Relationships between cow genetic merit and maintenance energy requirement and energetic efficiency in lactating Holstein-Friesian cows

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Introduction

- Genetic merit selection programme significantly improved milk production for dairy cows

  e.g. In UK, the average milk yield of national Holstein-Friesian (HF) herd increased from 5151 to 7533 kg between1990 and 2011.

- Improved genetic merit and production efficiency may influence maintenance energy requirement and energetic efficiencies under current feeding regimes

- However, there is little information available in the literature on the meta-analysis for the effect of cow genetic merit on maintenance energy requirement and energetic efficiencies using a large calorimeter dataset

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Objective

To evaluate if there was any significant relationship between genetic merit and energetic efficiency parameters using meta-analysis of calorimeter data

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AFBI calorimeter data

- **736** data collated from lactating Holstein-Friesian dairy cows
  - From **31** respiration calorimeter chamber studies at this institute
  - Forage only diets (n = 66) and mixed diets with majority from grass silage and others – maize silage, whole crop wheat, straw, fresh grass, dried grass and lucerne (n = 670)

- **Definition of genetic merit of Holstein cows in UK**

  2 economic indexes were used

  - **Profit Index** (PIN, £):
    Based on production traits – milk yield, and fat and protein yield (kg)
  - **Profitable Lifetime Index** (PLI, £):
    Production traits and other functional traits – health, fertility, life span, welfare and fitness, etc.
    These two indexes predict the expected revenue per lactation (PIN) or per year (PLI)

  - Genetic merit (PIN and PLI) values used in the current study is based on the 2010 UK Holstein population data. All PIN and PLI data obtained before 2010 have been converted to 2010 basis. More information can be found in the website of Holstein UK http://www.ukcows.com or DairyCo http://www.dairyco.org.uk/

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Statistical Analysis (1)

Two methods were conducted using meta-analysis

- **Method 1:**
  - Using the whole PIN and PLI dataset to evaluate if there was any significant relationship between genetic merit and ME requirement for maintenance (ME_m, $MJ/kg^{0.75}$), or efficiency of ME utilisation for lactation (k_l)

ME_m =	a × PIN (or PLI) + b
k_l =	a × PIN (or PLI) + b

  - ME_m (MJ/d) and k_l was calculated on individual animal basis

ME_m	The ME_m was calculated from HP minus energy losses from the inefficiencies of ME use for lactation, tissue change and pregnancy
k_l	$k_l = (E_l + a \times E_g)/(\text{ME intake} - ME_m)$

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Statistical Analysis (2)

- **Method 2:**
  - Dividing each whole PIN and PLI dataset into 3 sub-groups - categorised as low, medium, and high genetic merit group

  - To compare if there was any significant difference among coefficients (with a common constant) in linear regressions between energy intake and energy output parameters

For example, linear regressions between ME intake (MJ/kg$^{0.75}$) and milk energy output adjusted for zero energy balance ($E_{l(0)}$, MJ/kg$^{0.75}$) were developed within 3 sub-groups of PIN dataset

	Equations		
PIN sub-groups		Coefficient	Constant
Low	$E_{l(0)}$ =	$\mathbf{a_1}$ × ME intake	**b**
Medium		$\mathbf{a_2}$ × ME intake	
High		$\mathbf{a_3}$ × ME intake	

Genetic merit and animal performance data

	No. of data	Mean	S.D.	Minimum	Maximum
Profit Index (£)	736	10	15.9	-54	63
Profitable Life Index (£)	408	3	51.3	-131	145
Live weight (kg)	736	555	65.6	384	733
Body condition score	736	2.5	0.37	1.5	4.5
Milk yield (kg/d)	736	22	7.7	1	49
ME intake (MJ/d)	736	198	45	74	320

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Energy efficiency data (n = 736)

	Mean	S.D.	Minimum	Maximum
DE/GE	0.740	0.0527	0.498	0.879
ME/GE	0.637	0.0472	0.423	0.753
Heat production/ME intake	0.639	0.0865	0.480	1.315
Milk energy/ME intake	0.352	0.0829	0.037	0.711

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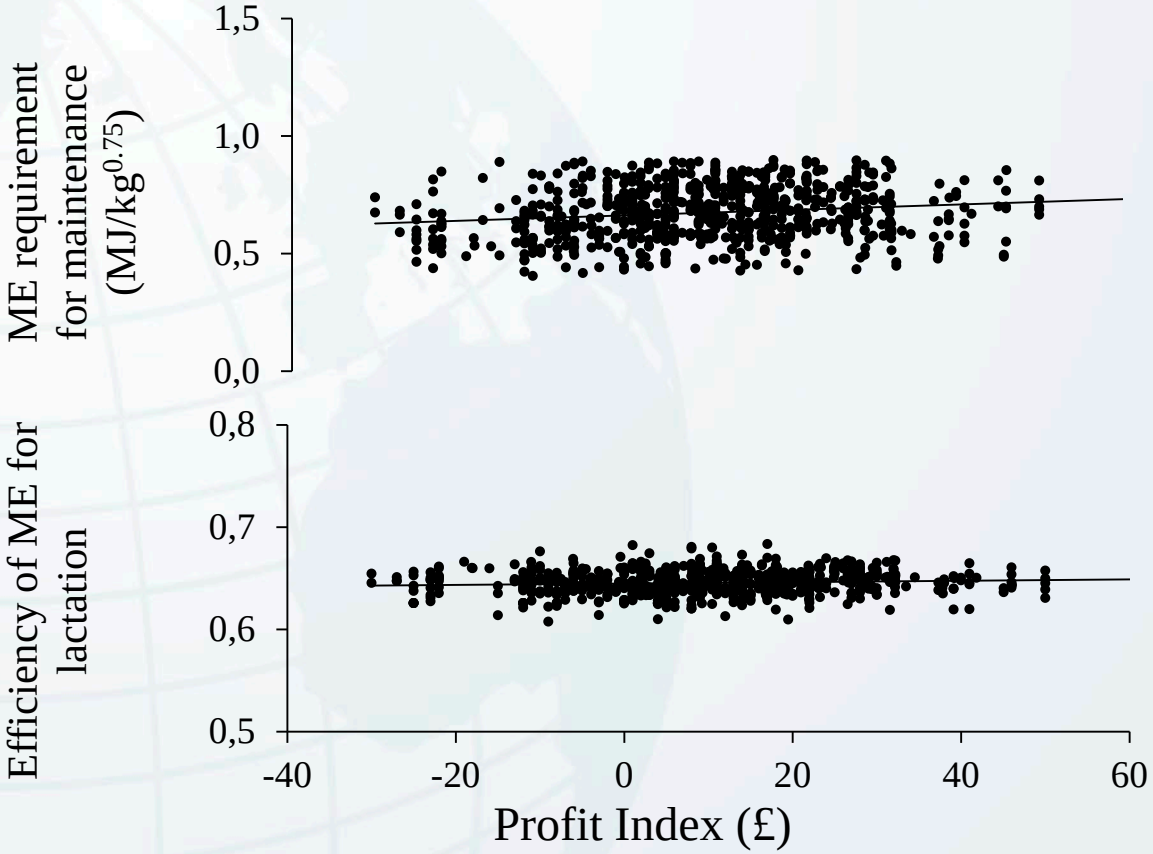
Relationship between PIN and ME_m or k_l



- With the whole dataset of PIN, there was no significant relationship between PIN and ME_m ($MJ/kg^{0.75}$) or k_l, which demonstrated that cow genetic merit have little effect on maintenance energy requirement or energetic efficiency

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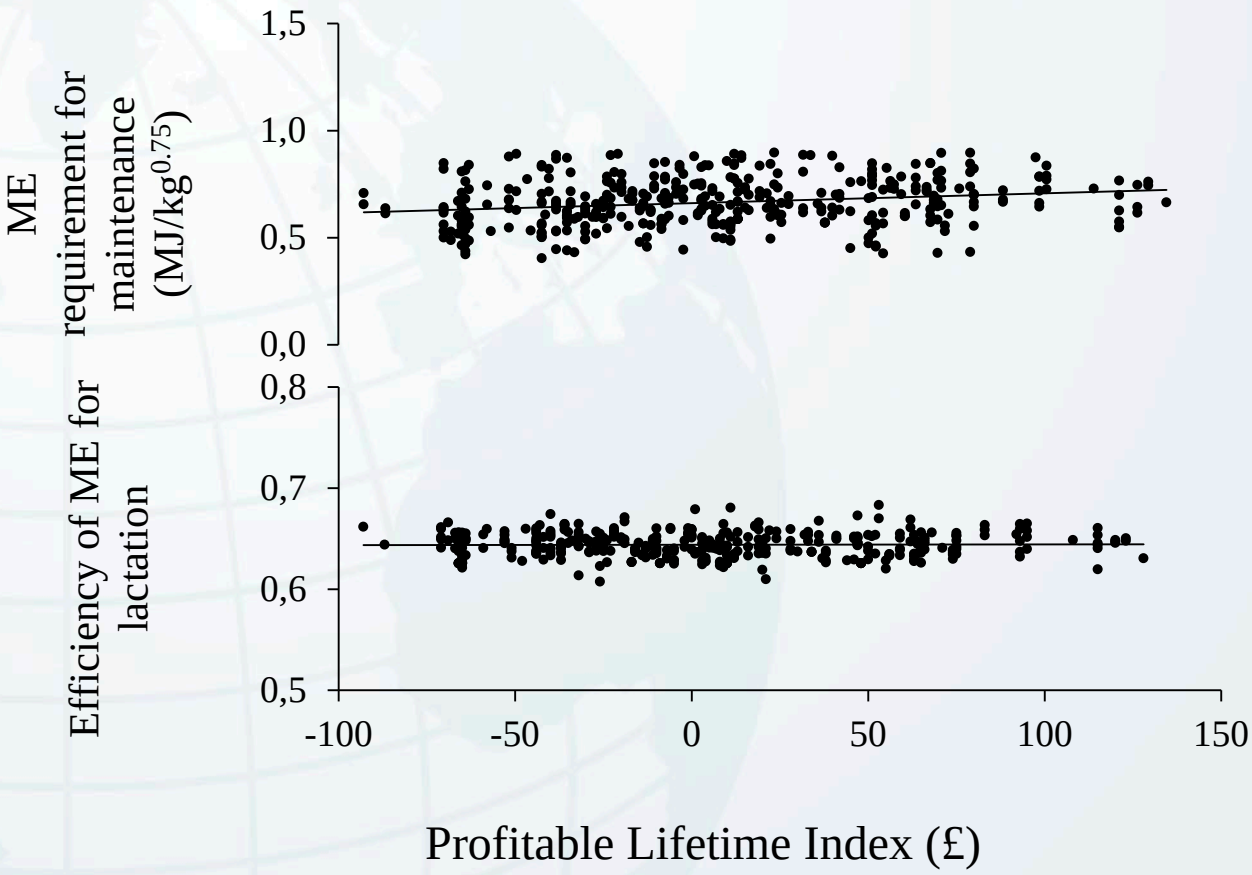
Relationship between PLI and ME_m or k_l



- With the whole PLI dataset, there was no significant relationship between PLI and ME_m (MJ/kg$^{0.75}$) or k_l, which demonstrated that cow genetic merit have little effect on maintenance energy requirement or energetic efficiency

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Comparison of energetic variables within low, medium and high GM groups---PIN sub-groups

Cow genetic merit		Slope		Constant	R^2
Low		**0.062**	ME intake		
Medium	ME_m =	**0.062**	ME intake	0.563	0.32
High		**0.065**	ME intake		
Low		0.631	ME intake		
Medium	$E_{l(0)}$ =	0.638	ME intake	-0.442	0.88
High		0.643	ME intake		
Low		0.321	ME intake		
Medium	HP =	0.317	ME intake	0.526	0.79
High		0.323	ME intake		

- With PIN dataset, there was no significant difference among coefficients in each set of 3 relationships (low vs. medium vs. high) between ME intake ($MJ/kg^{0.75}$) and ME_m ($MJ/kg^{0.75}$) , $E_{l(0)}$ ($MJ/kg^{0.75}$) , or heat production ($MJ/kg^{0.75}$)

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Comparison of energetic variables within low, medium and high GM groups---PLI sub-groups

Cow genetic merit		Slope		Constant	R^2
Low		0.058	ME intake		
Medium	ME_m =	0.056	ME intake	0.568	0.34
High		0.059	ME intake		
Low		0.632	ME intake		
Medium	$E_{l(0)}$ =	0.633	ME intake	-0.440	0.85
High		0.634	ME intake		
Low		0.336	ME intake		
Medium	HP =	0.336	ME intake	0.495	0.78
High		0.339	ME intake		

- With PLI dataset, there was no significant difference among coefficients in each set of 3 relationships (low vs. medium vs. high) between ME intake ($MJ/kg^{0.75}$) and ME_m ($MJ/kg^{0.75}$) , $E_{l(0)}$ ($MJ/kg^{0.75}$) , or heat production ($MJ/kg^{0.75}$)

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Conclusions

- Cow genetic merit has no significant effects on maintenance energy requirement or the efficiency of ME use for lactation in Holstein-Friesian cows; High milk production with high genetic merit cows may mainly be derived from their high feed intake

- Maintenance energy requirement (ME_m, $MJ/kg^{0.75}$) is not a constant value but increased with increasing feed intake

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