Genetics of temperament: What do we know about the "back test"?

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Introduction

The Back test is a behavioural measure of an animal's ability to cope with a stressful or challenging situation. The test itself involves rolling a piglet on its back and holding it gently on its back for a period of one-minute. During this time, the number of escape attempts that the animal makes while restrained is recorded. The animal is then returned to the litter, without any invasive procedure and with minimal fuss.

This test has been described as a repeatable measure of "coping style", unrelated to measures of aggression as assessed from resident-intruder tests (D'Eath and Burn, 2002), but predictive of physiological differences that are reported to be "characteristic" of different coping styles. For example, the results of Bolhuis et al. (2003) suggested that immune responsiveness was higher in pigs with passive coping style. Similarly, using different behavioural tests to evaluate coping style, Giroux et al. (2000) concluded that piglets with a passive reaction to stress had an improved post-weaning weight gain, but their study did not extend to grower or finisher weights. Geverink et al. (2004) later categorised twenty-four 13-month old gilts according to their earlier back test results (from N=72). They demonstrated improved weights and energy balance of low-resisting (LR) compared to high-resisting (HR) gilts one week after transfer to new housing conditions, suggesting that low-resisting gilts adapted better to the change. Nevertheless, body weights of LR and HR gilts were not different at the start of their study, implying no prior long-term effects. The much larger studies of van der Kooij at al. (2000) demonstrated a positive association between back test scores and lean meat percentage, such that animals with high back test scores had better carcase grading. Again, there were no associations between back test score and measures of daily gain.

Results from studies involving the back test have not always been consistent. For example, Ruis et al. (2000) failed to demonstrate consistency in back test results for 128 gilts recorded at different ages (2-4 days vs 4 weeks), but went on to report a higher salivary cortisol response to an administration of ACTH and lower aggression of LR compared to HR gilts, categorised based on the pre-weaning back test results. Geverink et al. (2002) summarise the lack of consistency in available literature of establishing the relationships between behavioural coping styles and aggressiveness, physiological responses, or productivity. However, many behaviourally based studies have generally involved only small numbers of animals (eg <50). Further, differences in the procedures used to obtain the back test records may be important, and this has not been considered to date. In reality, there are relatively few studies that assess the relationships between behavioural traits, such as the back test, and other economically important traits in pigs from recording in a production environment.

To be useful in an animal breeding context, traits such as the back test must be heritable when measured under commercial conditions, variable, and correlated with economically important traits. This section briefly describes results from a preliminary trial used to assess: a) whether hand positioning influenced the number of escape attempts; b) whether the addition of other information (eg vocalisation, shivering) assisted in differentiating between animals with similar back test scores; and c) whether the back test was a heritable trait as recorded in a commercial production environment. More data is currently being collected that will be used to establish whether there are any associations between back test results and crate activity or flight time, along with production performance and some meat quality traits.

Materials and methods

The trial was conducted at QAF Meats between the 3rd and 7th of May, 2004. Trial design comprised of four treatments for the back-test procedure. Each treatment was to be allocated to each of the 85 litters in duplicate, resulting in 8-treatment animals/litter and a total of 680 records. Piglets were placed on a **flat surface** on their back and gently restrained by either one of the following three methods:

1. placing one hand loosely over the hind leg stifles, with the other hand positioned in front of the front legs, towards the throat area. The front limbs were not held during the test period. Animals were free to move their front legs. However, hind limbs were not able to kick freely. Movement of the head was also discouraged during restraint.
2. placing one hand loosely around the forelimbs, with the other hand placed gently over the animal's throat (see Figure 1). Animals were free to kick their hind limbs and to either lay their legs backwards in a relaxed manner or to bring their legs up close to their chest in a more rigid display. Again, the head could not be thrown.
3. placing one hand loosely around the forelimbs, with the other hand loosely over the hind leg stifles. This variation to the back-test removed restraint from the head and throat region. However, all four limbs were restrained, preventing kicking,

   OR piglets were placed on a **small cradle** and restrained by:

4. placing one hand loosely around the forelimbs, with the other hand placed gently over the animal's throat. In this alternative, the animal experienced lateral restraint/support from the cradle. Hind limbs were free to move, though the head and forelimbs were restrained.

Experimental animals were individually removed for testing from their home farrowing crate in a random order, and the order in which the different back-test procedures were performed was alternated between litters, to prevent the development of associations between the 'easy' vs 'hard' to catch piglets and treatment. A single experienced operator conducted all tests (Richard Landsdowne). In reality, cross fostering prevented replication of treatments within all litters. Consequently, piglets from more than 85 litters were back tested in order to achieve the desired number of records.

Vocalisation was scored on a scale of 1-3, where a score of one indicated little or no vocalisation during the back test, score 3 animals vocalised regularly, and score 2 animals were intermediate. Comments regarding other physiological observations were also noted for each piglet. For example, whether piglets were aggressive (AGRO), became rigid (RIGID) or exhibited skin discolouration (COLOUR), shivered (SHIVER), voided urine or faeces (VOID), and/or appeared small or unhealthy (SICK) during the back test was recorded. These observations were translated to binary scores (characteristic observed=1; not observed=0) within each category.

Figure 1. The back test procedure (Treatment 2)

Traits evaluated included the number of escape attempts recorded and the degree of vocalisation. Escape attempts and vocalisation scores were also combined. Similarly, the number of escapes was summed with the binary scores for AGRO, RIGID, COLOUR, SHIVER and VOID independently and in a sequential manner to create a series of new traits. For example, a piglet with 3 escape attempts, a score of 2 for vocalisation, and with a sequence of binary scores for the physiological observations of: 0, 1, 0, 1, 0, would receive the following trait values:

Trait	Combining	Trait value
Escapes	Escapes (E)	3
Vocalisation	Vocalisations (V)	2
Combined	E+V	5
	E + RIGID (R)	4
	E + VOID (D)	3
	E + R + D	4
	E + A + R + C + S + D	5

Piglets tested were from nucleus litters of all lines held at QAF. Thus, piglet pedigree was established and preliminary estimates of heritabilities obtained. After removal of duplicate piglet records (N=8) and/or those with missing information (N=11), 703 records were available for analyses. Each piglet record contained information on: experimental treatment (ie hand positioning and restraint), date of testing, the number of escapes, a vocalisation score, pedigree (sire and dam), nurse sow details, along with piglet breed and age. Piglets recorded were progeny of 47 sires and 116 dams, nursed in litters of 110 sows only. Both piglets nursed by their own dams (87.2%) and cross-fostered to other sows (12.8%) were recorded for the back test procedures. In total, 866 animals were present in the pedigree file. Mean age of piglets tested was 14.1 days, with the bulk (98%) of piglets tested at 14±1 days of age.

Estimates of fixed and random effects were obtained using ASREML (Gilmour et al., 1999). Systematic effects evaluated included testing date (6 levels), sow parity group (4 levels), treatment (4 levels), breed (4 levels), sex (2 levels), and piglet age (treated as a linear covariate). Levels for each sow parity group contained the sow parities 1, 2, 3-4, and 5-7. Random effects included additive genetic and litter effects, the latter based on the nurse sow litter. Since piglets are cross-fostered early in life, the nurse sow litter was considered to better represent the common environment of rearing than the dam's litter, which in any case was not necessarily recorded during the trial period. Under an animal model, the fact that nurse littermates may have different dams is already accounted for.

Results and Discussion

Characteristics of the data for number of escape attempts and the degree of vocalisation are presented in Table 1. The number of escape attempts ranged from one to twenty, while vocalisation scores ranged from one to three. Distributions for the back test and vocalisation were not Normal. The back test distribution was left truncated and right skewed, whereas vocalisation scores took extreme values (1 and 3) more frequently than the intermediate value. Raw data means suggest that treatment three gave different results to the other back test treatments. Treatment three resulted in a significantly ($P<0.05$) larger number of escape attempts and vocalisations than treatments 1, 2 and 4, which did not significantly differ from each other. Treatment three was the only procedure where there was no restraint at the head and/or throat region, but full restraint of limbs.

Table 1. Raw data characteristics by treatment

Trait	Escapes			Vocalisation		
Treatment	**Mean**	**SD**	**CV**	**Mean**	**SD**	**CV**
All (1-4)	3.97	3.33	84	2.15	0.88	41
1	3.32	2.86	86	2.05	0.90	44
2	3.70	3.35	91	2.04	0.89	44
3	5.68	3.47	61	2.51	0.76	30
4	3.21	3.02	94	2.01	0.88	44

When random (eg additive genetic and common litter) effects were ignored, significant systematic effects for escapes and vocalisation included test date, piglet breed, sow parity, back test treatment and test age. However, only treatment remained significant for escape attempts, or treatment + breed for vocalisations, when random effects were included in the analyses. Least square means by treatment are therefore very similar to raw means by treatment shown in Table 1, and are not presented separately. Parameter estimates for the number of escape attempts and degree of vocalisation are presented in Table 2.

Table 2. Estimates of heritabilities (h^2), common litter effects (nurse sow: c^2) and phenotypic variances (σ^2_p) for the number of escape attempts and degree of vocalisation during the back test, along with a combined* score.

Trait	h^2	c^2	σ^2_p	LogL
Escape attempts	0.35±0.15	0.18±0.07	10.1	-1096.13
	0.75±0.10	-	10.7	-1099.61
	-	0.34±0.04	10.1	-1099.82
Vocalisations	0.32±0.13	0.10±0.05	0.71	-200.96
	0.52±0.10	-	0.73	-202.94
	-	0.22±0.04	0.70	-205.44
Combined*	0.44±0.15	0.14±0.07	13.9	-1194.56
	0.70±0.10	-	14.1	-1193.22
	-	0.34±0.04	13.8	-1199.09

*Summation of escape attempts & vocalisation score.

Based on the comparison of log-likelihood values, models containing terms for both additive genetic and common (nursing) litter effects were significantly better than models containing each effect considered alone. Both the number of escape attempts and the degree of vocalisation were moderately heritable, with low to moderate common litter effects. A combined score of escape attempts + vocalisation was more highly heritable and variable than each trait considered separately. This suggests that the degree of vocalisation provides additional information towards identifying genetic differences between piglets in behaviour during the back test.

In contrast, augmenting the record for number of escape attempts using information on piglet aggressiveness, rigidity, colour, voiding or shivering had only small effects on observed variation. Further, estimates of heritabilities were not greatly increased, ranging between 0.34-0.37, when this information was combined with the number of escape attempts. The less informative nature of these observations was partly to do with their low frequencies (<7% of animals were observed in any one category) along with their translation to a binary score. A more detailed scoring system for each of the categories may have been more informative. However, it is difficult to perceive how voiding, for example, can be expanded to more than one score (eg indicating degree of voiding). Further, increasing the number of variables that an operator must observe and score within the back test period would complicate the overall testing procedure.

Estimates of parameters for the number of escape attempts by treatment are shown in Table 3, along with estimates for the combined score (escapes + vocalisation). Although the number of records per treatment is low, results demonstrate that parameter estimates for the combined score (escapes + vocalisation) appeared more robust than parameters for the number of escape attempts. Heritability estimates (not presented) for log transformed data were slightly higher, and common litter effects lower (~0.10), than for the untransformed data.

Table 3. Parameter estimates by treatment

Treatment	N	h^2	c^2	σ^2_p
		Escape attempts		
1	177	0.07±0.24	0.31±0.15	8.23
2	178	0.25±0.26	0.24±0.14	11.2
3	174	0.32±0.26	0.10±0.16	12.1
4	174	0.0±0.0*	0.48±0.09	8.82
		Combined score		
1	175	0.14±0.25	0.27±0.15	11.9
2	177	0.29±0.27	0.25±0.15	15.1
3	172	0.38±0.27	0.07±0.16	15.2
4	172	0.31±0.30	0.26±0.16	12.5

* Fixed to boundary

Conclusions

Hand positioning affects outcomes from back test procedures, both in terms of the number of escapes and the level of vocalisation recorded. Where there was no restraint near the throat, but full limb restraint, the number of escape attempts and degree of vocalisation were higher. There was no significant difference between the remaining procedures, suggesting that the use of a cradle to provide lateral support is not required, and variation in fore and hind limb restraint has little impact on scores when combined with restraint in the throat area. Recording the level of vocalisation during the back test provided additional information that could be used to assess overall piglet behaviour during the back test.

Both the number of escape attempts and the level of vocalisation were moderately heritable traits.

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