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GENETIC AND NON-GENETIC EFFECTS ON FLIGHT SPEED AND AGITATION IN WEANED LAMBS

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SUMMARY

By identifying sheep with a genetic or environmentally-induced propensity for stress, it is possible to manage or select against those sheep to minimise stress and improve the welfare and ease of handling of the entire flock. In this study we used established behavioural measures, including flight speed and agitation scores. However, behavioural measurements can be difficult and time consuming. Therefore we also assessed the possibility of using facial wool cover, a subjective score already used by industry, as an indicator for behavioural reactivity in sheep.

This study investigated the 2008-2010 cohorts of the Information Nucleus. Eight flocks totaling 11,047 lambs were tested. Flight speed and agitation were measured at 2-6 weeks post-weaning. Lambs were assigned face cover scores at 8 months of age.

Low to moderate heritability estimates of flight speed (0.11±0.02) and agitation (0.20±0.02) indicate that while there is an inherent component to behaviour as measured in these tests, that component is small. A moderate genetic correlation was found between flight speed and agitation (0.19±0.10), though the phenotypic correlation was low. Heavier and female lambs were more reactive than lighter and male lambs in both behavioural tests. Terminal sire x Merino cross lambs were faster in the flight speed test than other types (pure Merino or second cross). In one flock, younger lambs were more reactive in the agitation test. The two behavioural traits varied independently such that flocks with high average flight speeds did not necessarily have high average agitation scores.

Face cover score was highly heritable (0.39±0.03), similar to earlier work. Phenotypic and genetic correlations between behaviours and face cover were low, indicating face cover will not be a useful indicator for these behavioural tests.

INTRODUCTION

Behavioural reactivity is an animal's behavioural response to stress. This is underlain by a pattern of neuro-endocrine system responses which may be controlled by genetics, and permanent and temporary environmental effects. By identifying sheep with a genetic or environmentally-induced propensity to react negatively to stress, it is possible to manage those sheep to minimise stress, or to select against them during breeding to improve the welfare and ease of handling of the entire flock (Burrow 1997).

Successful divergent breeding of sheep based on apparent differences in behaviour has been achieved, indicating that behaviour is heritable (Beausoleil *et al.* 2012). Identification of behavioural measures that are correlated with breeding objectives and that are heritable could result in the development of genetic improvement programs to reduce sheep reactivity to handling, enhancing flock welfare and ease of handling (Ponzoni and Newman 1989).

It is likely that non-genetic factors also affect the expression of behavioural reactivity. Agitation and flight speed are objective behavioural tests which have been used in Australian sheep research. Previous estimates of heritability for these traits were low to moderate (Blache and

Ferguson 2005; Hocking Edwards *et al.* 2011; Plush *et al.* 2011), supporting the hypothesis that flight speed and agitation are also influenced by non-genetic factors, such as sex, age and breed.

Measuring behaviour is difficult and time consuming. An indicator trait which is easy to assess, correlated to the behavioral trait of interest and heritable would make selection much easier. Facial hair patterning may be a potential candidate. There is evidence in cattle that facial hair patterning is related to behaviour, with associations found between the position of the facial hair whorl and agitation during restraint and handling (Olmos and Turner 2008). Hair whorl position has also been related to behaviour in other species (Tomkins *et al.* 2012). Sheep do not exhibit a facial hair whorl. However, a similar trait, face cover, is measured routinely in sheep.

This study aimed to estimate the heritability of agitation and flight speed, assess the impacts of non-genetic factors on these behaviours and evaluate the usefulness of face cover as an indicator for behaviour in lambs

MATERIALS AND METHODS

This study investigated the 2008-2010 cohorts of the Cooperative Research Centre for Sheep Industry Innovation's "Information Nucleus" lambs. The full structure of this flock has been described by Fogarty *et al.* (2007).

Flight speed and agitation were measured on lambs at two to six weeks after weaning. Flight speed was the average speed at which a lamb crosses a 1.7m distance (Burrow 1997), measured using infra-red start and stop beams attached to a timer. Flight speed was measured as the lamb exited the weigh crate. Agitation was measured using an isolation test. The lamb was restrained within a fully enclosed box with dimensions 1.5m x 0.7m x 1.5m. Vibrations caused by movement and vocalisation of the lamb over 30 seconds were measured (Plush *et al.* 2011).

Face cover is a subjective score of the amount of wool on the face (*Visual Sheep Scores* 2007). Scores range from 1: open face with no wool in front of the ears and top knot or on the jowls, to 5: heavy wool growth over the entire face with wool from the top and side of the muzzle joining. Animals are scored at four months of age or older.

Data. In 2008 a total of 3992 lambs were measured, with 3841 lambs in 2009, and 3214 lambs in 2010. Records for each of these animals included behavioural measures, weights and demographics such as age, sire and dam breeds, management group, flock and year of birth. Across the three years 5599 males and 5440 females were measured. A pedigree was available with up to three generations of data plus source genetic groups for most animals.

Analysis. A linear mixed animal model was fitted to the behaviours using ASReml (Gilmour *et al.* 2009). The model contained fixed effects of flock, sex, lamb age (nested within flock), birth-rearing type (11, 21, 22, 31, 32, 33), lamb breed (Merino, Maternal x Merino, Terminal x Maternal, Terminal x Merino), weaning weight and faecal worm egg count. No interactions were significant. Animal (pedigree), management group (within flock and drop) and sire (within flock) were fitted as random terms. This model was used to calculate variances and heritabilities for each trait, in addition to probabilities for the fixed effects. The model was then fitted as a bivariate to estimate phenotypic and genetic correlations between flight speed, agitation and face cover.

RESULTS AND DISCUSSION

The low to moderate heritability estimates of flight speed and agitation (Table 1) indicate that while there is an inherent component to behaviour as measured in these tests, that component is small. The values found here are in agreement with previous estimates (Hocking Edwards *et al.* 2011; Plush *et al.* 2011), but are lower than that suggested by Blache and Ferguson (2005).

Table 1. Variance (on the transformed scale) explained by each of the random effects as proportion of total variance, and heritability estimates for flight speed, agitation and face cover.

	Flight speed	Agitation	Face cover
Management group	0.035 (22%)	1.11 (20%)	0.081 (19%)
Genetic (animal)	0.014 (9%)	0.86 (16%)	0.139 (32%)
Genetic x Environmental (sire x site)	0.005 (3%)	0.11 (2%)	0.030 (7%)
Residual	0.107 (66%)	3.42 (62%)	0.186 (43%)
Heritability estimate	0.11±0.02	0.20±0.02	0.39±0.03

Flight speed and agitation were poorly correlated with each other phenotypically, though moderately genetically correlated (Table 2). This is supported by previous analyses of these tests in related sheep (Hocking Edwards *et al.* 2011; Plush *et al.* 2011), and suggests either that these are measuring different aspects of behavioural reactivity, or that one or both of these are poor measures of behavioural reactivity.

Table 2. Correlations between flight speed, agitation and face cover.

	Flight speed x Agitation	Agitation x Face cover	Flight speed x Face cover
Management group	0.23 ± 0.13*	0.09 ± 0.15	0.25 ± 0.13*
Genetic	0.19 ± 0.10*	-0.06 ± 0.07	-0.10 ± 0.08*
Genetic x Environment	0.15 ± 0.15	0.03 ± 0.13	-0.45 ± 0.10*
Residual	0.03 ± 0.02*	0.03 ± 0.03	-0.01 ± 0.03
Phenotypic	0.06 ± 0.01*	0.0004 ± 0.01	-0.05 ± 0.01*

* = correlation significantly different from zero

Heavier lambs were more reactive in both behavioral tests. Previous studies had mixed results (Amdi *et al.* 2010; Horton and Miller 2011). Hyper-responsiveness of the hypothalamic-pituitary adrenal (HPA) axis has been demonstrated in individuals with increased adipose tissue in sheep, rats and humans, suggesting a true physiological link between adiposity and stress response (Tilbrook and Clarke 2006).

Female lambs were more reactive in the agitation test than were males. This may indicate increased fear, or higher social motivation of females (Boissy *et al.* 2005). Several studies have found evidence that there are functional differences between sexes in the HPA axis in sheep (Hernandez *et al.* 2010).

Terminal x Merino first-cross lambs had faster flight speeds than the three other pure, first-cross and second-cross lamb types. Breed differences in behaviour have been found in several studies (Boissy *et al.* 2005) with some breeds displaying an active coping mechanism (high levels of locomotion, high-pitched bleats, escape attempts) and others a passive mechanism (immobilisation, quiet bleating, retreat from stimuli).

Younger lambs were more active in the agitation test than older lambs in a single flock (Katanning), similar to Viérin and Bouissou's (2003) work in which 3-4 month old lambs were more fearful than 5-6 month olds. Age and experience are difficult to separate, and although lambs in this study were tested at a young age (2-5 months), habituation to handling by humans may have contributed to the lack of significance across flocks for this effect.

There were significant but ambiguous effects of flock on both of the behavioural tests, with the two behaviours apparently varying independently of one another. Given that the eight flocks were chosen specifically to represent the diversity of sheep production across Australia, this effect may be due to a variety of factors, including weather, day length, facilities and handling style. Faecal worm egg count and birth-rearing type were not associated with either behavioural measure.

Face cover score was highly heritable, yielding similar values to previous studies (Mortimer *et al.* 2009). However, lack of correlation with either behavioural score indicates that face cover will not be a useful indicator for behavioural reactivity. The present study was opportunistic in utilising a face cover score designed to assess the risk of a sheep for wool blindness, rather than a measure designed to describe patterning. It is possible a relationship exists between facial hair patterning and behaviour in sheep, as demonstrated in cattle (Olmos and Turner 2008). More descriptive measures of facial wool patterning may be useful as indicators of inherent sheep behaviour.

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