final report

Project code: SHGEN.025

Prepared by: Dominique Blache and Drewe Ferguson University of Western Australia and CSIRO Livestock Industries

Date published: May 2005

ISBN: 1 74036 977 7

PUBLISHED BY
Meat & Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Increasing Sheep Meat Production Efficiency and Animal Welfare by Selection for Temperament

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

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 the selection for temperament. The primary aims of this study were to develop and evaluate practical tests for the on-farm assessment of temperament in sheep and secondly, to estimate the genetic parameters for temperament and the genetic correlations with production traits. Two behavioural tests, the isolation box test (IBT) and the measurement of flight time (FT) were evaluated. The repeatability of IBT (0.4 – 0.76) was significantly higher than FT (<0.1) although the measurement of FT was found to be more practical as an on-farm test. The two tests were moderately heritable with higher heritability observed for the IBT (0.35) compared with FT (0.21). No clear conclusions were made with regard to the correlations between the two temperament traits and between them and other important production traits due to insufficient common records within the database. The IBT which was found to be highly repeatable and reliable now enables sheep producers (meat and wool) to select for temperament on-farm. The moderate heritability indicates that reasonable rates of genetic progress are feasible if adopted. 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 and stress during handling.

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 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 firstly, develop a simple reliable method for the on-farm assessment of temperament in sheep and secondly, 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 $1.5m^3$ box and measuring the degree of agitation for a period of 1 minute. Agitation was measured objectively via a purpose built agitometer located on the box. The agitation reflects the animal's inherent fear of isolation but also it's 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 on exit from a weigh crate or IBT. The sensors were placed 1 – 2 m apart. 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.

Two versions of the IBT (v2 and v3) were developed and evaluated. For the IBTv3, the box size (1.5 m H x 1.5 m L x 0.75 m W) was reduced. In addition, a purpose built calibration system for the IBT was developed because the acoustic properties of the individual boxes can vary and moreover, the conditions where each IBT is setup can also vary from farm to farm. Consequently, by calibrating each agitometer, any extraneous variation and bias between IBTs and farms was effectively reduced thus ensuring measurement consistency.

The practical merits of the IBT (v2 and v3) and FT were evaluated with particular emphasis on the repeatability of the tests. The repeatability of the IBT was moderate to high (0.40 – 0.76) which was in contrast to the poor repeatability of FT (<0.1). The effect of reducing the test duration of the IBT was also evaluated. It was shown that the test could be reduced to 30 s without greatly decreasing the accuracy. It was concluded that the modified IBTv3 with its more compact design and reduced test duration (30 s) offers a more practical on-farm test compared with the original IBTv2. FT on the other hand is perhaps the simplest and most practical of the two tests as it can be easily accommodated in combination with weighing animals. However, the lower repeatability of FT needs to be taken into consideration.

The IBTv2 was used to collect phenotypic measurements of temperament on a total of 5,997 progeny (9-11 mth) from 25 flocks comprising four breeds (Merino, White Suffolk, Poll Dorsett and Border Leicester. Flight time was also measured at a different age on some of these progeny and other progeny from these and other breeds. The genetic analysis revealed that sheep temperament as defined by the two behavioural tests was moderately heritable with higher heritability observed for the IBTv2 (0.35) compared with FT (0.21). Overall, no clear conclusions can be made with regard to the correlations between the two temperament traits and between them and other important

production traits due to insufficient common records within the database. In view of the deficiencies within the database, it is recommended that further progeny records are collected to determine the strength of association between the two temperament tests which will confirm whether they are assessing the same trait. In addition, it will allow a more conclusive analysis of the associations between sheep temperament, production and animal welfare-related traits.

The development of the IBT which was found to be highly repeatable and reliable now enables sheep producers (meat and wool) to select for temperament on-farm. The moderate heritability indicates that reasonable rates of genetic progress are feasible if adopted. 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. It is not clear at this stage whether selection for temperament may directly or indirectly influence other production or animal welfare related traits. However, it will be possible to explore these associations in more detail after collection of additional phenotypic data from flocks affiliated with Lambplan and/or Merino Genetic Services and within another MLA project (AHW.085) which aims to specifically investigate the association between ewe temperament and neonatal lamb survival.

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).

In addition to the benefits associated with ease of handling and adaptability, selection for temperament has also been shown to be positively correlated with some production traits such as growth rate (Voisinet*, et al.* 1997; Burrow 1998; Fell*, et al.* 1999), immune function in beef cattle (Fell*, et al.* 1999) and milk yield in dairy cattle (Lawstuen*, et al.* 1988). Furthermore, in cattle (Reverter*, et al.* 2003) and poultry (Jones and Hocking 1999), 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 show a 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.

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. Within cattle populations, temperament, as defined by these behavioural tests, is moderately heritable (h^2 0.2 – 0.4, see review by Burrow 1997). Unfortunately, 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 first, develop a simple reliable method for the on-farm assessment of temperament in sheep and second, to estimate the genetic parameters for temperament and the genetic correlations with production traits.

2 Project Objectives

(i) Develop a simple, reliable objective test for the on-farm measurement of temperament in sheep.

(ii) Estimate the genetic parameters for temperament and the genetic correlations with production traits in commercial flocks.

(iii) Deliver outcomes to seed-stock and commercial producers.

3 Methodology

3.1 Development of the isolation box test (IBT)

A prototype version of IBT was originally developed by Putu (1988) and Murphy (1999). This prototype has been used successfully by researchers at the University of Western Australia in conjunction with another behavioural test to develop the Allandale Merino flock which comprises lines divergent for temperament.

The test involves isolating an animal in a 1.5m^3 box and measuring the degree of agitation for a period of 1 minute. Agitation is measured objectively via a purpose built agitometer located on the box. The principle of the test is based on the inherent aversion by sheep of being isolated and separated from their conspecifics. The agitation reflects the animal's inherent fear of isolation but also it's capacity to adapt to the isolation challenge. It is also likely that some proportion of the animal's response is influenced by the fear of human contact given that animals have to be manually moved into the box.

The aims here were:

- (i) To develop a robust transportable version of the IBT (IBTv2 x 4)
- (ii) To develop a system to calibrate the IBT in the field
- (iii) To develop a modified IBT (IBTv3) that was more compact in size

3.2 Evaluation of the IBT

In addition to the heritability of the trait, the utility of the IBT as an on-farm test is also governed by a number of operational factors such as its repeatability. Key operational aspects of the IBT were evaluated in a study using 351 weaner sheep from the two Allandale selection lines. In addition to the IBT, the measurement of flight time (FT) was also evaluated. The measurement of FT is an objective and highly effective test to assess temperament in cattle (Burrow 1997) however, its efficacy in sheep is not known. The test is based on the time an animal takes to break two infrared sensors (1-2 m apart) on release from a crush or weigh crate.

The aims of the study were:

- (i) determine the repeatability of the IBTv2, IBTv3 and FT
- (ii) quantify the correlation between the agitation scores from IBTv2 and IBTv3
- (iii) quantify the correlation between the FT and the IBT
- (iv) examine the effect of reducing the duration of the IBT

Sample
A sample of 351 Merino weaners (16 weeks of age) from the Allandale temperament selection line flock was used for this study. All the weaners were tested using the IBTv2 on the 22 Nov 2004. The weaners, stratified for selection line (based on the combination of the IBTv2 and arena test), were randomly allocated into two groups. Group 1 (n=176) comprised 109 rams and 67 ewes and group 2 (n = 175) comprised 79 rams and 96 ewes.

Measurements
The agitation score on Group 1 was determined using the IBTv3 (modified IBT) on 3 occasions (26, 28 and 30 Nov 2004). In addition, flight time over 1 and 2 m after exiting the IBTv3 was measured. Groups 1 and 2 were then retested through the IBTv2 on the 2 Dec 2004. On each test day, the calibration of the agitometers was set prior to testing and this was subsequently monitored during and at the conclusion of testing.

Repeatability and IBT measurement duration
The repeatbability of the IBTv2 was assessed using the data collected on the 22 Nov and 2 Dec. The measurements collected on the 26, 28 and 30 Nov were used to assess the repeatability of the IBTv3 and FTT. Repeatability was defined by the intraclass correlation according to the method described by Falconer and Mackay (1996).

To assess the effect of reducing the time of the IBTv2, it was necessary to develop a data acquisition program to automatically collect agitation scores at 1 s intervals over the entire 1 min test period. Regression analysis was used to examine the associations between the 1 min agitation score and those at 10, 20, 30, 40 and 50 s.

Correlation between temperament tests
Regressions analysis was used to test the association between agitation scores from the IBTv2 (22 Nov) and IBTv3 (26 Nov) and between the IBTv3 and FT.

3.3 Genetic analysis of the IBT and FT

The aim of this component of the project was to determine the heritability of the IBT and to examine the phenotypic and genetic correlations between temperament and production traits.

Progeny
Phenotypic measurements of agitation score (IBTv2) were collected on a total of 5,997 progeny from 25 flocks comprising four breeds (Merino, White Suffolk, Poll Dorsett and Border Leicester. The flock details including breed and number of progeny/flock are shown in Table 1. The progeny were measured between 9-11 mth of age on-farm. The liveweight of each animal just prior or immediately following the IBT.

These data were added to the Lambplan and Merino Genetic Services databases which included production trait and flight time measurements for these flocks. These databases were used to perform genetic analysis of the traditional traits and the two temperament traits (IBT and flight time). Flight time was measured by Stephen Spiker at different times to when the IBT was conducted.

Statistical analysis

Fixed effect analysis was conducted in SAS without fitting any random or genetic effects to the model. All fixed effects and their probabilities are from the SAS analyses. Genetic analyses were then performed using ASREML. Both univariate and bivariate analyses were performed. The model fitted included the fixed effects of contemporary group (CG, defined using breed, flock, sex, year and management group), age, birth type rear type combination, dam age (linear and quadratic) and weight. For the IBT, sequence was also fitted and sex was fitted independently of the CG effect. In the IBT data, in all cases the CG and Flock effects were completely confounded as all animals were run together within flocks. Therefore the effects of flock and sex were fitted rather then CG. For the flight time data a CG effect was fitted.

Table 1: Flock details and progeny numbers

Flock	Owner	State	Breed	Progeny No.
Inverbrackie	Lynton Arney	SA	Border Leicester	289
Johnos	Neil Johnson	SA	Border Leicester	280
Kegra	Graeme Golder	NSW	Border Leicester	272
Wongajong	Allan Wilson	NSW	Border Leicester	243
			Total	**1084**
Gienna	John Gill	NSW	Merino	320
Hilltop	Adam Mort	NSW	Merino	246
Linden	Peter Holding	NSW	Merino	51
Petali	Martin Oppenhiemer	NSW	Merino	513
Westvale	Leo Blanch	NSW	Merino	300
Yadin	Robert and Debbie Shea	Vic	Merino	109
Grindon	Roland Ritson	WA	Merino	302
Edale	Philip Gardiner	WA	Merino	296
Centre Plus Poll	Robert Mortimer	NSW	Merino (Poll)	290
Goyarra Poll	Steve Parker	Vic	Merino (Poll)	65
Billandri Poll	Ron Sandilands	WA	Merino (Poll)	294
			Total	**2786**
Ardoe	George Spring	Vic	Poll Dorset	96
Pepperton	Dianne Trewick	Vic	Poll Dorset	133
Lyndoch Park	Mary Currie	Vic	Poll Dorset	220
Jolma	Perry Jasper	WA	Poll Dorset	253
Lockier River	Peter Horwood	WA	Poll Dorset	293
			Total	**995**
Ashmore	Brian Fischer	SA	White Sufflok	279
Ardoe	George Spring	Vic	White Suffolk	108
Langley Heights	Barry Lang	NSW	White Suffolk	407
Linden	Peter Holding	NSW	White Suffolk	54
Glengarry	Julie Wiesner	NSW	White Suffolk	284
			Total	**1132**

4 Results and Discussion

4.1 Development of the IBT and calibration unit

(i) IBTv2
Four IBTv2 and agitometers were built. The construction details and user manual for the IBTv2 are documented in Appendix 1. The IBTv2 is shown in Figures 1 and 2.

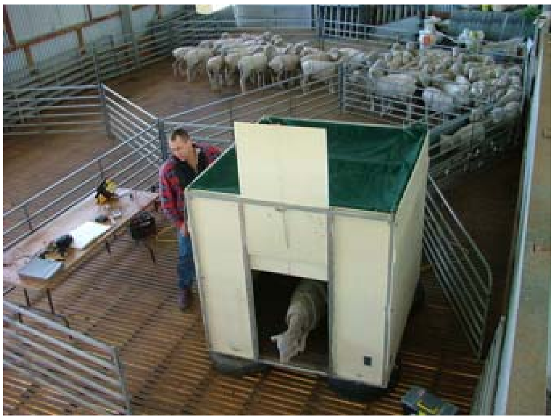

Figure 1 IBTv2 in use in shearing shed

Figure 2 IBTv2 showing position of agitometer

The development of a system for calibrating the IBT was required because the acoustic properties of the individual boxes can vary and moreover, the conditions where each box is setup can also vary from farm to farm. Therefore, in order to minimise any extraneous variation and bias between boxes and farms, a suitable means for calibrating the agitometers was required.

The calibration units were designed to simulate the action of a sheep whilst in the box (see Figure 3) The four feet of the unit make contact with the box floor via spring loaded solenoids. These switches are regulated by pre-programmed low medium and high settings on the unit. The unit is powered by a 12v 26 Amp/h sealed battery. The calibration units were extensively tested in each of the four boxes to establish the mean agitation score at each of three settings.

(a) (b)

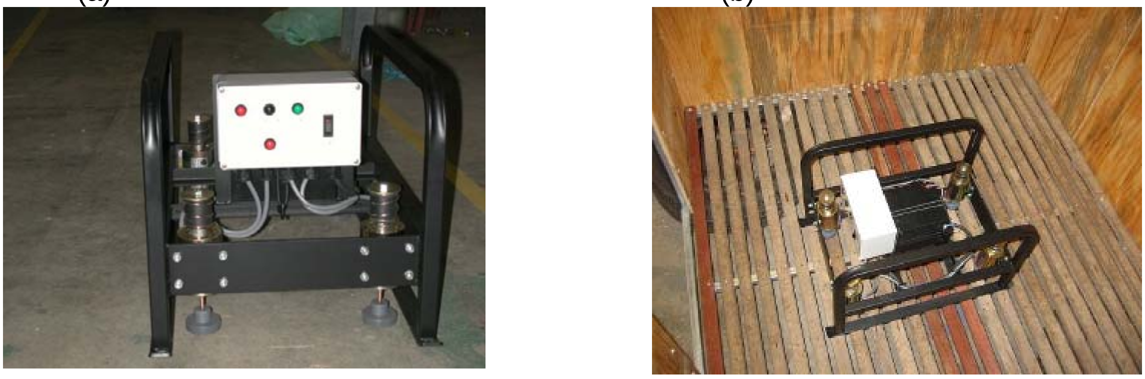

Figure 3 IBTv2 calibration unit. (a) Front view and (b) Inside the isolation box

When each box is setup and during the course of a days measurement, calibrations are performed. Depending on the score, the sensitivity of the agitometers is adjusted until the desired score is obtained at each of the calibration settings.

IBTv3

The main design issues of the isolation box that warranted modification were its overall size and floor construction. Specifically, questions were raised during the course of the on-farm phenotyping as to whether the box could be reduced in size such that it could be accommodated within a race. The wooden slatted floor was an issue as it absorbed moisture from urine and faeces which in turn influenced the acoustic properties. In view of these design issues, a modified version of the IBT (IBTv3) was developed and tested. The box size was reduced to 1.5 x 0.7 x 1.5 m compared to the original IBT (1.5 m^3). In addition, it included a plastic mesh floor and had pneumatic wheels fitted (see Figure 4). The latter serves two purposes, one to insulate the box from the ground and to assist in the placement/movement of the box.

(a) (b)

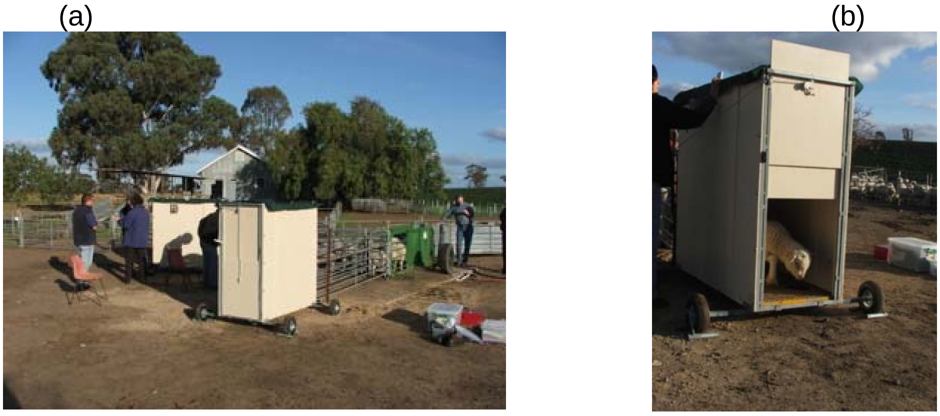

Figure 4(a) and (b) IBTv3.

The results comparing the IBTv2 and IBTv3 are discussed below.

The construction details of the IBTv3 are reported in Appendix 1.

4.2 Evaluation of the IBT

The means ± standard deviations of the agitation scores from the IBTv2 and IBTv3 on each of the testing days are shown in Table 2.

Table 2: Mean (± sd) agitation scores for the IBTv2 and IBTv3 on each test day

Test	**22 Nov**	**26 Nov**	**28 Nov**	**30 Nov**	**2 Dec**
IBTv2	72.4 ± 66.4 (n=351)				59.1 ± 45.7 (n=351)
IBTv3		74.8 ± 58.2 (n=170)	78.1 ± 58.0 (n=172)	87.9 ± 67.9 (n=173)	

4.2.1 Repeatability of the IBT and FT

The repeatabilities of both versions of the IBT range from moderate to high (Table 2). The IBTv3 had the highest repeatability which is highly encouraging. The lower repeatability of the original IBTv2 for Group 2 is most likely associated with the additional handling/testing this group received during the evaluation of the IBTv3.

Table 3: Repeatabilities (intraclass coefficients) for the IBTv2 and IBTv3

IBT	**Repeatability**
IBTv2 (2 tests)	
Group 1	0.59
Group 2	0.40
IBTv3 (3 tests)	
Group 2	0.76

In comparison with the repeatability of other ruminant behavioural tests (Kilgour et al 2005), the repeatabilities are relatively high and reinforce the utility of the IBT. It is also pertinent to highlight that unlike other traits (eg. liveweight), the repeatability of most behavioural tests will always be by influenced by the fact that animals tend to habituate to the test conditions. Consequently, this influences their overall reactivity during repeated exposures (see Table 5).

Table 4: Repeatabilities (intraclass coefficients) for the FT measurements over 1 and 2 m

FT (Group1)	**Repeatability**
1 m	0.004
2 m	0.008

In contrast to the IBT in this study, the measurement of flight time in sheep was not repeatable (Table 4). This outcome was somewhat unexpected given earlier results by Ferguson (unpublished) where low to moderate repeatabilities (0.1 – 0.4) for FT were found. Clearly, as a measure of temperament/emotional reactivity, flight time is less repeatable than the IBT. The extremely low repeatabilities here are difficult to explain other than the fact that the experimental conditions may have influenced the result. In our case, FT was measured on exit from the IBT rather than a weigh crate as in study by Ferguson (unpublished).

4.2.2 Effect of selection line, sex and measurement day on IBTv3 score

An additional analysis was undertaken to examine the magnitude of the effect of selection line and sex on IBTv3 agitation score (ie. Group 2). The results of the repeated measures analysis are shown in Table 5.

Table 5: Effect of selection line, sex and day of measurement on IBTv3 score

Main effects and interactions	**IBTv3 Score**
Selection line	
Calm	51.1
Nervous	139.4
sed	*6.2*
Signif.	*P<0.001*
Sex	
Ram	93.1
Ewe	97.3
sed	*6.1*
Signif.	*ns*
Day	
1	89.5
2	91.9
3	104.4
sed	*3.3*
Signif.	*P<0.001*
Selection line x Replicate[1]	
Calm x 1	46.9[a]
Nervous x 1	132.1[c]
Calm x 2	51.1[a]
Nervous x 2	132.6[c]
Calm x 3	55.3[b]
Nervous x 3	153.4[d]
sed	*3.9 – 7.3*
Signif.	*P<0.05*
Selection line x Sex	*ns*
Sex x Replicate	*ns*
Selection line x Sex x Replicate	*ns*

[1]Least square means with different superscripts are significantly different (P<0.05)

As expected, there was a very large difference in agitation score between the selection lines (P<0.001). The interaction between selection line and day of measurement was found to be significant (P<0.05). For both lines, agitation score increased significantly on day 3 compared to days 1 and 2 where there was no difference. This was contrary to expectations as the trend is normally for the score to reduce with repeated exposures as the animals habituate to the test conditions. No other significant interactions were observed. Importantly, agitation score did not differ between the sexes which is consistent with previous observations (Blache unpublished data). However, differences in fearfulness between the sexes have been found in cattle although there was no consistent trend (Burrow 1998). In his review on animal fearfulness, Boissy (1995) reports evidence that strongly implicates gonandal steroids for the sex differences in ruminant responses to fear-eliciting situations. The young age of the animals (ie. not sexually mature) in the current study may have been a mitigating factor for the absence of any sex effect in agitation score.

4.2.3 Correlation between IBTv2 and IBTv3

Table 6: Regression coefficients, R^2 and RSE for the association between the IBTv2 and IBTv3

Modified IBT	Intercept	Slope	R^2	RSE*
26 Nov	8.43	0.86	0.58	42.9
28 Nov	10.73	0.80	0.49	47.7
30 Nov	16.35	0.65	0.44	50.1

RSE* - residual standard error

Moderate correlations were found between original IBT (22 Nov) and the modified IBT agitation scores. The associations were linear over the range. As expected, the modified IBT correlation with the original IBT deteriorated with time (ie. between the 1st and 3rd exposure) as evidenced by the reduction and increase in the R^2 and RSE, respectively. On the basis of these results, the modified IBT will rank animals in a similar manner to that using the original IBT.

4.2.4 Correlation between FT and IBTv2 measurements

The correlations between measurements of flight time (at 1 and 2 m) and the IBTv2 agitation score were close to zero (ie. r < 0.01). This could indicate that the two measures describe completely independent components of temperament. However, whilst this is plausible, the low repeatability of FT tends to indicate that flight time may be a less informative and reliable measure of sheep temperament.

4.2.5 Reducing the duration of the IBT

The R^2 and residual standard errors (RSE) from the regression regression analyses between the IBT scores at the standard 1 min and reduced test durations from 10 – 50 s are presented in Table 7. As expected, the correlations with the IBT score at 1 minute improved from 10 to 50 s. The results tend to indicate that a reduction in the test duration below 30 s would increase the prediction error. Consequently, the rankings between animals could be affected. This is quite likely, given the fact that animals vary considerably in their behaviour during the IBT. Some show a linear increase in agitation with time. Others display minimal activity initially and more agitation during the latter stages of the test. Given this, it would be our recommendation that the test could be reduced to 30 s without greatly affecting the accuracy or reliability of the IBT.

Table 7: Effect of reduced IBT duration on predictive accuracy (R^2 and RSE)

Duration	**IBT 26 Nov**		**IBT 28 Nov**		**IBT 30 Nov**	
	R^2	**RSE**	**R^2**	**RSE**	**R^2**	**RSE**
10 s	0.71	31.3	0.65	34.3	0.73	35.2
20 s	0.86	21.8	0.81	25.1	0.87	24.7
30 s	0.93	15.8	0.89	19.5	0.94	16.2
40 s	0.97	10.3	0.96	11.7	0.97	12.5
50 s	0.99	6.6	0.99	6.5	0.99	7.5

4.2.6 Genetic analysis of the IBT and FT

Unfortunately, the number of progeny with common records for both the IBT and FT were very low (see Table 8). Consequently, some care has to exercised in the interpretation of the genetic correlations between the two temperament measures and when comparing the correlations between the temperament measures and production traits. Certainly, clear conclusions cannot be drawn at this juncture until additional records are collected.

Table 8: No of progeny and flocks within breed with flight time and IBT records

	Border Leicester	**Poll Dorset**	**Whit Suffolk**	**Merino**	**Poll Merino**
No IBT records	1062	630	743	1807	609
No of FT records	946	1229	1866	509	2138
IBT flocks	4	5	5	8	4
FT flocks	3	6	6	3	6
No. of overlapping records	263	0	0	0	313

The mean ± sd for IBTv2 agitation score and flight time was 98.9 ± 55.6 and 1.01 ± 0.53, respectively.

(i) Analysis of fixed effects

The analysis of the fixed effects revealed that contemporary group/flock was significant for both temperament measures (Table 9).

Table 9: Significance of the fixed effects on flight time and IBTv2

	FT[1]	**IBTv2**
R^2	0.28	0.20
Birth and rearing types	NS	NS
Ewe age	NS	NF
Ewe age^2	NS	NF
Age	NS	NS
Liveweight	NS	P<0.001
Contemp. group/flock	P<0.001	P<0.001
Measurement sequence	NF	P<0.001
Sex	NF	P<0.001

[1] FT - Flight time recorded early post-weaning
NF – not fitted in the model; NS – not significant

Liveweight, sex and measurement sequence all had a highly significant effect on IBTv2. The coefficient for liveweight (1.11 ± 0.11) indicated that agitation score increased with increasing liveweight. Liveweight was not significant in the case of flight time. For measurement sequence, there was a slight reduction in agitation score (-0.04 ± 0.01) with time. The sex effect was quite pronounced where the rams had much lower scores compared to the ewes (Rams 80.6 ± 2.4; Ewes 104.9 ± 2.6). This contrasts earlier results (Section 4.2.2) and is possibly explained by the differences in animal age. The animals were older (mean ± sd age 287 ± 40.6 days) compared to the weaners in the earlier study (age range 84 – 112 days).

(ii) Heritability of temperament traits

Sheep temperament as defined by the two behavioural tests was moderately heritable with higher heritability observed for the IBT (Table 10). The latter may be a function of the higher repeatability of the IBT compared to flight time in sheep (Section 4.2.1). The moderate heritability is consistent with the findings in cattle for various temperament tests (Burrrow 1998) including flight time (Burrow 1998; Kadell et al 2005). The heritability of the IBT is higher than the earlier estimate reported by Murphy (IBTv1 h^2 =0.22)

Table 10: Heritability estimates and phenotypic variances for flight time and IBT in sheep breeds

	FT (early pre-weaning)			**IBTv2**		
	No. of records	Phenotypic variance	h^2	No of records	Phenotypic variance	h^2
Breed						
Border Leicester	587	0.28 (0.02)	0.07 (0.06)	1062	2085.0 (96.8)	0.22 (0.07)
Poll Dorset	1178	0.17 (0.01)	0.35 (0.10)	630	2187.0 (144.9)	0.38 (0.12)
White Suffolk	1763	0.15 (0.01)	0.28 (0.07)	743	2829 (180.8)	0.49 (0.12)
Merino	138	0.07 (0.01)	0.16 (0.30)	1807	2447.0 (97.2)	0.41 (0.09)
Poll Merino	1097	0.23 (0.01)	0.16 (0.07)	609	2211.0 (140.3)	0.39 (0.12)
Overall	**5623#**	**0.20 (0.00)**	**0.21 (0.04)**	**4849**	**2364.0 (54.5)**	**0.35 (0.04)**

Includes additional records from other breeds (Coopworth, Texel, Corriedale)

Differences in heritability were found between breeds for both traits, however, no firm conclusions can be drawn given the differences in progeny records between breeds.

(iii) Genetic and phenotypic correlations between temperament and productions traits

The genetic and phenotypic correlations between traits are presented in Table 11. Unfortunately, the lack of common records between traits makes it extremely difficult to draw any meaningful conclusions about the results.

Table 11: Genetic and phenotypic correlations between IBT, flight time and production traits

Trait	**No. of recs.**	**IBTv2**		**No. of recs.**	**FT[1]**	
		Genetic correlations	Phenotypic correlations		Genetic correlations	Phenotypic correlations
Birth weight	2138	-0.24 (0.09)	-0.02 (0.02)	2915	0.12 (0.09)	0.02 (0.02)
Weaning weight	4337	0.00 (0.08)	-0.01 (0.02)	4215	0.24 (0.09)	0.04 (0.02)
PW weight	3898	0.03 (0.08)	0.02 (0.02)	5484	0.05 (0.09)	0.01 (0.01)
Y. weight	2014	0.02 (0.12)	0.01 (0.03)	1279	0.21 (0.15)	0.06 (0.03)
H. weight	1407	0.10 (0.13)	0.05 (0.03)	755	0.08 (0.20)	0.08 (0.04)
A. weight	43	-0.06 (0.28)	0.10 (0.14)	-	NE	NE
PW fat depth	1313	0.00 (0.12)	0.02 (0.03)	4355	0.11 (0.11)	0.03 (0.02)
Y. fat depth	590	0.03 (0.17)	0.03 (0.05)	267	0.36 (0.22)	0.05 (0.06)
H. fat depth	696	0.14 (0.23)	-0.05 (0.04)	126	0.80 (0.00)	1.05(0.00)
PW eye muscle depth	1318	0.07 (0.12)	0.05 (0.03)	4365	-0.04 (0.10)	-0.03 (0.02)
Y. eye muscle depth	590	-0.12 (0.14)	0.03 (0.04)	269	0.02 (0.20)	0.00 (0.06)
H. eye muscle depth	539	-0.02 (0.21)	0.06 (0.05)	98	1.24 (0.25)	-0.19 (0.11)
Y. greasy fleece weight	1927	0.09 (0.12)	0.02 (0.03)	837	0.23 (0.21)	0.02 (0.04)
H. greasy fleece weight	384	0.15 (0.20)	-0.05 (0.05)	315	0.12 (0.19)	0.03 (0.05)
A. greasy fleece weight	-	NE	NE	-	NE	NE
Y. clean fleece weight	288	0.16 (0.21)	-0.03 (0.06)	-	NE	NE
H. clean fleece weight	130	0.02 (0.31)	-0.11 (0.08)	89	0.17 (0.64)	0.11 (0.12)
A. clean fleece weight	-	NE	NE	-	NE	NE
Y. clean fleece weight	1368	0.03 (0.14)	-0.03 (0.03)	266	0.16 (0.13)	0.03 (0.05)
H. fibre diameter	430	0.00 (0.16)	-0.17 (0.05)	90	NE	NE
A. fibre diameter	NCR	-0.09 (0.25)	-0.05 (0.14)	NCR	-0.06 (0.89)	-0.03 (0.38)
Y. fibre diameter cv	1358	-0.11 (0.15)	-0.06 (0.03)	265	-0.08 (0.25)	0.12 (0.07)
H. fibre diameter cv	431	-0.01 (0.20)	0.03 (0.05)	90	0.83 (0.48)	0.11 (0.11)
A. fibre diameter cv	NCR	0.14 (0.29)	0.06 (0.13)	-	NE	NE
Y. staple strength	108	-0.20 (0.33)	-0.06 (0.08)	-	NE	NE
H. staple strength	127	-0.37 (0.40)	-0.05 (0.09)	NCR	0.08 (1.96)	0.02 (0.56)
A. staple strength	-	0.62 (0.84)	0.22 (0.27)	-	NE	NE
Y. staple length	541	0.17 (0.18)	0.02 (0.05)	221	-0.20 (0.26)	-0.05 (0.07)
H. staple length	342	0.02 (0.23)	-0.01 (0.06)	91	0.80 (0.55)	0.11 (0.13)
A. staple length	-	NE	NE	-	NE	NE
Y. curv	1162	0.11 (0.13)	0.02 (0.03)	265	0.01 (0.23)	-0.09 (0.07)
H. curv	365	0.07(0.16)	0.10 (0.05)	90	0.67 (0.50)	-0.01 (0.12)
A. curv	-	NE	NE	-	NE	NE
No. lambs born	160	0.03 (0.31)	-0.09 (0.09)	270	-0.27 (0.32)	-0.03 (0.06)
No. lambs weaned	153	0.16 (0.49)	-0.06 (0.09)	203	-0.72 (0.89)	-0.08 (0.07)
PW faecal egg count	886	0.30 (0.16)	0.04 (0.04)	1017	-0.02 (0.16)	-0.02 (0.03)
Y. faecal egg count	601	-0.01 (0.21)	-0.06 (0.04)	110	-0.21 (0.50)	0.37 (0.09)
Y. scrotal circumference	544	-0.05 (0.15)	-0.02 (0.05)	540	0.08 (0.20)	0.01(0.05)
H. scrotal circumference	481	0.20 (0.20)	-0.03 (0.05)	231	0.20 (0.30)	0.03 (0.07)
IBTv2 score				576	-0.04 (0.25)	0.00 (0.05)

[1] Ft - flight time recorded early post-weaning. NCR – no common records on progeny. Correlations estimated through sires. PW - early post-weaning; Y - yearling; H - hogget; A - adult

For trait combinations with a reasonable number of records (ie. > 2000), the genetic correlations were relatively low with the exception of the negative association between IBT and birth weight (-0.24 $\pm$ 0.09) and the positive associations between FT and birth (0.12 $\pm$ 0.09) and weaning weight (0.24 $\pm$ 0.09). Genetically at least, the progeny with a less fearful temperament (ie. lower IBT score and slower flight times) had higher birth weights (IBT and FT) and weaning weights (FT only). Intuitively, the association between birth weight and temperament is plausible as gestational stress is a factor in the aetiology of behavioural disorders in developing offspring in both human and rodent studies (see review by Kofman 2002). The question however, is whether *in utero* nutritional deprivation which presumably in the primary reason for the low birth weights, can elicit a similar effect to the psychological stressors that have been applied during gestation in the rodent studies. Against this, the extremely low phenotypic correlations must also be taken into consideration. Another exception was the low positive genetic correlation between post-weaning fat depth and flight time (0.11 $\pm$ 0.11).

No interpretation can be made of the correlation between the IBT and FT due to insufficient common records within the database.

5 Success in Achieving Objectives

Overall, the majority of the project objectives were achieved. It was not possible to reliably estimate the genetic and phenotypic correlations between the IBT and FT and other production traits due to insufficient common records across the traits. The collection of the other phenotypic data was not within the control of the project team.

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

The development of the IBT which was found to be highly repeatable and reliable now enables sheep producers (meat and wool) to select for temperament on-farm. The measurement of FT may also be applied in the same manner. The moderate heritability indicates that reasonable rates of genetic progress are feasible if adopted. 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. It is not clear at this stage whether selection for temperament may directly or indirectly influence other production or animal welfare related traits. However, it will be possible to explore these associations in more detail after collection of additional phenotypic data from flocks affiliated with Lambplan and/or Merino Genetic Services and within another MLA project (AHW.085) which aims to specifically investigate the association between ewe temperament and neonatal lamb survival.

7 Conclusions and Recommendations

Temperament in sheep breeds can be objectively measured using either the IBT or via the measurement of FT. The modified IBTv3 with its more compact design and reduced test duration (30 s) offers a more practical on-farm test compared with the original IBTv2. 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 IBT was found to be more repeatable and had a higher heritability than FT and therefore, may be more appropriate within genetic improvement programs targeting sheep temperament.

It can be concluded that reasonable rates of genetic improvement in temperament are feasible given the moderate heritability of the IBT. Overall, no clear conclusions can be made with regard to the correlations between the two temperament traits and between them and other important production traits due to insufficient common records within the database. The one exception here was the low to moderate genetic correlation between birth weight (and weaning weight in the case of flight time) and temperament. In view of the deficiencies within the database, it is recommended that further progeny records are collected to determine the strength of association between the two temperament tests which will confirm whether they are assessing the same trait. In addition, it will allow a more conclusive analysis of the associations between sheep temperament, production and animal welfare-related traits.

The on-farm adoption of the IBT would enable selection for temperament within multi-trait genetic improvement programs. Selection for temperament, or reduced fearfulness, will bring about direct improvements in handling ease and animal adaptability. Both are highly relevant to improved animal welfare on-farm.

8 Bibliography

Boissy, A (1995). Fear and ferfulness in animals. *The Quarterly Review of Biology* **70**:165-191.

Burrow H.M. (1997). Measurements of temperament and their relationships with performance traits of beef cattle. *Animal Breeding Abstracts,* **65**, 477-495.

Burrow HM (1998). The effects of inbreeding on productive and adaptive traits and temperament of tropical beef cattle. *Livestock Production Science,* **55**, 227-243.

Fell LR, Colditz IG, Walker KH and Watson DL (1999). Associations between temperament, performance and immune function in cattle entering a commercial feedlot. *Australian Journal of Experimental Agriculture,* **39**, 795-802.

Jones RB and Hocking PM (1999). Genetic selectic for poultry behaviour: big bad wolf or friend in need? *Animal Welfare,* **8**, 343-359.

Kadel, MJ, Johnston, DJ, Burrow, HM, Graser, HU and Ferguson DM (2005). Genetics of flight time and other measures of temperament and their value as selection criteria for improving meat quality traits in tropically adapted breeds of beef cattle. *Australian Journal of Agricultural Research* (accepted).

Kofman O (2002). the role of penatal stress in the etiology of developmental behavioural disorders. *Neuroscience and Biobehavioural Reviews* **26**, 457-470.

Lawstuen DA, Hansen LB, Steuernagel GR and Johnson LP (1988). Management traits scored linearly by dairy producers. *Journal of Dairy Science,* **71**, 788-799.

Murphy PM (1999). Maternal behaviour and rearing ability of Merino ewes can be improved by strategic feed supplementation during late pregnancy and selection for calm temperament. *PhD Thesis,* University of Western Australia, Perth.

Murphy PM, Purvis IW, Lindsay DR, Le Neindre P, Orgeur P and Poindron P (1994). Measures of temperament are highly repeatable in Merino sheep and some are related to maternal behaviour. *Proceedings of the Australian Society of Animal Production,* **20**, 247-250.

Pottinger TG (2000). Genetic selection to reduce stress in animals in: *The biology of animal stress: basic principles and implications for animal welfare*. 291-308pp. Eds; GP Moberg and JA Mench. CABI publishing, Wallingford.

Putu, G (1988). Maternal behaviour in merino ewes during the first two days after parturitiob and survival of the lamb. *PhD Thesis*, University of Western Australia, Perth.

Reverter A, Johnston DJ, Ferguson DM, Perry D, Goddard ME, Burrow HM, Oddy VH, Thompson JM and Bindon BM (2003). Genetic and phenotypic characterisation of animal, carcass, and meat quality traits from temperate and tropically adapted beef breeds. 4. Correlations among animal, carcass, and meat quality traits. *Australian Journal of Agricultural Research,* **54**,

Vandenheede M and Bouissou MF (1993). Sex differences in fear reactions in sheep. *Applied Animal Behaviour Science,* **37**, 39-55.

Voisinet BD, Grandin T, Tatum JD, O'Connor SF and Struthers JJ (1997). Feedlot cattle with calm temperaments have a higher average daily weight gains the cattle with excitable temperaments. *Journal of Animal Science,* **75**, 892-896.

9 Acknowledgements

We would like to express our gratitude for the time and effort of the industry collaborators involved on the project (listed in Table 1). Also thanks are extended to Drs Rob Banks and Alex Ball for assistance in the identification of the industry flocks. Finally, we would like to acknowledge Dr Daniel Brown (AGBU) who undertook the genetic analysis of the data.