# CLASSIFYING SHEEP GRAZING ENVIRONMENTS USING SATELLITE DATA TO QUANTIFY GENOTYPE BY ENVIRONMENT INTERACTIONS

**M. B. Whelan[1], D. J. Cottle[2], K. G. Geenty[3] and D. J. Brown[4]**

[1]Southern Cross University, Lismore, NSW 2480
[2]University of New England, Armidale, NSW 2351
[3]CRC for Sheep Industry Innovation, University of New England, Armidale, NSW 2351
[4]Animal Genetics and Breeding Unit*, University of New England, Armidale, NSW 2351

## SUMMARY

Australian sheep grazing environments are currently classified into 3 very broad zones (High Rainfall, Wheat/Sheep and Pastoral) that do not differentiate sheep grazing environments to a level allowing sheep producers to assess the impact grazing environments may have on sire progeny performance. If a genotype by environment interaction (GEI) is expressed more as environments diverge then a finer classification of environments may help breeders when selecting stud rams. A sheep grazing environment classification system has been developed in this study using readily-obtainable monthly Normalised Difference Vegetation Index (NDVI), from satellite data, and monthly maximum temperature for a 10 year period.

Cluster analysis was used on the NVDI and temperature data to create 25 sheep grazing environment classes (SGEclass) around Australia. Two-way analysis of variance revealed a significant interaction between sire progeny performance and SGEclass for hogget weight, fibre diameter and greasy fleece weight. Further ASReml analysis of Merino data from Sheep Genetics illustrated that sire by SGEclass explained similar amounts of variation as sire by flock. Recording the geographic location of the flock would improve the ability to account for environmental differences between flocks.

## INTRODUCTION

The Sheep Genetics (SG) database contains records for approximately 2 million sheep and is used by ram breeders and commercial producers throughout Australia (Sheep Genetics 2008). SG offers breeders and commercial growers information about the breeding value of sheep from all sheep growing regions. However, selecting sires bred and evaluated in environments that differ greatly from where their progeny will be farmed increases the chances of GEI being expressed for some traits (Amores *et al.* 1999; Brown *et al.* 1999; Carrick 2005). On the other hand, ignoring superior sires because of an expectation of GEI may be reducing productivity on some farms (Kaine *et al.* 2002).

Many researchers consider that GEI is not uniform for all traits (Atkins *et al.* 1998; Carrick 2005). SG accommodates a large number of traits and using many of these in a breeding objective increases the likelihood of GEI. Therefore, classifying environments for a national breeding system will improve the effectiveness of breeding values because environment can be included as a fixed effect in the model. Providing a mechanism that enables breeders and commercial growers to quantify GEI will enable them to be more objective in selecting sires.

Classification of farming land has been used to help quantify GEI in beef cattle (Bertrand *et al.* 1985) and dairy cattle (Weigel and Rekaya 2000). Bertrand *et al.* (1985) considered that predicted breeding values of beef sires would be less accurate if a significant sire x environment interaction existed. The present ABARE division of grazing environments into High Rainfall, Wheat/Sheep

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and Pastoral zones is probably too broad to be useful in describing environments in the context of GEI. The aim of this study was to evaluate a sheep grazing environment classification derived from satellite data to determine if it could be successfully used as a fixed factor representing grazing environments in the SG database.

## MATERIALS AND METHODS

The Sheep Grazing Environment classes (SGEclasses) were derived by combining temperature data, as a surrogate for pasture quality, (Wilson and Ford 1972) and the normalised difference vegetation index (NDVI) derived from National Oceanic and Atmospheric Administration, Advanced Very High Resolution Radiometer (NOAA AVHRR) data as a measure of pasture quantity (Hill *et al.* 1998). These data were recorded monthly for each cell of a 10km by 10km grid of Australia for a 10 year period (1996 to 2005). Cluster analysis of the resulting image (120 layers of NDVI/temperature data) was used to generate 25 SGEclasses. The SGEclasses formed a mosaic of grazing environments across Australia.

The SG data were collected without any geographic information. The postcodes recorded as part of the property managers' addresses were used to locate SG sites. A SGEclass was allocated to each postcode by overlaying the postcode coverage on a map of SGEclasses.

**Preliminary analysis.** Preliminary analysis was conducted by filtering the data to select sires whose progeny were represented in 5 SGEclasses. The same sires could not be evaluated for all traits. The performance of progeny was based on hogget weight (4 sires, 1265 progeny), fibre diameter (5 sires, 1123 progeny) and fleece weight (2 sires, 1383 progeny) and were compared in 5 SGEclasses. Two-way analysis of variance, with sire and SGEclass as main effects and Sire x SGEclass as an interaction term, was used to determine if an interaction between sire progeny performance and SGEclasses existed. The significance ($P<0.05$) of the interaction was used to determine the need for further analysis.

**Analysis of Sheep Genetics data.** Data for yearling body weight, greasy fleece weight and fibre diameter were extracted from the MERINOSELECT database (Brown *et al.* 2007) for animals born in 2000 and later to conduct a more detailed analysis. The dataset contained 168,685 animals with pedigree information and 77,744, 70,461 and 80,337 animals with records for body weight (WT), greasy fleece weight (GFW) and fibre diameter (FD) respectively. The 95 flocks with data were grouped into 12 SGEclasses based on the post code of the flock. Three models were analysed for each trait; 1) normal Sheep Genetics model; 2) a model with sire by flock interactions fitted as an additional random effect; and 3) a model with sire by SGEclass interactions fitted as an additional random effect. A more detailed description of the models for analyses can be found in Brown *et al.* (2009).

## RESULTS AND DISCUSSION

**Preliminary results.** Two-way analysis of variance revealed a significant interaction ($P<0.001$) between sire and SGEclasses for all traits. Figure 1 illustrates the differences in progeny performance (hogget weight) in the different environments. Similar differences were found for GFW and FD. SGEclass 25 represents the best grazing environment while class 16 represents the worst grazing environment illustrated with the other classes falling between these extremes. However, the gradation between the classes is not scaled.

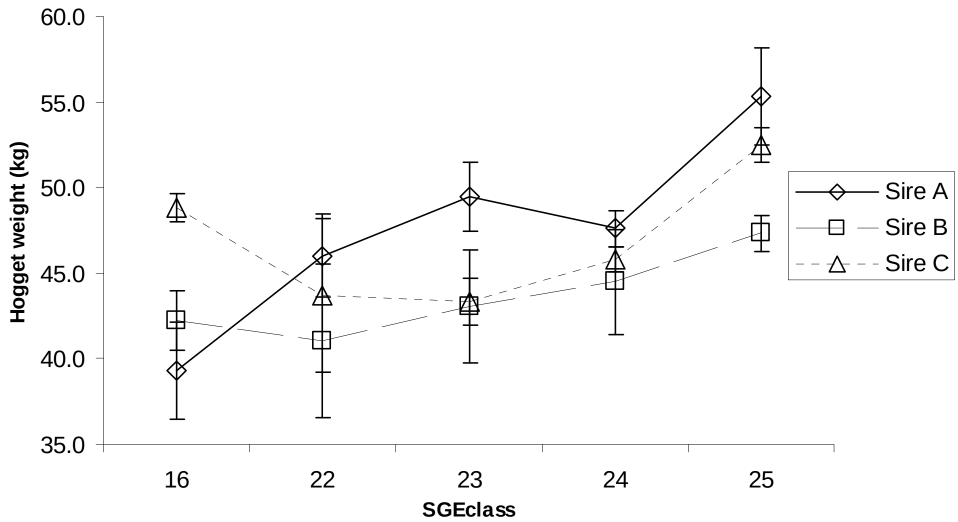


**Figure 1. Hogget weight of sire progeny in 5 SGEclasses with 95% confidence interval.**

**Sheep Genetics data.** The preliminary analysis was restricted to a small number of sires represented in 5 SGEclasses. The ASReml analysis included a much larger number of observations of progeny performance and took into account genetic and maternal effects and included a larger number of sires from the SG database. The significant interaction between sire and SGEclass meant that the more robust analysis using ASReml was warranted.

**Table 1. Phenotypic variance ($\sigma^2_p$), direct ($h^2_d$) and maternal ($h^2_m$) heritabilities, maternal permanent environmental ($c^2$) and sire by flock-year (Model 2) or sire by SGEclass (Model 3) ($s^2$) effects as a proportion of phenotypic variance with and without sire by flock-year or SGEclass interactions included in the model (se in parentheses)**

| Trait | Model | $\sigma^2_p$ | $h^2_d$ | $h^2_m$ | $c^2$ | $s^2$ | LogL |
|---|---|---|---|---|---|---|---|
| Wt | 1 | 34.68 (0.23) | 0.44 (0.01) | 0.03 (0.01) | 0.02 (0.01) | | -995.3 |
| Wt | 2 | 35.29 (0.26) | 0.38 (0.02) | 0.03 (0.01) | 0.03 (0.01) | 0.05 (0.00) | -859.3 |
| Wt | 3 | 35.32 (0.26) | 0.39 (0.02) | 0.02 (0.01) | 0.03 (0.01) | 0.04 (0.00) | -891.5 |
| Gfw | 1 | 0.41 (0.00) | 0.36 (0.01) | 0.03 (0.01) | 0.03 (0.01) | | -1841.9 |
| Gfw | 2 | 0.42 (0.00) | 0.25 (0.02) | 0.02 (0.01) | 0.04 (0.01) | 0.08 (0.01) | -1574.5 |
| Gfw | 3 | 0.42 (0.00) | 0.25 (0.02) | 0.02 (0.01) | 0.04 (0.01) | 0.08 (0.01) | -1627.0 |
| FD | 1 | 1.34 (0.01) | 0.61 (0.01) | | | | -5530.6 |
| FD | 2 | 1.35 (0.01) | 0.58 (0.01) | | | 0.03 (0.00) | -5470.4 |
| FD | 3 | 1.35 (0.01) | 0.58 (0.01) | | | 0.03 (0.00) | -5476.0 |

Sire by flock (Model 2) had the greatest improvement in Log likelihood of the 3 models, however sire by SGEclass (Model 3) explained similar amounts of phenotypic variation as sire by flock (Table 1). This suggests that the SGEclass category may provide a simpler way of accounting for environmental variance and GEI in SG analyses than fitting flock effects, as there are much fewer SGEclasses than there are flocks.

To accurately estimate interactions of sire across flocks or SGEclasses adequate representation of sire across different flocks or SGEclasses is essential however in these data 25% of all progeny were from sires used across more than 1 flock, while 21% of all progeny came from sires used across SGEclasses.

## CONCLUSIONS

When breeders choose a sire to improve performance, the flock-year term in SG analyses represents the grazing/management environment of the sire's progeny, the effect of ewes on production traits and other factors (e.g. incorrect data recording, preferential treatment of link sires and heterosis). Recent research has indicated that fitting an additional random interaction term for sires used across flocks and years improved the accuracy of breeding values. The results presented here demonstrate that it may be possible to replace the flock-year term with SGEclasses. Given that the SGEclasses are based on 10 years of pasture availability (NDVI) and quality (temperature) it may provide a more usable measure of the grazing environment than the many flock-year effects. The flock in the SG database represents a single geographic point in sheep grazing areas of Australia. The SGE classification provides a method of clustering flocks into groups that have similar grazing environments. These groupings may give breeders more confidence when selecting sires from other flocks within the same SGEclass or the ability to determine the level of risk of selecting a desirable sire with performance records from a different SGEclass.

In this study the geographic location of a property was based on the postcode of the contact address and not the location of the property. Many flocks had to be removed from the analysis because the postcodes were not in sheep grazing areas or the area covered by a single postcode was represented by a number of SGEclasses. Collecting GPS coordinates of the flocks would enhance the reliability of the allocation of flocks to the SGEclasses.

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