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Genetic Estimates for Temperament Traits in Sheep Breeds

Abstract

Selection for sheep which are better able to adapt to the normal range of production challenges has the potential to yield improvements in both production efficiency and animal welfare. This, in part, can be achieved via selection for temperament. The primary aim of this study was to collect phenotypic records of temperament in wool, maternal and terminal sire flocks to develop more robust and accurate estimates of the genetic parameters for temperament, including the genetic correlations with key production traits. Two behavioural tests, the isolation box test (IBT) and the measurement of flight time (FT) were evaluated. The study confirmed that the two tests were moderately heritable with the IBT having marginally higher heritability (0.30) compared with FT (0.23). The two temperament traits were not highly correlated however, as the genetic correlation between them was only -0.2. There were very few significant correlations between the two temperament traits and the various production traits. The notable exception here was the moderate positive genetic correlation (0.22) between IBT agitation score and post-weaning faecal egg count. It was recommended that further analysis of the existing SheepGenomics database be undertaken to confirm this association. The release of the industry package covering the strategies for, and benefits of selecting for temperament in sheep breeding programs should be deferred until the results of this analysis and another relevant MLA project (AHW.085) are known.

Executive Summary

Selection for sheep which are better able to adapt to the normal range of production challenges has the potential to yield improvements in both production efficiency and animal welfare. A key component of adaptability is the temperament of the animal. Numerous tests have been developed to assess temperament particularly in cattle, and these are usually based on the measurement of escape and/or avoidance behaviours. Moreover responses to these tests have been shown to be moderately heritable. In contrast, there is very little information about the heritability of temperament in sheep. However, it is reasonable to assume that similar genetic variation exists. In view of this, and the potential benefits through selection for temperament, this study was undertaken to estimate the genetic parameters for temperament and the genetic correlations with production traits.

Two tests, the isolation box test (IBT) and the measurement of flight time (FT), were selected for evaluation during this study. The IBT involved isolating an animal in a 1.5 m (L) x 1.5 m (H) x 0.75 m (W) box and measuring the degree of agitation for 30 seconds. Agitation score was measured objectively via a purpose built agitometer located on the box. The agitation reflects the animal's inherent fear of isolation but also its capacity to adapt to the isolation challenge. Flight time was measured by recording the time it takes for an animal to break two infrared sensors (1.5 m) on exit from a weigh crate. The principle of both tests is based on the inherent aversion by sheep of being isolated and separated from their conspecifics and close human contact.

The main objective of this study was to collect additional progeny records (n = 12,152) of temperament from wool, maternal and terminal sire flocks and to estimate genetic parameters for the temperament traits and the correlations with important production traits including growth, wool, carcass, reproduction and parasite resistance traits. The genetic analysis revealed that sheep temperament, as defined by the two behavioural tests, was moderately heritable with marginally higher heritability observed for the IBT agitation score (0.30) compared with FT (0.23). The two temperament traits were not highly correlated however, as the genetic correlation between them was only -0.2. This low correlation could mean that different genetic components of temperament are being captured by the two tests. This also needs to be considered if the tests are to be adopted in breeding programs. There were very few significant correlations between the two temperament traits and the production traits. The notable exception here was the moderate positive genetic correlation (0.22) between IBT agitation score and post-weaning faecal egg count. It was recommended that further analysis of the existing SheepGenomics database be undertaken to confirm this association. Furthermore, the results of another MLA project (AHW.085) will determine whether temperament is relevant in the context of maternal behaviour and neonatal lamb survival.

In the mid-term, selection for temperament will facilitate improvements in management and handling ease and the capacity of animals to adapt to production challenges. In addition, selection for less fearful animals will also yield benefits in terms of animal welfare through reductions in injuries during handling. Further analysis of existing databases (SheepGenomics) and the outcomes of other MLA projects (AHW.085) will conclusively determine whether selection for temperament may directly or indirectly influence other production or animal welfare related traits.

Contents

1 Background

Selection for sheep which are better able to adapt to the normal range of production challenges has the potential to yield improvements in both production efficiency and animal welfare. The challenge of course, is to develop practical and accurate methods to evaluate this trait on-farm. One strategy involves examining the animal's response (usually behavioural) to a given challenge (eg. human contact or exposure to novel/threatening environments). The response, which is generally referred to as temperament, represents the emotivity of "fearfulness" and the reactivity of an animal to the challenge (Murphy 1999). It is believed that animals that show less reactivity will display greater adaptability in their production environments and this is indirectly supported by the results of Vandenheede and Bouissou (1993).

Research in sheep and cattle indicates that elements of behaviour, specifically fearfulness or emotional reactivity, are heritable and can have favourable genetic and phenotypic associations with both animal welfare and production traits. For example, temperament has been shown to be phenotypically correlated with growth rate (Voisinet, *et al.* 1997; Burrow 1998; Fell, *et al.* 1999) and milk yield in dairy cattle (Lawstuen, *et al.* 1988). Furthermore, in cattle (Reverter, *et al.* 2003, Kadel *et al.* 2006), significant genetic associations have been established between measures of temperament and/or stress responsiveness and meat quality, specifically tenderness. The results from Murphy (1999) based on a Merino selection flock divergent for temperament clearly shows an association between temperament and neonatal lamb survival. Lower levels of neonatal lamb mortalities were evident for ewes from the calm selection line compared to those from the nervous line.

The initial MLA project SHGEN.025, revealed that temperament in sheep could be measured using either the measurement of flight time (FT) or via the isolation box test (IBT) and moreover, the trait was moderately heritable (h^2 0.2 – 0.35). This project was undertaken to collect additional phenotypic records to augment the SHGEN.025 database in order to develop more robust accurate estimates of the genetic correlations between these temperament traits and key production traits.

2 Project Objectives

(i) Collect 10,000 phenotypic records of temperament using the IBT and FT in pedigreed flocks including wool, terminal sire and maternal breeds.

(ii) Quantify the phenotypic and genetic correlations between the two temperament tests and between them and other production traits.

(iii) Develop recommendations for the application of each test in genetic improvement programs in wool, terminal sire and maternal sheep breeds.

3 Methodology

3.1 Temperament phenotyping in industry flocks

Progeny

A total of 12,152 progeny from 24 commercial flocks were phenotyped for temperament. These flocks included wool (Merino), terminal sire (Poll Dorset and White Suffolk) and maternal (Border Leicester and Coopworth) breeds. The flock details including breed and number of progeny/flock are shown in Table 1. The majority of the progeny were less than 12 months of age when phenotyped.

Table 1: Flock details and progeny numbers

Flock	Owner	State	Breed	Progeny No.
Kelso	Bruce Starritt	VIC	Border Leicester	305
Johnos	Neil Johnson	SA	Border Leicester	353
Kegra	Graeme Golder	NSW	Border Leicester	431
Wongajong	Allan Wilson	NSW	Border Leicester	369
			Total	**1458**
Merinotech	Ian Robertson	WA	Merino	575
Mooringa	Brook Evans	WA	Merino	367
Turretfield	SARDI	SA	Merino	1683
Westvale	Leo Blanch	NSW	Merino	363
Woolumbool	Phil Clothier	SA	Merino	185
Grindon	Roland Ritson	WA	Merino	451
Billandri Poll	Ron Sandilands	WA	Merino	1394
Centre Plus	Robert Mortimer	NSW	Merino	377
Edale	Phillip Gardiner	WA	Merino	502
			Total	**5897**
Majardah	Dale Price	SA	Poll Dorset	257
Pepperton	Dianne Trewick	VIC	Poll Dorset	405
Lyndoch Park	Mary Currie	VIC	Poll Dorset	235
Jolma	Perry Jasper	WA	Poll Dorset	409
Lockier River	Peter Horwood	WA	Poll Dorset	423
Woolumbool	Phil Clothier	SA	Poll Dorset	143
			Total	**1872**
Gleneith	Wes Kember	NSW	White Sufflok	428
Ardoe	George Spring	VIC	White Suffolk	363
Koonawarra	Mark Grossman	SA	White Suffolk	234
Woolumbool	Phil Clothier	SA	White Suffolk	96
Glengarry	Julie Wiesner	NSW	White Suffolk	312
			Total	**1433**
Oaklea	Don Pegler	SA	Coopworth	578
Cashmore Park	John Keiller	VIC	Coopworth	909
			Total	**1487**

Temperament measurements

Temperament was measured using the modified isolation box test (IBT) and via the measurement of flight time (FT). The modified IBT comprised isolating an animal in a 1.5 m (L) x 1.5 m (H) x 0.75 m (W) box for 30 seconds and measuring objectively the degree of agitation (see Blache and Ferguson 2005). The agitometers on each IBT were calibrated before the commencement of testing and this calibration was checked throughout the period of testing. In some instances, small adjustments were made to the sensitivity of the agitometers if calibration drifts were evident. Flight time was measured on exit from a weigh crate where the infra-red sensors were set 1.5 m apart.

The IBT was conducted first and on exit the animal entered a weigh crate where the liveweight was recorded. After a set period of time (10 s) the animals were released and flight time was recorded.

Animals with either high IBT agitation scores or low flight times were considered more fearful (i.e. poor temperament).

Statistical analysis

This data was added to the Sheep Genetics Australia (SGA) database which included production trait measurements for these flocks. In addition, the SGA database included IBT and FT records that were collected in the earlier project SHGEN.025.

The fixed effect analysis was conducted in SAS (SAS 1999) without fitting any random or genetic effects to the model. Flock, year, sex and management group were fitted individually rather than as a contemporary group effect. All fixed effects and their probabilities are from the SAS output. Genetic analyses, including univariate and bivariate analyses were then performed using ASReml (Gilmour et al 2002). For production and temperament traits, the model included the fixed effects of contemporary group (CG) (defined using breed, flock, sex, year and management group), age, birth type/rear type combination, age of the dam (linear and quadratic) and liveweight (IBT only). Birth/rear type is a variable that defines the litter size (singles, twins or triplets) during gestation or at birth and also at the time of weaning. The inclusion of liveweight as a covariate was necessitated for the IBT model because the agitometers detect the sound changes associated with movements in the box. These sound changes are likely to be influenced by the size of the animal. For the IBT model, measurement sequence (i.e. order of measurement each day) was also fitted. The bivariate analyses were conducted on the combined dataset (only those animals where both traits were recorded) and on the dataset that was collected as part of the current project (AHW.140).

4 Results and Discussion

4.1 Datasets

After collating and cleaning (removing incomplete or erroneous records), the combined dataset (SHGEN.025 + AHW.140) comprised a total of 19,778 records. Of these, there were 11,887 progeny where both FT and IBT were measured. The IBT agitation score and FT means and standard deviations for each breed are shown in Table 2.

Table 2: Number of progeny within breed with flight time (FT) and IBT records

Breed	IBT	FT
Border Leicester		
Number	2,934	2,728
Mean	63.3	0.9
sd	40.4	0.4
Coopworth		
Number	1,443	1,847
Mean	43.9	0.7
sd	25.6	0.3
Poll Dorset		
Number	2,937	3,301
Mean	55.2	1.1
sd	41.6	0.4
White Suffolk		
Number	1,822	2,745
Mean	88.2	0.8
sd	61.3	0.3
Merino		
Number	5,110	4,467
Mean	65.2	1.0
sd	48.2	0.4
Poll Merino		
Number	3,070	4,690
Mean	62.4	0.9
sd	41.7	0.4

sd – standard deviation

The mean age of the progeny at the time of testing was 308 days and ranged from 66 – 654 days.

The number of progeny with records for both temperament traits and the various production traits was not as high (refer Table 5). This was due to several reasons such as the production traits were not measured, the progeny were not old enough for evaluation (eg. maternal traits) or there had been delays sending or processing the data on the SGA database. This issue is discussed further in 4.2.

4.2 Temperament trait analysis

4.2.1 Fixed effects

The analysis of the fixed effects revealed that flock/year was significant for both temperament measures (Table 3). Birth and rearing types were not significant for either temperament traits. Similarly, the covariates of ewe age and measurement sequence (IBT) were not significant terms in the models.

Table 3: Significance of the fixed effects on flight time and IBT

	FT	IBT
R^2	0.35	0.4
Liveweight	NF	P<0.001
Flock/Year	P<0.001	P<0.001
Measurement sequence	NF	NS
Age	P<0.01	P<0.001
Sex	P<0.001	P<0.001
Birth and rearing types	NS	NS
Age of the dam	NS	NS

NF – not fitted in the model; NS – not significant

The fixed effect of sex was highly significant for both temperament traits where ewes had a much higher agitation score (mean difference 12.1 units, sem 0.01 units) and lower flight times (mean difference 0.02 s, sem 0.005 s). The literature on cattle is somewhat equivocal with regard to the differences between the sexes for temperament (see review by Burrow 1997). However, in sheep, French workers (Vandenheede and Bouissou 1993a) reported similar findings to those observed in the present study in that rams were less fearful than ewes. Vandenheede and Bouissou (1993b) provide further support for this effect when they treated ewes with the male androgen testosterone propionate and observed lower fear responses in this group compared to the control ewes. This led these workers to conclude that the sex effect was largely driven by gonadal steroids.

Liveweight (IBT) and age (IBT and FT) were significant covariates in the models. The regression coefficient for liveweight was 0.56 units (sem 0.04 units) indicating that agitation score increased with increasing liveweight. This is consistent with earlier observations (Blache and Ferguson 2005) and vindicates the inclusion of liveweight within the model. Within the age range of the progeny (66 – 654 days), the older progeny had lower agitation scores (regression coefficient -0.07 sem 0.014) and higher flight times (regression coefficient 0.0003 sem 0.0001). This would suggest that younger progeny were more fearful based on the two tests even after adjustment for liveweight differences. This finding has not always been observed in ruminant temperament research (Boissy 1995, Murphy 1999).

4.2.2 Heritability of temperament traits

Sheep temperament, as defined by the two behavioural tests, was moderately heritable with higher heritability observed for the IBT (Table 4). The heritability estimates are very similar to those reported by Blache and Ferguson (2005) in an earlier study on (IBT h^2 = 0.35, 4849 progeny; FT h^2 = 0.21, 5623 progeny). The moderate heritability observed in these sheep studies is consistent with those reported for cattle using various temperament tests, including flight time (Burrow 1998; Kadel *et al.* 2006). Although similar in magnitude, there were breed differences in the heritability estimates for both temperament traits. The most notable was the very low heritability estimate for Border Leicester IBT agitation score relative to the other five breeds including the Coopworth which is another maternal breed. The high heritability estimate for FT for the Poll Dorset breed is difficult to explain.

Table 4: Heritability estimates and phenotypic variances for flight time and IBT in sheep breeds

	FT			IBT		
	No. of records	Phenotypic variance	h^2	No of records	Phenotypic variance	h^2
Breed						
Border Leicester	2,680	0.08 (0.00)	0.14 (0.04)	2,886	1212.0 (33.3)	0.14 (0.03)
Coopworth	1,806	0.07 (0.00)	0.14 (0.05)	1,402	560.5 (25.9)	0.34 (0.08)
Poll Dorset	3,162	0.13 (0.00)	0.73 (0.04)	2,800	1081.0 (36.3)	0.41 (0.05)
White Suffolk	2,740	0.08 (0.00)	0.25 (0.05)	1,816	1906.0 (73.1)	0.29 (0.07)
Merino	4,443	0.12 (0.00)	0.14 (0.03)	5,085	1272.0 (29.9)	0.38 (0.05)
Poll Merino	4,664	0.11 (0.00)	0.18 (0.04)	3,044	1,290.0 (39.9)	0.41 (0.07)
Overall	**20,146**	**0.10 (0.00)**	**0.23 (0.02)**	**17,120**	**1227.0 (15.23)**	**0.30 (0.02)**

The heritability estimates for FT and the IBT for those progeny that were phenotyped in the current project (n = 12,152) were 0.18 (0.02) and 0.24 (0.03), respectively. The heritability for the IBT was marginally lower than that previously reported by Blache and Ferguson (2005) and the estimate based on the combined dataset shown in Table 4. The modified IBT was used in the current study and this may have accounted for the difference in the heritability estimates. Relative to the original IBT used by Blache and Ferguson (2005), the current IBT differs in construction and size and the animals are only isolated for 30 s compared to the original 60 s test. To examine this further, the genetic and phenotypic correlations between the original and current IBT records were determined. In this instance, the correlations were estimated through the sire term as the two versions of the IBT were not applied on the same progeny. A high genetic correlation of 0.68 (0.12) was found indicating that both versions are capturing similar genetic components of the trait. In contrast, a lower phenotypic correlation of 0.19 (0.04) was observed.

4.2.3 Correlation between the temperament traits

In the combined dataset where both temperament traits were evaluated on the same progeny, the genetic and phenotypic correlations between them were -0.21 (0.08) and 0.04 (0.01), respectively. The negative genetic correlation intuitively makes sense as it indicates the higher the agitation score, the lower the flight time (i.e. more fearful). However, the traits were not highly correlated genetically. Furthermore, the phenotypic correlation was not significantly different from zero. It is plausible that the weak genetic association between the tests is because the tests may be capturing independent genetic aspects of fearfulness. If so, the corollary here is which of these tests then is more useful with respect to improving temperament?

The lack of a phenotypic association was not totally unexpected as previous research in cattle has shown that phenotypic correlations between traits measured using different behavioural tests are generally weak to moderate (Kilgour et al 2006). However, it is a concern that the correlation was virtually zero.

It is possible that because the FT test was conducted after the IBT, there may have been a carry-over effect from the IBT that influenced the flight times and therefore, the correlation between the traits. However, it is worth noting that the genetic correlation between the two temperament traits was similar in magnitude in the study by Blache and Ferguson (2005) when the two tests were conducted independently at different times.

4.2.4 Correlations between temperament and production traits

The genetic and phenotypic correlations between traits from the combined dataset are presented in Table 5. Some caution needs to be exercised when interpreting the results as not all trait combinations have sufficient records to draw meaningful conclusions. For those that do, the general picture is that the genetic correlations between the two temperament traits and growth, carcass, wool, parasite or reproduction traits are, at best, weak (<0.10). There were some wool traits (eg curvature, staple strength and length) where the genetic correlations with IBT agitation score were marginally higher (0.10 – 0.15). However, in the case of staple length, the slope of the association changed over time (yearling to hogget) which does not engender confidence in this relationship. Flight time was weakly to moderately correlated with age-specific carcass traits (hogget fat depth and post-weaning eye muscle depth) and wool traits (hogget clean fleece weight). The correlations were lower at the other ages for these traits. There appears to be direct genetic correlation between IBT agitation score and faecal egg count (FEC), particularly at the post-weaning age. As yearlings this was not evident but re-appeared when assessed as hoggets, however, the number of records at this age were substantially lower than the previous ages. It also must be recognised that the FEC assessments are not repeated measures on the same progeny. Nevertheless, this association warrants further examination as it suggests that selection for temperament, based on the IBT, may convey genetic improvements in gastrointestinal parasite resistance. This is reinforced by the findings of Hohenhaus et al (1998) who reported an association between the responses to another temperament test (arena test) and FEC phenotypes in sheep. In their study, the low FEC phenotype (more resistant) displayed less fearful behaviours during the arena test. For FT, there was a positive correlation with yearling FEC but this seems counter-intuitive and contrasts the findings above, as it indicates that high flight times (less fearful) are genetically correlated with higher FECs.

The genetic correlations between the temperament traits and the growth and reproduction traits were generally low. However, the number of available records for the reproductive traits was low as many of the female progeny that were phenotyped for temperament had not reached their breeding age. Similarly the majority of the phenotypic correlations were very low.

Since there were slight differences in the test protocols for the IBT and FT between the original (SHGEN.025) and current studies, a second bivariate analysis was undertaken on only those records collected in the current study (AHW.140). Emphasis was given to those production traits where there were a significant number of progeny records for each trait. These results are presented in Table 6.

Table 5: Genetic and phenotypic correlations between IBT, flight time and production traits on the combined dataset

Trait	No. of records in both traits IBT	No. of records in both traits FT	Genetic correlations		Phenotypic correlations	
			IBT	FT	IBT	FT
Birth weight	9,591	10,947	-0.06 (0.05)	0.08 (0.05)	-0.03 (0.01)	0.02 (0.01)
Weaning weight	16,031	16,606	-0.05 (0.04)	0.04 (0.04)	-0.02 (0.01)	0.00 (0.01)
PW weight	12,929	14,729	-0.07 (0.04)	0.04 (0.05)	0.00 (0.01)	0.00 (0.01)
Y weight	7,984	8,455	-0.04 (0.04)	0.00 (0.05)	0.00 (0.01)	0.00 (0.01)
H weight	2,971	3,309	-0.03 (0.05)	0.02 (0.06)	0.01 (0.02)	0.01 (0.02)
A weight	236	562	-0.19 (0.09)	0.03 (0.09)	-0.03 (0.05)	0.00 (0.04)
PW fat depth	5,198	8,224	0.06 (0.06)	0.01 (0.06)	0.02 (0.01)	0.00 (0.01)
Y fat depth	991	2,424	-0.01 (0.08)	0.06 (0.09)	0.01 (0.03)	-0.02 (0.02)
H fat depth	2,013	1,599	0.09 (0.10)	-0.14 (0.12)	-0.03 (0.02)	-0.01 (0.02)
PW eye muscle depth	5,219	8,247	0.02 (0.06)	-0.24 (0.06)	0.03 (0.01)	-0.04 (0.01)
Y eye muscle depth	1,326	2,762	-0.07 (0.07)	0.02 (0.07)	0.05 (0.02)	-0.06 (0.02)
H eye muscle depth	1,458	1,111	0.09 (0.10)	0.01 (0.12)	0.03 (0.03)	-0.02 (0.03)
Y greasy fleece weight	5,047	5,224	0.02 (0.06)	-0.06 (0.07)	0.02 (0.01)	-0.01 (0.01)
H greasy fleece weight	1,552	1,511	0.05 (0.06)	-0.05 (0.06)	0.00 (0.02)	0.00 (0.02)
A greasy fleece weight	191	131	-0.06 (0.07)	-0.17 (0.09)	-0.01 (0.05)	-0.06 (0.06)
Y clean fleece weight	1,684	1,097	0.03 (0.09)	-0.04 (0.12)	0.02 (0.02)	0.01 (0.03)
H clean fleece weight	1,071	1,074	0.06 (0.09)	-0.13 (0.08)	-0.04 (0.03)	-0.01 (0.03)
A clean fleece weight	28	10	0.08 (0.13)	-0.22 (0.12)	-0.09 (0.13)	-0.04 (0.36)
Y fibre diameter	3,591	3,526	0.01 (0.06)	-0.01 (0.06)	0.00 (0.02)	0.01 (0.02)
H fibre diameter	1,588	1,272	0.01 (0.06)	0.07 (0.07)	-0.08 (0.02)	0.03 (0.02)
A fibre diameter	60	10	0.01 (0.07)	0.13 (0.08)	-0.02 (0.09)	-0.40 (0.19)
Y fibre diameter cv	3,586	3,527	0.03 (0.07)	0.06 (0.08)	-0.03 (0.02)	0.00 (0.02)
H fibre diameter cv	1,587	1,270	0.00 (0.07)	0.07 (0.08)	0.00 (0.02)	0.00 (0.02)
A fibre diameter cv	60	10	0.03 (0.09)	0.06 (0.11)	0.05 (0.10)	0.17 (0.23)
Y staple strength	1,408	979	-0.10 (0.12)	0.02 (0.16)	0.00 (0.02)	-0.03 (0.03)
H staple strength	1,115	961	0.04 (0.11)	0.08 (0.10)	-0.02 (0.03)	0.02 (0.03)
A staple strength	-	-	0.17 (0.25)	0.51 (0.31)	0.08 (0.10)	0.20 (0.12)
Y staple length	2,032	1,547	0.12 (0.08)	-0.04 (0.09)	0.02 (0.02)	0.01 (0.02)
H staple length	1,488	1,141	-0.10 (0.08)	-0.15 (0.08)	-0.06 (0.03)	-0.03 (0.02)
A staple length	-	-	-0.04 (0.13)	-0.63 (0.16)	-0.01 (0.05)	-0.23 (0.06)
Y curvature	3,387	3,527	0.08 (0.07)	-0.03 (0.08)	0.00 (0.02)	-0.01 (0.02)
H curvature	1,378	1,271	0.10 (0.08)	-0.06 (0.09)	0.11 (0.03)	0.03 (0.02)
A curvature	60	10	0.19 (0.11)	0.23 (0.17)	0.03 (0.09)	-0.35 (0.28)
PW faecal egg count	2,679	2,597	0.22 (0.10)	0.04 (0.12)	0.03 (0.02)	0.02 (0.02)
Y faecal egg count	1,793	1,637	-0.03 (0.09)	0.24 (0.10)	-0.03 (0.02)	0.07 (0.03)
H faecal egg count	740	699	0.16 (0.13)	-0.10 (0.16)	0.10 (0.04)	-0.02 (0.04)
No of lambs born	1,106	1,139	0.06 (0.07)	-0.05 (0.08)	0.01 (0.03)	-0.05 (0.04)
No of lambs weaned	1,127	1,186	0.03 (0.12)	-0.05 (0.13)	0.04 (0.03)	0.06 (0.04)

PW - early post-weaning; Y - yearling; H - hogget; A - adult

Table 6: Genetic and phenotypic correlations between IBT, flight time and specific production traits on the AHW.140 dataset

Trait	No. of records in both traits IBT	No. of records in both traits FT	Genetic Correlations		Phenotypic Correlations	
			IBT	FT	IBT	FT
Birth weight	7,188	6,906	-0.07 (0.07)	0.04 (0.08)	-0.03 (0.01)	0.02 (0.01)
Weaning weight	10,906	10,469	-0.18 (0.05)	0.01 (0.06)	-0.04 (0.01)	-0.01 (0.01)
PW weight	8,460	8,173	-0.17 (0.06)	-0.03 (0.07)	-0.04 (0.01)	-0.01 (0.01)
Y weight	5,160	4,941	-0.04 (0.06)	-0.03 (0.05)	0.00 (0.02)	-0.01 (0.02)
PW fat depth	3,341	3,322	0.10 (0.09)	0.04 (0.11)	0.02 (0.02)	0.01 (0.02)
PW eye muscle depth	3,355	3,336	-0.04 (0.09)	-0.37 (0.09)	0.03 (0.02)	-0.04 (0.02)
Y greasy fleece weight	2,604	2,576	-0.01 (0.08)	0.00 (0.09)	0.01 (0.02)	0.02 (0.02)

PW - early post-weaning; Y - yearling; H - hogget; A - adult

When the analysis was performed on the reduced dataset, there were some changes in the magnitude of the genetic correlations. The genetic correlations between the IBT agitation score and the liveweight traits at different ages all increased but most noticeably for the weaning and post-weaning liveweights. A similar increase in the genetic correlation was evident for FT and post-weaning eye muscle depth. The relationship indicates that sires with higher flight times (less fearful) will produce progeny with smaller eye muscle depths. There was very little change in the magnitude of the phenotypic correlations between the temperament and production traits on the reduced dataset.

Finally, with respect to the bivariate analysis of the associations between the temperament and production traits, it may be prudent to rerun the analyses in the future as more production trait records would have been added to the database. Of note here, there will be more records for the reproduction traits of numbers of lambs born and weaned from the female progeny and the association between temperament and lamb survival is clearly one of interest to the industry.

5 Success in Achieving Objectives

All project objectives were achieved within the scheduled time frame of the project. It was proposed that the recommendations to industry regarding the selection of sheep temperament on-farm be deferred pending further analysis of existing databases.

6 Impact on Meat and Livestock Industry – now & in five years time

The modified IBT and the measurement of flight time can be reliably and practically applied on-farm to enable sheep producers (meat and wool) to select for temperament. The moderate heritability indicates that reasonable rates of genetic progress are feasible if adopted. Selection for temperament should facilitate improvements in management and handling ease and potentially improve the capacity of animals to adapt to production challenges. In addition, selection for less fearful animals has the potential to yield benefits in terms of animal welfare through reductions in injuries during handling. The current evidence indicates that selection for temperament is not likely to positively or negatively affect key production traits with the possible exception of faecal egg count (FEC). If the genetic association between IBT agitation score and FEC can be confirmed, then selection for temperament would offer sheep breeders the additional benefit of improving internal parasite resistance in their flocks. The one issue that will require further consideration is the choice of which test to apply on-farm given the lack of strong association between the two tests. Hopefully, clarity on this issue will be achieved following completion of current MLA projects and the recommended analyses. It is also worth noting that although the association between the two tests is not strong, selection on either would be expected to bring about a reduction in inherent fearfulness and this in turn, is expected to improve ease of handling.

7 Conclusions and Recommendations

Temperament in sheep breeds can be objectively measured using either the IBT or via the measurement of FT. FT is perhaps the simplest and most practical of the two tests as it can be easily accommodated in combination with weighing animals. However, the genetic correlation between the two temperament tests was relatively low which may indicate that the two tests are assessing different genetic components of fearfulness in response to isolation and/or human contact. Alternatively, it could simply be that one test is a more informative test of fearfulness than the other. Nevertheless, sheep breeders need to be cognisant of this if they decide to adopt either of these tests in their breeding programs.

It can be concluded that reasonable rates of genetic improvement in temperament are feasible given the moderate heritability of both temperament tests and the level of phenotypic variation. Realisation of this will of course be dependent on the level of adoption. There will be some sheep breeders who will adopt the tests to specifically improve temperament, as this will bring about direct improvements in handling ease and animal adaptability. Both are highly relevant to improved animal welfare on-farm. However, more widespread adoption of these tests is likely if it can be shown that selection for temperament will yield genetic improvements in other production traits that are expensive or difficult to phenotype (eg. maternal reproductive traits). Unfortunately, there were very few production traits that were genetically correlated with either of the temperament traits. Of the trait correlations where a slight to moderate correlation was evident and after taking into consideration salient factors (eg. the total number of records, standard error of the correlation coefficient, and biological validity of the association), the positive correlation (0.22) between IBT agitation score and faecal egg count was the most notable. Further analysis to confirm this important association is recommended. To that end, the SheepGenomics (Fallkiner Flock) resource is an ideal database to re-examine this association as the progeny were phenotyped for intestinal worm resistance and temperament (IBT - 2005 and 2006 progeny and FT – 2006 progeny). Therefore, it is recommended that this be given some priority. It is also recommended that the bivariate analyses (temperament and production traits) on the SGA database should be re-run in another 12 -18 months as there will be more records in the database particularly for the reproductive traits as the female progeny from the most recent round of temperament testing would have produced lambs within that period. The current analysis revealed very low genetic correlations between the temperament traits and number of lambs born and weaned. Although disappointing, this may not be definitive in a genetic context, as this could still be a function of the considerable environmental noise within the database and the modest number of records. The results from another MLA project (AHW.085 Improving lamb survival by selection for temperament) will clearly be more conclusive as to whether temperament influences maternal behaviour and therefore, neonatal lamb survival.

In view of the recommendations to undertake further analyses of existing databases, it is our final recommendation to defer the release of the industry package covering the strategies for and benefits of selecting for temperament in sheep breeding programs until the results of these analyses and that of Project AHW.085 are known.

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