

# Genetics of temperament: Flight time and the movement meter

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## Introduction

At the 2003 Pig Genetics Workshop, Roger Giles spoke on the topic of recording temperament of pigs with particular reference to the movement meter that had been developed in collaboration with Ruddweigh International Scale Company (Giles et al., 2003). The movement meter is a modification of Ruddweigh's scales to allow collection of all weights generated during a brief time period by a device attached to the weight display. Base on research elsewhere, it was proposed that variability in weights could be used as a measure of an animal's agitation while constrained in the weighing station, thereby offering a practical measure of temperament. An additional measure discussed at this time was that of flight time. However, neither trait had been extensively recorded for pigs under commercial conditions.

Little work has been done on the genetics of temperament in pigs particularly with regard to the traits discussed here. Reverter et al. (2003) reported favourable genetic correlations between flight time in beef cattle and meat quality traits. Flight time in this case is the time taken for an animal to pass between two points on exiting a restraining crush. This work prompted a proposal that the genetics of both flight time and the movement meter be investigated for pigs. A discussion of this proposal was led by Hans Graser at the 2003 Pig Genetics Workshop (Graser, 2003).

With the support of the Pig Genetics Consultative Group, this project was initiated in mid-2003 with the purchase and distribution of the necessary hardware to the cooperating breeders recruited at the workshop. Data recording has been carried out at three sites (Cefn Genetics, QAF Meat Industries and Belmont) from different starting dates and for different periods of time depending on various operational constraints.

The primary aim of this initial trial is to ascertain whether flight time and traits derived from the movement meter data are heritable. If these traits are not heritable, then there would be no point in proceeding on to investigate their genetic relationships with meat quality traits that are expensive to record. However, the presence of genetic relationships between these traits and routinely recorded performance test traits can be investigated at this stage.

It is intended that the data-recording part of this initial study will be regarded as complete in early-2005, by which time there should be 5000 movement meter records in the largest data set.

This paper reports results of early analyses on the Cefn data.

## Recording

The recording equipment was set-up independently at each of the three sites. Consequently there is variation in the physical design of the recording area layout and the recording practices at these farms. Consideration was given to preventing pigs from interfering with the pig being recorded at all sites.

At Cefn Genetics and Belmont the performance test consists of weighing and scanning at the completion of finishing. Flight time and movement meter recording was carried out at this time. At QAF Meat Industries, a subset of boars is performance tested on electronic feeders for a constant period. This provided the opportunity for recording flight time and movement meter records at both the start and end of test, and this was carried out for a relatively small number of animals.

Animals went through the testing area in groups. That is, a group of pigs were brought into a holding area, and then they went through the procedure one at a time finishing up in a second holding area. When all pigs in the group had been tested the group was removed from the test area and the next group brought in.

At Cefn each of the groups was expected to correspond to a pen. An average pen was reported to contain 12 animals that were tested. One pen is brought into the recording area at a time. The pen identifiers were not recorded but animals could be assigned retrospectively to a 'processing group' based on the time gap between consecutive records. Each record within a data file was considered in turn. If greater than 5 minutes elapsed between consecutive records, a new processing group was begun. If the finalised processing group contained 20 or more animals it was split at the largest time interval within it, and this process was repeated so that all processing groups contained less than 20 animals.

### 1. Movement meter

After entering the movement meter the pig was left for 20 seconds with minimal interference. After this period, other data on the animal was collected.

The movement meter equipment generated weight records at the rate of five every two seconds, there was therefore no possibility for manual recording of this data. Ruddweigh supply appropriate software for Palm handheld devices and Tony Henzell (AGBU) developed a PC application for use with a Windows Personal Computer during recording (two of the volunteer groups were already using PCs in the recording shed). All the analyses reported in this paper are on data recorded via the PC software, and so descriptions of the data analysed relate to the output from that system.

The PC application recorded an animal identifier as input manually by the operator, a time and date (based on the PCs internal clock), 51 weights passed from the scales and any additional comments that the operator chose to make.

## 2. Flight Time

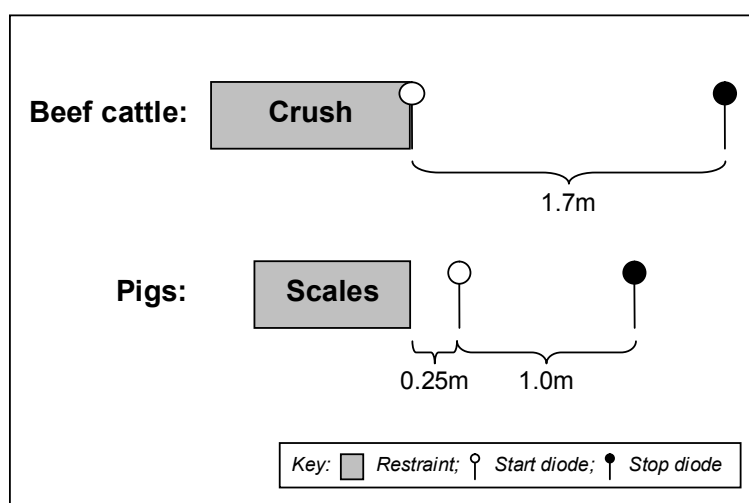
The equipment for recording flight time (FT) consists of two light-emitting diodes connected up to a time display. The equipment is identical to that used in beef cattle recording, however the set-up is different.

In beef cattle, the start diode is placed directly at the exit from the crush and the stop diode is positioned 1.7m from this. When cattle are released from the crush, they tend to exit quickly, rarely with any hesitation.

In pigs, we proposed positioning the flight time equipment as for beef cattle but directly after the weigh scales. However, during initial tests of the flight time equipment at Cefn Genetics, the following became apparent.

- Many pigs require some encouragement to leave the weigh scales, and so a subjective score (0-5) to indicate the level of encouragement was required, along with an indication of the operator (in order to allow operator differences in the understanding of the level of encouragement to be accounted for).
- Many pigs hesitate when leaving the weigh scales, sticking their snouts out and having a look round before committing themselves to leaving. If the start diode was directly outside the weigh scales, this could result in an early triggering of the FT recording. It was decided to allow a 25cm gap between the weigh scales and the start diode so that pigs were actively leaving the crate before triggering the start of recording.
- Many pigs did not travel 1.7m before stopping and possibly requiring some encouragement to go further. The distance between the start and stop diodes was reduced to 1m in order to reduce the number of failed FT readings because of this (the FT recording equipment resets itself after a short time if an animal has not passed the stop diode).

The resultant differences in the set-up are summarised in Figure 1.



**Figure 1** Comparison of Flight Time recording equipment set-up for beef cattle and pigs

## Traits analysed

As will be discussed later, there is scope for defining numerous traits from the movement meter data. For this preliminary study, a single measure of the variability in weight measurements was chosen. The standard deviation of the middle 25 weight records (**SD**) for each animal was regarded as being our movement meter trait of interest. The reason for this being that this eliminated the earliest and latest serial weight records where most recording problems were apparent.

Flight time in seconds (**FT**) is the second temperament trait considered here.

Performance traits analysed were daily gain from birth until end of test (**DG**), ultrasonic backfat depth (**BF**) and ultrasonic muscle depth (**MD**).

Some summary information for these traits as recorded at Cefn, along with weight (**WT**) and age at recording (**AGE**) is presented in Table 1.

The Cefn data set consisted of 4316 animals with temperament records that matched to PIGBLUP data. These originated from four selection lines and from both male and female pigs. Animals recorded represented nearly all of the performance-tested animals for this period and no historical performance test data was included in the analyses. Pedigree information on all ancestors of the 4316 recorded animals was collected from the PIGBLUP data files and included in the genetic analyses.

In Table 1, there are only 4270 SD and 2913 FT records. The difference between SD and performance record counts was caused by failure to record the movement meter record for some animals and editing to remove some records that were obviously in error. The discrepancy between FT and SD counts is due to a combination of FT recording starting a few weeks later than SD recording, a malfunction in the FT equipment and removal of SD records that were obviously in error. For the analyses performed, animals had to have a performance test record and FT records had to be associated with an SD record in order for all explanatory variables to be present for FT.

**Table 1** Summary information for traits and covariates included in the analyses after editing.

| Variable | Units   | Observations | Mean | Range     |
|----------|---------|--------------|------|-----------|
| AGE      | days    | 4316         | 145  | 124-167   |
| WT       | kg      | 4316         | 93.5 | 61-136    |
| DG       | g/day   | 4316         | 646  | 421-877   |
| BF       | mm      | 4316         | 10.9 | 3.8-24.5  |
| MD       | mm      | 3592         | 62   | 37-89     |
| FT       | seconds | 2913         | 2.1  | 0.02-12.3 |
| SD       | kg      | 4270         | 0.85 | 0-4.8     |

## Analyses

Final results presented in this paper are taken from a 5-trait multivariate residual maximum likelihood analysis fitting an individual animal model.

Fixed effect models were investigated for FT and SD using the R statistical package (R Development Core Team, 2004). A consensus model was fitted across the two traits, with the exception of encouragement score which was only fitted for FT. The consensus fixed effects model fitted consisted of week, sex, breed, user-defined management group, linear and quadratic regressions on position within the processing group fitted within processing group size, the interaction of breed with processing group and linear regressions on WT and AGE.

Fixed effect models for performance traits were the defaults used in PIGBLUP. Line and the interaction between user-defined management group, sex and week were fitted for all three traits. For BF and MD linear and quadratic regressions on WT were also fitted.

Individual animal model residual maximum likelihood analyses were performed with ASREML for the estimation of genetic parameters. Univariate analyses were used to establish the significance of common litter of birth effects and to provide starting values for subsequent analyses. Using a likelihood ratio test the common litter effects were judged to be significant for DG, BF and SD, and were included in the model for these traits for all subsequent analyses.

Bivariate analyses among all combinations of the five traits were performed to obtain starting values for the five-trait multivariate analysis.

## **Results and Discussion**

Results of the 5-trait genetic analysis are given in Tables 2 and 3.

Both FT and SD were heritable. There was a significant common litter of birth effect associated with SD. Without this effect included in the model the heritability for SD was estimated at around 0.17 in univariate analyses. Estimates of heritability and common litter effects for performance traits were consistent with expectation.

The estimated genetic correlation between FT and SD was -0.56. Given the interpretation of these traits, that lower FT and higher SD pigs are more agitated and have worse temperament, if the traits were genetically the same the genetic correlation between them would be expected to be -1. The approximate standard error of the estimate suggests that the observed value was significantly different from -1. This was supported by a likelihood ratio test carried out on the bivariate estimate of the genetic correlation between FT and SD.

Standard errors of the genetic correlation estimates between temperament and performance traits were high relative to the magnitude of the estimates themselves and caution should be exercised in their interpretation. However, the values in Table 2 suggest that selection for improved temperament using either FT or SD may result in some increase in DG, little change in MD, but with some associated increase in BF.

**Table 2** Genetic correlation ( $r_g \times 100$ , below diagonal), phenotypic correlation ( $r_p \times 100$ , above diagonal), heritability ( $h^2 \times 100$ ; bold, on diagonal) and phenotypic variance ( $\sigma_p^2$ ) estimates.

|              | DG            | BF            | MD            | FT            | SD            |
|--------------|---------------|---------------|---------------|---------------|---------------|
| $\sigma_p^2$ | 3104          | 4.27          | 29.2          | 1.50          | 0.205         |
| DG           | <b>16 ± 4</b> | 15 ± 2        | 0 ± 2         | 7 ± 3         | -8 ± 3        |
| BF           | -20 ± 15      | <b>33 ± 5</b> | 0 ± 2         | 3 ± 3         | -1 ± 2        |
| MD           | 0 ± 13        | -8 ± 10       | <b>35 ± 4</b> | 0 ± 3         | 5 ± 2         |
| FT           | 33 ± 17       | 16 ± 14       | 1 ± 14        | <b>21 ± 5</b> | -12 ± 2       |
| SD           | -35 ± 21      | -27 ± 17      | 1 ± 15        | -56 ± 17      | <b>12 ± 4</b> |

Phenotypic correlations between the five traits were low (Table 1) as were the residual correlations (Table 3). As with the genetic correlation estimates, the approximate standard errors of the correlations between common litter effects for trait combinations were also high and their over-interpretation should be avoided. The common litter of birth correlation between SD and BF was positive.

**Table 3** Litter effect correlation ( $r_c \times 100$ ; below diagonal), residual correlation ( $r_e \times 100$ ; above diagonal) and litter effect variance as a percentage of the phenotypic variance ( $c^2 \times 100$ ; bold, on diagonal) estimates.

|    | DG            | BF           | MD    | FT     | SD           |
|----|---------------|--------------|-------|--------|--------------|
| DG | <b>10 ± 2</b> | 25 ± 3       | 0 ± 4 | 1 ± 4  | -6 ± 3       |
| BF | 43 ± 16       | <b>5 ± 2</b> | 5 ± 4 | -2 ± 4 | 3 ± 3        |
| MD | -             | -            | -     | 0 ± 04 | 6 ± 3        |
| FT | -             | -            | -     | -      | -4 ± 4       |
| SD | 18 ± 22       | 47 ± 29      | -     | -      | <b>4 ± 2</b> |

## Conclusions

The first phase of this process has been a qualified success – both FT and SD are heritable when measured under practical commercial conditions, although obviously a higher heritability estimate for SD would be preferable. It is possible that identifying improvements in procedures will alter heritability estimates. In addition, there may be other traits that can be defined from the movement meter data that are more heritable and which remain correlated with performance data. The full analysis of these data should answer this.

Improved editing procedures may also act to reduce the residual, unexplained variation in SD. More comprehensive identification of erroneous SD records can be carried out based on within and between animal comparisons. Moreover, no editing with respect to FT outliers was performed, but some of the extreme FT records in these data may not be correct given the resetting capability of the equipment.

The two temperament traits appear not to be different expressions of exactly the same genetic trait. Therefore, they may provide information on different aspects of temperament and have different relationships with meat quality traits. The inclusion of both flight time and movement meter traits in future studies is recommended.

## Where to next?

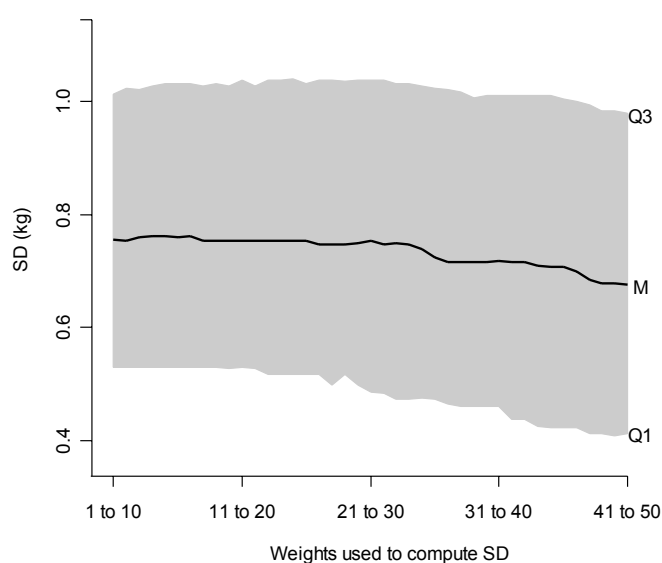
### 1. This trial

Data collection for this trial will be regarded as completed in early 2005, when the Cefn data is expected to have reached 5000 movement meter records. After this, a full analysis of these data will be performed.

As far as possible the analyses will be replicated using the data from the other sites. Belmont used a Palm handheld to record the movement meter data with the software provided by Ruddweigh, this does not record the time of the record so it will not be possible to consider all of the effects included here. The QAF data set is too small to provide accurate estimates of genetic parameters, however the repeated records will give an indication of the repeatability of the measurement.

*Alternative movement meter traits.* One question is whether the 20-second period can be reduced. To look at this the 20-second period will be split into shorter periods and both the variability within these and the relationship between them studied.

Figure 2 shows the change in the standard deviation of weights across the 20-second recording period. The standard deviation of consecutive 10-weight record groups was calculated for each animal. Then the median, first quartile (Q1) and third quartile (Q3) of the standard deviation of each of these 10-weight groups were calculated across animals. If the standard deviation values were sorted, the median would be the middle value and Q1 and Q3 would be the boundaries defining the middle 50% of the values. From Figure 2 it can be seen that there is a decline in the standard deviation across the 20-second recording period and that there is an increase in the inter-quartile range (Q3-Q1). As the inter-quartile range has increased the decline in the standard deviation cannot be constant across animals. This between-animal variation in the rate of decline may be under genetic control and this will be investigated using appropriate statistical techniques.



**Figure 2** Across-animal median (M) and first and third quartiles (Q1, Q3) of the within-animal standard deviation of 10 consecutive weight records.

Traits can be defined in terms of how the variability is summarised, variance, standard deviation or possibly Fourier transforms of the data. Fourier transforms treat the records within an animal as if they were a wave, like a sound wave or a sine wave, and summarise them in terms of frequencies and amplitudes. These values, or combinations of them, can be treated as traits.

*Alternative analysis models.* It may be expected that having an agitated pig will have a bigger effect upon the agitation of the next (or previous) pig in the queue than the one after (or before) that, and so on. This can be modelled by assuming relationships between the residuals that decrease as the distance between animals in the queue increases (for example, an auto-correlation model).

Also, Muir and Schinckel (2002) proposed models in which individual animals within a group have a genetic effect upon the performance of other animals in the same group. That is, the observation on an animal is the sum not only of its own direct genetic and environmental effects for that trait but also the so-called 'associative' genetic and environmental effects of all of its pen mates. It is reasonable to think that this type of model may be appropriate for temperament traits, as the level of agitation of animals is likely to affect the degree of agitation of other animals housed with it. If a clear, precise assignment of pigs to their pens can be achieved then this type of analysis will be investigated with the current data sets, otherwise it may be left for a future study.

## **2. Project APL 1927**

Flight time, movement meter and back test data are also being collected as part of Project APL 1927 (Bunter, these proceedings). Animals recorded for these temperament traits are also recorded for the back test, along with production traits (including feed intake), carcass pH and meat colour. The number of records available from this trial will not allow accurate estimation of genetic correlations between the temperament traits and the two meat quality traits, but will provide preliminary information.

## **3. Relationships with breeding objectives**

In order that the temperament traits being studied can be used as selection criteria for temperament and meat quality the relationships of these traits with temperament and meat quality traits must be known and be of sufficient magnitude to provide accurate estimates of genetic merit.

The temperament traits that we wish to improve, those in the breeding objectives, would include such things as maternal behaviour towards her offspring and the ease of handling of commercial animals. Genetic analysis of these breeding objective traits is not straightforward – the traits are poorly defined and their recording would be difficult. Some information may be gleaned with respect to sow temperament from the extension of the current data over time to include sow culling reasons.

Evaluation of relationships with meat quality will require a further project, and a proposal will be developed to accompany the final report on the analysis of the current data.



## References

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