# GENETICS OF FEED INTAKE AND EFFICIENCY IN GRAZING DAIRY COWS

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**Alan Michael Hurley**

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## Abstract

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Feed efficiency in dairy cows is widely acknowledged as a highly desirable characteristic to improve because of its well-documented impact on production costs. Traditional measures of feed efficiency have used ratio traits, specifically energy conversion efficiency, but these have undesirable statistical properties. Alternative measures of feed efficiency are those based on the residuals from regression-type statistical models, the most common of which is residual energy intake (**REI**). Residual energy intake is defined as the difference between actual and predicted intake and is usually derived from least squares regression models. The general objective of this thesis was to quantify phenotypic and genetic (co)variances between the feed intake complex, performance, and fertility traits in lactating Holstein-Friesian dairy cows. A total of 8,199 feed intake records from 2,693 lactations on 1,412 grazing lactating Holstein-Friesian dairy cows from experimental farms were used. Several alternative efficiency definitions were developed, each with their own respective strengths and weaknesses. Exploitable genetic variation was demonstrated to exist for the range of alternative efficiency traits, and the magnitude of this variation was sufficiently large to justify consideration of the feed efficiency complex in future dairy breeding goals. The heritability estimates for the different efficiency traits estimated using repeatability models varied from 0.06 to 0.21. Variance components, however, differed across lactation when estimated using random regression models; for example, the heritability of REI varied from 0.04 (34 DIM) to 0.11 (280 DIM) across lactation. Phenotypic

correlations among many traits including REI and energy balance (EB) differed not only by stage of lactation but also by cow parity. Moderate to strong genetic correlations existed between REI and EB across lactation (ranging from 0.45 to 0.90). Albeit associated with large standard errors, estimated genetic correlations between feed efficiency and reproductive performance were either neutral or favourable suggesting greater genetic merit for feed efficiency does not appear to be antagonistically genetically correlated with reproductive performance. Selection index calculations using the current economic weights in the Irish Economic Breeding Index, and genetic (co)variances estimated in this thesis, indicate that the inclusion of REI in the index with an economic weight of €0.078/UFL will generate animals with improved REI.

## Declarations

This thesis contains no material that has been accepted for a degree or diploma by the University or any other institution. To the best of my knowledge no material previously published or written by another person has been used, except where due acknowledgement has been made in the text.

This thesis has been written with chapters formatted as papers for publication. Therefore there is some repetition of chapter methods; each chapter contains a full discussion, with the final general discussion chapter providing a succinct discussion of key findings of this thesis. Each chapter has been formatted for the Journal of Dairy Science and each chapter has a complete list of references. The submitted manuscripts include supervisors as co-authors; however, for each chapter I planned the study, undertook the analysis and wrote the manuscripts with directions of those co-authors.

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Go raibh maith agaibh as bun mo chroí.

"One day, in retrospect, the years of struggle will strike you as the most beautiful"

Sigmund Freud

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## List of Abbreviations

AFC = Age at first calving
BCS = Body condition score
BW = Body-weight
$BW^{0.75}$ = Metabolic body-weight
CFS = Calving to first service interval
CIV = Calving interval
CV = Coefficient of variation
DIM = Days in milk
DMI = Dry matter intake
EB = Energy balance
ECE = Energy conversion efficiency
$ECE_{adj}$ = Energy conversion efficiency adjusted
$ECE_{maint}$ = Energy conversion efficiency taking account of maintenance
ECR = Energy conversion ratio
EBI = Economic breeding index
EBV = Estimated breeding values
FC = Fat concentration
FtW = Feed to body-weight
ICBF = Irish cattle breeding federation
KG = Kilogram
KR = Kleiber ratio
LC = Lactose concentration
MEff = Metabolic efficiency
MS = Milk solids
NEI = Net energy intake
NEL = Net energy for lactation
NEM = Net energy of maintenance
NS = Number of services
PEMEP = Partial efficiency of milk production
$PEMEP_{Nut}$ = Partial efficiency of milk production based on nutritional tables
PC = Protein concentration
PRFS = Pregnancy rate to first service
PR42 = Pregnancy in first 42 days of breeding season
PR84 = Pregnancy in first 84 days of breeding season
REI = Residual energy intake
$REI_{maint}$ = Residual energy intake taking account of maintenance
REP = Residual energy production
$REP_{maint}$ = Residual energy production taking account of maintenance
RIEP = Residual intake and energy production
SE = Standard error
SR21 = Submission rate in the first 21 days of the breeding season
UFL = Unité fourragère du lait

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