*Proc. Assoc. Advmt. Anim. Breed. Genet.* ***17****: 553-556*

# GENETIC VARIATION IN RECTAL TEMPERATURE AND ITS ASSOCIATION WITH HEAT TOLERANCE IN AUSTRALIAN DAIRY CATTLE

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## SUMMARY

Hot environments negatively affect dairy cattle in Australia both in regard to health issues including reproduction and also productive performance. Dairy cattle become stressed when they can no longer maintain their body temperature within the thermoneutral zone.

This paper examines the effect of heat stress under Australian conditions on dairy cattle as well as estimating genetic parameters for important heat stress traits specifically rectal temperature and milk yield. Genetic correlations were estimated using multivariate analyses between Milk Yield and Rectal Temperature and also between the difference in Milk yield between hot and cool days and the difference in Rectal temperature.

Rectal temperature data was collected from sixteen dairy operations in the Hunter Valley from October 2001 to March 2002. Individual animals had multiple rectal temperature and milk production records taken. The majority of the dairy cattle were pure Holstein Friesian. The data set included 2314 cows from 519 sires and 1538 dams from which 5559 rectal measurements were recorded from 59 individual herd-testing days.

Heritability was estimated for Rectal temperature and difference in Milk yield between hot and cool THI days and difference in rectal temperature between hot and cool THI days with the estimates being 0.11, 0.46 and 0.17 respectively.

The genetic correlation between Hot-Cool day difference in Milk yield and in Rectal temperature was 0.28± 0.33. Genetic gain for both production and heat tolerance could be achieved and would be especially useful for areas that have periods of high heat and humidity. However the additional benefit of measuring rectal temperature is limited. In contrast using difference in milk yield as a trait of heat tolerance could be implemented with no need for additional animal or production measurements.

## INTRODUCTION

Heat stress plays a significant negative role in milk production throughout the world especially in countries with tropical or hot and dry conditions. Australia is no exception with many areas having periods when conditions are not ideal for dairy cattle production systems.

This is of concern especially in Australia with the threat of increased temperatures due to global warming. These conditions combined with the importation of semen from highly productive American and European bulls can lead to exacerbated heat stress problems. Overseas bulls whose semen is used in Australia pass onto their Australian daughters the genetic potential to metabolize large amounts of energy and therefore produce large amounts of milk under temperate conditions and high input management regimes. However these are not the conditions under which the Australian daughters are producing. In contrast Australian conditions consist of low input management systems relying mostly on pasture based feeding within a sometimes-hostile environment that places heavy demands on these Australian daughters especially during periods of elevated temperature and humidity.

There are several ways to lessen the effect of heat stress on dairy cattle including both genetic selection of dairy cattle and modification of the dairy cattle's environment. This paper will look at the ability of genetic selection to help ease the burden of increased temperature and humidity on the dairy cattle.

Breeding for heat tolerance in dairy cattle could provide a solution to the problems of heat stress in Australian dairy herds. However as yet in Australia there is no genetic evaluation system that includes a heat tolerance trait. By incorporating a heat tolerance trait into genetic evaluation farmers would be able to select appropriate bulls for the level of heat stress that they expect. But what is the best trait to select for in heat tolerance in dairy cattle? Two options are available including selection on performance under heat stress conditions or selecting on traits related to thermo tolerance of dairy cattle chief among which is core body temperature.

**MATERIALS AND METHODS**

In this study, traits measured on animals and included in analyses include Milk yield (MY), Rectal Temperature (RT), Fat percentage of milk (FP), Protein percentage of milk (PP). Climatic variables included in analyses include Temperature Humidity Index (THI), Maximum Temperature (TMAX), Minimum Temperature (TMIN), Solar Radiation (RAD) and Relative Humidity (RH). Individual cow variables recorded include stage of lactation (DIM) and age (YEARS). Additional Heat stress related traits have also been included in the analyses including difference in milk yield between low THI and high THI days (DMY) and difference in rectal temperature between low THI and high THI days (DRT). Fixed effects included in the analyses include herd effects (HERD), Herd Test day effect (HERDTD), additive genetic effects of cow (A), and permanent environmental effects of cow (PE). Table 1 below shows a summary of the data used in this project.

**Table 1. Data Summary**

| | Minimum | Average | Maximum | SD |
|---|---|---|---|---|
| THI | 61.8 | 83.0 | 105.6 | 8.4 |
| TMAX (ºc) | 11.0 | 25.9 | 39.0 | 5.2 |
| TMIN (ºc) | 3.0 | 11.2 | 21.0 | 4.4 |
| RAD (MJ/m$^2$) | 9.0 | 22.0 | 31.0 | 5.7 |
| RH (%) | 30.3 | 48.6 | 77.1 | 11.2 |
| RT (ºc) | 36.5 | 38.7 | 41.8 | 0.6 |
| MY (L) | 2.5 | 24.6 | 57.0 | 7.6 |
| FP (%) | 0.0 | 3.6 | 6.6 | 0.6 |
| PP (%) | 0.0 | 3.2 | 4.7 | 0.3 |
| DIM | 2.0 | 160.1 | 305.0 | 83.7 |
| YEARS | 1.9 | 5.5 | 17.0 | 2.5 |

Rectal temperature data was collected from sixteen dairy operations in the Hunter Valley from October 2001 to March 2002. Individual animals had multiple rectal temperature and milk production records taken. The majority of the dairy cattle are pure Holstein Friesian with a small percentage of Three quarter Friesian Crosses or Half Friesian crosses. Records were removed from the data set that had multiple rectal temperatures associated with a single animal on a single test day. Additionally records with days in milk more than 305 days were also removed from the dataset. Test Day production records for milk yield, fat percentage and protein percentage for the period were obtained from the Australian Dairy Herd Improvement Scheme for those herds and cows which had rectal temperature data collected. The final data set included 2314 cows from 519 sires and 1538 dams. A total of 5559 rectal measurements were recorded on 59 individual herd-testing days.

The sixteen dairy herds involved in this study are located in the Hunter Valley region in NSW. Temperature Humidity Index was calculated as $THI = TMAX + 0.36\ TDP + 41.2$ (Davison et al. 1996). The meteorological data used in this project was obtained from the Victorian Department of Primary Industries.

**RESULTS AND DISCUSSION**

Heritability and repeatability estimates for RT are low in this study 0.11 and 0.28 respectively. This suggests that if rectal temperatures are to be used to make informed decisions in regard to the heat tolerance of dairy animals more accurate methods need to be used to assess core body temperature. Possible solutions to this problem that could be investigated include milk temperature, repeated rectal temperatures, and tympanic and other core temperatures. However rectal temperatures with there low heritability and repeatability are not a good method of quantifying heat stress.

Table 2 below shows the genetic parameters estimates for the heat sensitivity traits of Difference in Rectal Temperature and the Difference in Milk yield.

**Table 2. Phenotypic variance, Covariance, Heritability, Genetic and Phenotypic Correlations estimated simultaneously by regression analysis of Difference in Milk Yield and Difference in Rectal Temperature**

| | Estimate | S.E |
|---|---|---|
| Phenotypic variance of DMY | 20.93 | 1.24 |
| Phenotypic variance of DRT | 0.26 | 0.01 |
| Covariance | 0.10 | 0.01 |
| Heritability DMY | 0.46 | 0.14 |
| Heritability DRT | 0.17 | 0.11 |
| Genetic correlation | 0.28 | 0.33 |
| Phenotypic correlation | 0.04 | 0.04 |

The heritability of DMY is 0.46 ± 0.14 this high level of heritability suggests that the genes of the dairy cow are playing a large role in the sensitivity of animals to changes in THI. However these results are obtained from a rather small number of records (836) hence the large standard error. However even if the estimate 0.46 is at the high end, and a more reasonable estimate was actually more like 0.32 this is still a moderately high heritability. This is an interesting result, as it would be possible to use this information to help select for more heat tolerant animals

The heritability of DRT is 0.17 ± 0.11 like the heritability estimate for DMY the DRT has a large error associated with it due to small number of records. Difference in rectal temperature also has the same problems that rectal temperatures have in terms of difference of measurements due to error in measurement. If this heritability for DRT is accurate it may be possible to use it as a measure of heat tolerance however this seems impractical as the measurement of large number of rectal temperatures would be costly and time consuming.

**CONCLUSIONS**

This project has examined heat stress effects on production in Australian dairy cows under Australian conditions in the Hunter valley. Several genetic parameters for this population have been estimated including heritability of rectal temperature and the difference between high and low THI days in milk yield and rectal temperature. The genetic correlation was calculated between milk yield and rectal temperature differences.

Rectal temperature was responsive to changes in climatic conditions, however the repeatability of rectal temperature was relatively low at $0.28 \pm 0.0164$. If a more accurate technique for measurement of rectal temperature could be developed and the repeatability of rectal temperature was increased rectal temperature could be considered for use to aid in selection decisions.

Difference in milk yield between the hottest and the coolest day (i.e. sensitivity to heat stress) has a heritability of $0.46 \pm 0.14$. Showing that there is a genetic basis for heat sensitivity that could therefore be selected for in breeding programs. An advantage of using difference in milk yield as a trait of heat tolerance is that unlike rectal temperature or respiration rate no additional animal measurements are needed except for milk yield which is already recorded.

**ACKNOWLEDGMENTS**

This research was funded by Dairy Australia with the support of the University of New England, Australian Dairy Herd Improvement scheme (ADHIS) and the Department of Primary Industries Victoria.

**REFERENCES**

Davison, T., McGowan, M., Mayer, D., Young, B., Jonsson, N., Hall, A., Matschoss, A., Goodwin, P., Gaughan, J. & Lake, M. (1996) "Managing hot cows in Australia", Queensland Department of Primary Industry, Australia

Gilmour, A.R., Thompson, R., Cullis, B.R., and Welham, S. (1999) “ASREML Reference Manual,” NSW Agriculture, Orange, Australia