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# BEHAVIOURAL TRAITS RECORDED IN GILTS AND ASSOCIATIONS WITH REPRODUCTIVE PERFORMANCE AS GROUP-HOUSED SOWS

**K.L. Bunter**

Animal Genetics and Breeding Unit, a joint venture of NSW Department of Primary Industries and University of New England, University of New England, Armidale, NSW 2351, Australia

## SUMMARY

Gilts from two maternal lines were recorded for flight time (FT, N=8854) and scored for the count of lesions resulting from fighting 24 hours after selection and mixing into new groups (N=3238). Anterior (ANT) and posterior lesion counts were scored on a progressive four point scale representing none to multiple lesions (0-3), and aggressive gilts (0/1 scores) were defined by ANT>1. Lesion counts over the whole body were subsequently rescored pre-farrowing (PFBLES). Genetic correlations were estimated between these behavioural traits and average daily gain (ADG), gilt removals without a farrowing event and first parity litter size (TB: total born; NBA: number born alive) and birth weight. All behavioural traits scored for gilts and pregnant sows pre-farrowing were lowly to moderately heritable ($h^2$<0.15), implying that selection could alter FT or reduce fighting behaviour and hence skin lesions at different time points. However, lesion scores for gilts were not highly correlated with later PBFLES, reflecting changes to individual participation in fighting behaviour over time. Skin lesion traits were also uncorrelated with FT. These traits therefore represent assessment of different behaviours. Flight time was genetically correlated with ADG (rg: 0.24±0.10) only. All behavioural traits were generally not significantly correlated (either genetically or phenotypically) with subsequent reproductive performance, implying a neutral association between behavioural phenotypes and selection criteria in maternal lines. However, low adverse phenotypic correlations between lesion and locomotion scores or gilt removals illustrate a detrimental impact of fighting on welfare. Using management strategies to reduce fighting and developing a better understanding of the genetic basis for long term behaviour remain important for ongoing improvement of welfare and performance of group housed sows.

## INTRODUCTION

Relative to stall housing, reintroduction of group housing for sows during gestation has several positive welfare benefits, but also enables negative interactions between sows. In particular, aggression amongst sows within groups can compromise their welfare and reproductive performance (Anil *et al*. 2006; Spoolder *et al*. 2009). However, observing behaviours of individual pigs directly is time consuming and impractical, and therefore an individual's contribution to aggression is frequently unknown. In addition, aggressive behaviours alter as the social hierarchy is established within stable groups (Anil *et al*. 2006), so the timing of observation is important. Behavioural indicators previously studied in commercial growing pigs include flight time (Crump 2004; Hansson *et al.* 2005) and the counting of skin lesions resulting from fighting, with anterior lesions in particular used as an indicator of participating in reciprocal fighting (Turner *et al.* 2006, Turner *et al.* 2009). In this study I investigated the genetic basis of behavioural traits recorded for purebred pedigreed gilts at selection, and their associations with lesion scores recorded again pre-farrowing, along with first parity reproductive performance under group housing during gestation.

## MATERIALS AND METHODS

From January 2013 through to December 2014, approximately 10000 gilts from two maternal lines (Large White and Landrace) were recorded at a single site for lifetime average daily gain (ADG, g/day) at 24 weeks of age. Behavioural traits recorded concurrently included flight time and shortly after skin lesion scores resulting from fighting. Flight time (FT, s) was recorded upon release from weigh scales at the end of performance testing (N=8854)(see Crump 2004), while skin lesion counts were scored (N=3238) 24 hours after mixing into new groups <1 week later. Skin lesions resulting from fighting were scored on a progressive four point scale separately for each quarter, as 0: no lesions; 1: 1-5 lesions; 2: 6-10 lesions; and 3:10+ lesions. Scores were summed into anterior (ANT) and posterior (POS) quarters and regrouped (0, 1-2, 3-4, 5-6) into 4 scores for analyses. Gilts with ANT>1 were classified as an aggressive behavioural type (AGRO).

Gilts selected as breeding replacements were subsequently exposed to boars after 28 weeks of age and mated using AI. Gilts removed from the herd without a farrowing event were identified (REM0=0/1; removed=1). Pregnant gilts were housed in small static groups throughout gestation. A subset (N=1929) were re-scored for the count of skin lesions over their whole body upon transfer to the farrowing house (PFBLES) using the same scale as above (0-3), along with locomotion (PFLOCO: 0-3) and condition scores (-1,0,1) representing under-, at target, or over-condition. Reproductive performance traits recorded in the first parity included total born and number born alive (TB and NBA, pigs/litter). A subset of sows had records for average piglet weight at birth (ABWT, kg/piglet). Historical and male sibling data for ADG, all contemporary gilt reproductive data and 4 generations of pedigree were used to estimate genetic parameters.

Parameter estimates were obtained using linear mixed models under an animal model with ASREML software (Gilmour *et al.* 2009). Systematic effects included year-month of recording (24 levels), line (2 levels), and gender (M vs F, for ADG only). An additional random effect for birth litter was fitted when significant ($P<0.05$) based on a likelihood ratio test. Correlations between traits were estimated using a series of bivariate analyses.

## RESULTS AND DISCUSSION

Raw data characteristics are provided in Table 1, along with heritability estimates for each trait. Behavioural traits scored for gilts (FT, ANT, POS and AGRO) and pregnant sows pre-farrowing (PFBLES) were lowly to moderately heritable, at the lower end of the range in heritability estimates reported for FT (Hansson *et al.* 2005) or lesion counts (Turner *et al.* 2009; Desire *et al.* 2015) for growing pigs. Scoring was preferred to lesion counts from the perspective of increasing the number of animals which could be recorded in a commercial setting, but reducing continuous traits to scoring categories can reduce estimates of heritabilities. The relatively lower heritabilities in our study could also indicate that as animals mature the genetic contribution to aggressive behaviours decreases (e.g., through learned behavioural responses to mixing).

Flight time was not significantly correlated, genetically (rg) or phenotypically (rp) with lesion score traits (not shown). This suggests that variation in FT is not associated with aggressive behaviours implied by lesion scores. Flight time was significantly correlated with ADG in this and previous studies (Hansson et al 2005), but the correlations with reproductive outcomes were negligible (Table 2). Growth is genetically uncorrelated with litter size traits (Bunter et al, 2010), supporting this result. Therefore, FT did not seem to yield any behavioural information strongly associated with either welfare or future sow reproductive performance.

With respect to skin lesion scores, relatively few gilts remained unmarked (0 scores) by 24 hours after mixing. Lesions were more common on the anterior than posterior parts of the body, but greatly reduced over the whole body before farrowing (Table 1) (see Bunter and Boardman, 2015). Anterior scores and POS were highly correlated with each other (rg: 0.99±0.05; rp: 0.66±0.05) but not significantly correlated with PFBLES observed approximately six months later (range rg: 0.20 to 0.30±0.23; range rp: 0.01 to 0.02±0.02)(Table 2). The genetic correlation between AGRO and PFBLES was stronger (0.42±0.26), but rp remained negligible. Lesion counts greatly decreased in the time interval between selection and farrowing because gilts were regrouped after mating and subsequently housed in stable groups. Aggressive interactions are known to reduce over time within stable groups (Anil *et al.* 2006). Lesion score traits had low positive genetic correlations (rg: 0.11 to 0.23, P>0.05) with ADG, similar in magnitude to those presented by Desire *et al.* (2015) and rp were negligible.

**Table 1. Raw data characteristics including the distribution across scores (Distribution: %×100), along with heritability ($h^2$), common litter effects ($c^2$) and the phenotypic variance ($\sigma^2_p$). (na: not applicable; ns: P>0.05; PF: pre-farrowing)**

| Trait | N | Mean (SD) | Distribution -1/0/1/2/3 | Parameters $h^2_{SE}$ | $c^2_{SE}$ | $\sigma^2_p$ |
|---|---|---|---|---|---|---|
| Flight time: FT (s) | 8854 | 1.00 (0.54) | na | $0.07_{0.02}$ | ns | 0.324 |
| Anterior score: ANT (0-3) | 3238 | 2.82 (1.59) | na/8/38/39/15 | $0.14_{0.04}$ | $0.07_{0.03}$ | 2.34 |
| Posterior score: POS (0-3) | 3237 | 2.05 (1.34) | na/16/52/28/4 | $0.12_{0.04}$ | $0.11_{0.03}$ | 1.62 |
| Aggressive type: AGRO (0/1) | 3238 | 0.54 (0.50) | na/46/54/na/na | $0.12_{0.03}$ | ns | 0.235 |
| Av. daily gain: ADG (g/day) | 30926 | 575 (79.4) | na | $0.19_{0.02}$ | $0.07_{0.01}$ | 4935 |
| Gilt removal: REM0 (0/1) | 3575 | 0.25 (0.43) | na/75/25/na/na | $0.10_{0.03}$ | $0.06_{0.03}$ | 0.180 |
| PF lesion score: PFBLES (0-3) | 1929 | 0.92 (0.74) | na/29/54/14/3 | $0.10_{0.04}$ | ns | 0.516 |
| PF locomotion: PFLOCO (0-3) | 1945 | 0.34 (0.58) | na/72/23/5/0 | $0.05_{0.04}$ | $0.08_{0.04}$ | 0.333 |
| PF condition: PFCS (-1/0/1) | 1950 | 0.01 (0.38) | 7/85/8/na/na | $0.09_{0.04}$ | ns | 0.139 |
| Total born: TB (pigs/litter) | 5097 | 11.8 (2.94) | na | $0.11_{0.02}$ | ns | 8.38 |
| Born alive: NBA (pigs/litter) | 5097 | 11.1 (2.86) | na | $0.10_{0.02}$ | ns | 7.95 |
| Av. birth weight: ABWT (kg/pig) | 2154 | 1.38 (0.22) | na | $0.36_{0.05}$ | ns | 0.042 |

**Table 2. Genetic (1st row) and phenotypic (2nd row) correlations (SE in subscript) between behavioural traits (FT: flight time; ANT: anterior scores; POS: posterior score; AGRO: aggressive phenotype; PFBLES: PF lesion score) and performance outcomes**

| Traits | FT | ANT | POS | AGRO | PFBLES |
|---|---|---|---|---|---|
| Av. daily gain | $0.24_{0.10}$ | $0.16_{0.12}$ | $0.22_{0.12}$ | $0.11_{0.14}$ | $0.23_{0.15}$ |
| | $0.07_{0.01}$ | $-0.01_{0.02}$ | $-0.01_{0.02}$ | $-0.01_{0.02}$ | $-0.00_{0.02}$ |
| Gilt removal | $0.18_{0.17}$ | $0.21_{0.21}$ | $0.19_{0.21}$ | $0.26_{0.18}$ | $-0.15_{0.25}$ |
| | $0.02_{0.02}$ | $0.03_{0.02}$ | $0.01_{0.02}$ | $0.04_{0.02}$ | $0.01_{0.03}$ |
| PF locomotion | $0.42_{0.27}$ | $-0.02_{0.32}$ | $-0.20_{0.33}$ | $0.41_{0.28}$ | $0.92_{0.25}$ |
| | $0.04_{0.03}$ | $-0.00_{0.02}$ | $-0.01_{0.02}$ | $-0.01_{0.03}$ | $0.10_{0.02}$ |
| PF condition | $0.11_{0.21}$ | $0.07_{0.23}$ | $0.14_{0.23}$ | $-0.25_{0.26}$ | $-0.09_{0.27}$ |
| | $-0.00_{0.03}$ | $-0.02_{0.02}$ | $-0.00_{0.02}$ | $-0.05_{0.03}$ | $-0.06_{0.02}$ |
| Total born | $-0.14_{0.15}$ | $0.15_{0.17}$ | $0.10_{0.17}$ | $0.10_{0.17}$ | $0.01_{0.22}$ |
| | $0.01_{0.02}$ | $0.01_{0.02}$ | $-0.02_{0.02}$ | $0.00_{0.02}$ | $-0.00_{0.02}$ |
| Born alive | $-0.11_{0.16}$ | $0.11_{0.18}$ | $0.04_{0.18}$ | $0.04_{0.19}$ | $-0.05_{0.22}$ |
| | $0.02_{0.02}$ | $0.01_{0.02}$ | $-0.02_{0.02}$ | $0.00_{0.02}$ | $-0.00_{0.02}$ |
| Av. birth weight | $0.09_{0.13}$ | $-0.12_{0.15}$ | $-0.17_{0.16}$ | $-0.01_{0.16}$ | $-0.30_{0.20}$ |
| | $0.02_{0.03}$ | $-0.04_{0.03}$ | $-0.05_{0.03}$ | $-0.04_{0.03}$ | $0.04_{0.04}$ |

The most significant phenotypic associations were between AGRO and REM0 and PBFLES with PBLOCO. These particular combinations represent traits measured close together in time. Low positive phenotypic correlations between these traits indicated that fighting of gilts post-selection increased undesirable (forced) removals. This association is not linear, however, because the highest scoring gilts are more likely to be removed (Bunter, 2015). Since correlations represent linear associations, non-linear associations can lower estimates. Similarly, sows which engaged in fighting pre-farrowing showed evidence of compromised locomotion and elevated rates of lameness pre-farrowing (Lumby *et al.* 2015). Genetic correlations between these trait combinations mirrored the direction of phenotypic correlations, but standard errors were large. Behavioural traits were generally not significantly correlated with reproductive outcomes for first parity sows. The exceptions were low negative phenotypic correlations between POS and ABWT, and between AGRO and ABWT or PFCS, which suggest that gilts engaged in fighting post-mixing were more likely to have poorer condition and lighter piglets at their first farrowing.

The overall lack of significant genetic correlations between the behavioural and other traits resulted from the relatively low magnitude of most estimates combined with large standard errors. Negligible phenotypic correlations also reflect accompanying near zero residual correlations. In combination, these results imply that measures of behavioural traits on gilts will not provide much information on later behaviour, or indirectly on reproductive outcomes of group housed sows. This included skin lesion traits, which directly reflect detrimental interactions between animals. Studies which have reported positive correlations between skin lesion counts repeatedly recorded younger animals over a short time frame without remixing in the interim (eg. Desire *et al.* 2015; Turner *et al.* 2009). Results from this study support the conclusions of Turner *et al.* (2009) that selection against high lesion counts would reduce aggression at mixing. However, while rg tended to be positive between repeated scores, results from this study throws some doubt on interpreting longer term outcomes from selection based on earlier lesion scores. Our results do not support strong genetic associations between the behaviour of finisher gilts and their later scores pre-farrowing or their reproductive performance outcomes, but do support some more immediate consequences from fighting (eg removals). Therefore, management strategies to reduce fighting and understanding genetic contributions to long term behaviour remain important for improving welfare of group housed sows. Overall, genetic correlations between behavioural traits and reproductive outcomes were generally favourable, implying that selection on maternal attributes would be expected to have neutral to favourable effects on the fighting behaviour of gilts.

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