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**QUANTIFYING GENETIC VARIATION IN
ENVIRONMENTAL SENSITIVITY OF NEW ZEALAND
DAIRY CATTLE TO APPLY IN THE DEVELOPMENT
OF A DAIRY CATTLE SIMULATION MODEL FOR
PASTORAL SYSTEMS**

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ABSTRACT

The objectives of this research were firstly, to investigate if dairy cattle genotypes in NZ exhibit genetic variation in environmental sensitivity and to determine if this genetic variation is statistically significant from a genetic evaluation perspective, and secondly, to use genetic information including environmental sensitivity data to simulate dairy cattle responses to changes in nutritional regime and variation in climate.

A comprehensive review identified that simulation models either overlook, or do not represent environmental sensitivity information where genotypes and breeds respond differently when exposed to variations in environment. A large dataset of daily and total lactation records (yields of milk, fat and protein) from herds participating in the progeny testing of sires from 1989 to 2002 was obtained to test for differences in the environmental sensitivity of dairy cattle in New Zealand. Production data was matched with environmental data relating to climate, herd size, altitude and herd average production levels (a proxy for feeding level). The statistical analyses applying univariate and bivariate multibreed models to environmental character states identified minimal sire re-ranking between environmental character states as measured by genetic and rank correlations. However, differences in yields of milk, fat and protein between New Zealand Jersey and overseas Holstein Friesian systematically diverged with production level, in herds expected to use different levels of supplements. These results suggest New Zealand Jersey cattle are best suited to a grassland-type environment, and overseas Holstein Friesian cattle are more suited to an intensive-type environment. A phenotypic analysis identified thermal environment (cold and hot conditions) significantly affected the expression of production traits in Holstein Friesian, New Zealand Jersey and Holstein Friesian x New Zealand Jersey cattle. Holstein Friesian dairy cattle were more susceptible to the effects of heat conditions than New Zealand Jersey cattle with yields of milk, and concentrations of fat and protein of the former compromised at a lower value for temperature humidity index. Dairy cattle performance is likely to be compromised by heat more frequently than cold conditions in New Zealand.

A simulation model that considers how dairy cow genotypes respond to different environments, incorporating the results presented above, was then developed. An initial estimate of feed intake is used to define cow genetic potential based on estimated breeding values for total yields milk, fat and protein, and environmental sensitivity information. A mammary gland module then predicts daily yields of milk, fat and protein based on the cow's genetic potential after considering her age, stage of lactation, body condition score, nutritional status and thermal environment. Live weight change is also predicted via a body energy stores module, which considers the effect of age, stage of lactation, current body condition score, nutritional status, and an estimated breeding value for body condition score. Feed intake is predicted from the requirements for maintenance, growth and pregnancy, and the genetic drive for yields of milk, fat and protein and body fat change. The predictive ability of the model was tested using information from a prior study with two Holstein Friesian genotypes managed in a pasture-based system. The model simulated to a high degree of accuracy, mean values for yields of milk, fat and protein, and concentrations of fat and protein of each genotype. Various tests identified the major source of error between simulated and observed values were due to a lack of simulated variation.

In conclusion, the extent of genetic variation in environmental sensitivity for total lactation yields of milk, fat and protein within the range of New Zealand environments are not sufficient to warrant the formation of separate breeding schemes for distinct environments. However, New Zealand Jersey cattle are best suited to a grassland-type environment, and overseas Holstein Friesian cattle are more suited to an intensive-type environment. Genetic variation in the suitability of different breeds for specific environments existed within breeds. A simulation model was developed that was able to simulate the effect of genotype, environment and genotypic differences in environmental sensitivity on daily cow performance.

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LIST OF ABBREVIATIONS

Abbreviation	Full Description
BCS	Body condition score
BGT	Black globe temperature
CNCPS	Cornel Net Carbohydrate and Protein System
CSI	Cold stress index
DIM	Days in milk
E	Environment
EBV	Estimated breeding value
EI	Economic index
E_p	Permanent environmental effects
E_t	Temporary environmental effects
G	Genotype
G_{max}	Global maximum
GxE	Genotype by environment interaction
HF	North American, European Holstein Friesians or New Zealand Friesian
HGM	High genetic merit
HLI	Heat load index
HYS	Herd-year-season
LCI	Lower confidence interval
LGM	Low genetic merit
ME	Metabolisable energy
MGM	Medium genetic merit
MS	Milk solids
NZ	New Zealand
NZF	New Zealand Friesian
NZJ	New Zealand Jersey
OHF	North American or European Holstein Friesians
RH	Relative Humidity
r²	Coefficient of determination
r_e	Expected correlation
r_s	Spearman's rank correlation
T	Temperature
THI	Temperature humidity index
UCI	Upper confidence interval
WS	Wind speed