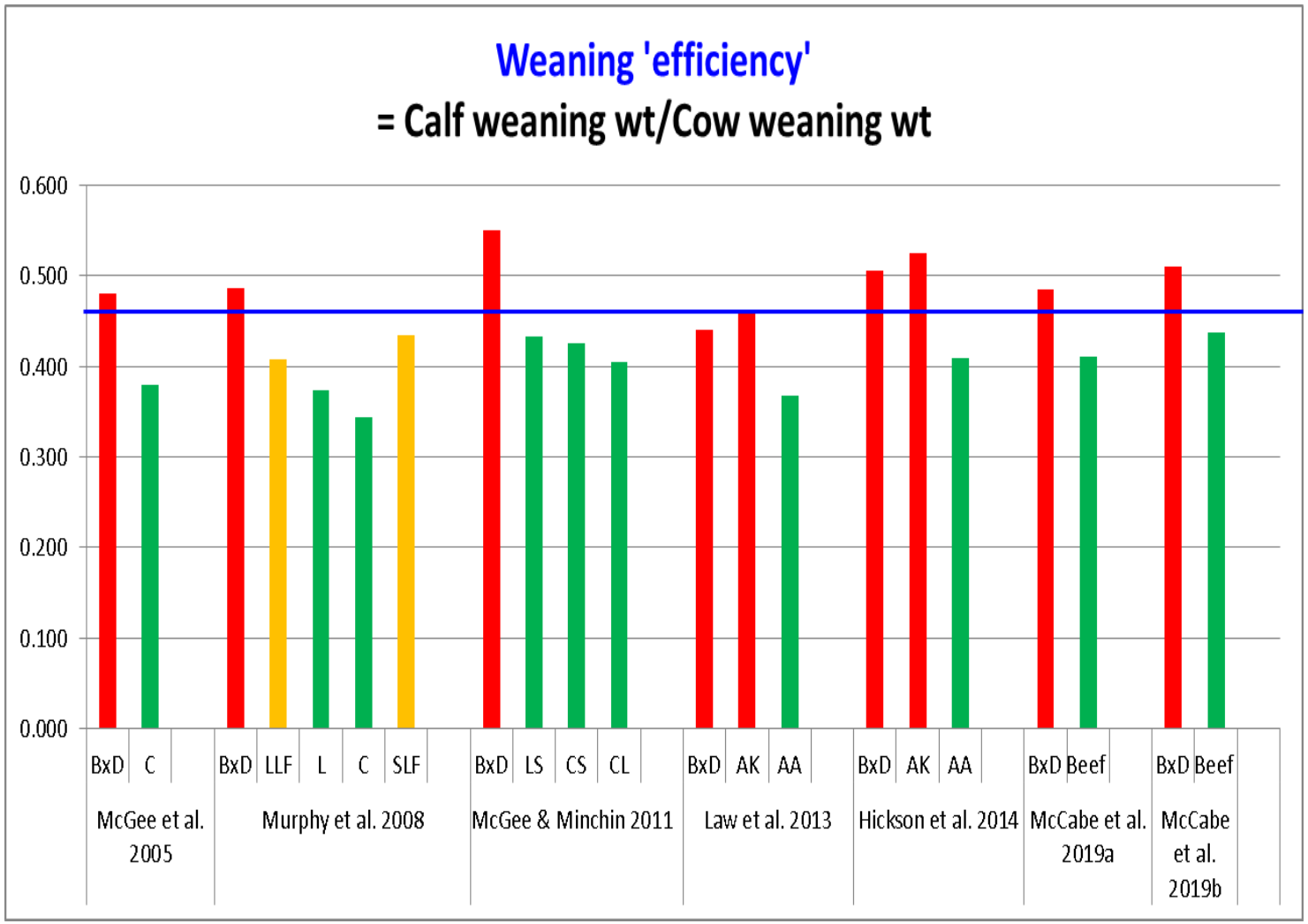
‘Weaning efficiency’ of cow breed types



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‘Weaning efficiency’ of cow breed types ?

↳ = calf weaning wt. / cow weaning wt.

	Beef x Dairy	Beef x Beef			Beef x Dairy	Beef x Beef	
Milk yield (kg/day)	9.0	7.3	**		7.7	5.9	***
Cow wt (kg)	598	659	***		561	616	***
BCS (0-5)	2.7	3.1	***		2.69	3.00	***
Calf Weaning Wt (WW) (kg)	290	271	*		286	269	*
Grass DMI (kg/day)	13.8	13.0	P=0.07		12.4	11.6	***
Grass DMI/kg BW (g)	22.7	19.9	***		23.0	19.6	***
Milk yield/100kg BW (kg)	1.52	1.13	***		1.44	0.99	***
Milk yield/GDMI (kg)	0.68	0.57	**		0.63	0.52	***
Calf ww/Cow wt	**0.485**	**0.411**	**1.18**		**0.510**	**0.437**	**1.17**
Calf ww/Cow DMI (kg LW)	**21.0**	**20.8**	**1.01**		**23.1**	**23.2**	**0.99**

Overall: 4-year study:

Cow breed types did **not differ** (P>0.05) in,

- Calving date
- Calf birth weight
- Calving ease
- Reproduction
- Calf mortality
- Cow survival

Source: McCabe et al. (2019a & b) – Teagasc Grange