2015

The effect of selection for residual feed intake on scale-activity and scale-exit scores in Yorkshire gilts

Larry J. Sadler
Iowa State University

Anna Johnson
Iowa State University, johnsona@iastate.edu

Dan Nettleton Dr.
Iowa State University, dnett@iastate.edu

C. R. G. Lewis
PIC Europe

J. M. Young
Iowa State University

See next page for additional authors

The effect of selection for residual feed intake on scale-activity and scale-exit scores in Yorkshire gilts

Abstract

The objectives of the present study were to use scale-activity and scale-exit scores to (1) determine the extent to which selection for improved residual feed intake (RFI) correlates with individual gilt temperament, (2) determine whether the timing of assessment affects the scores, and (3) determine whether gilts habituate to the process of weighing. To achieve these objectives, 192 grow–finish purebred Yorkshire gilts (39.7 ± 5.7 kg; 98 ± 6 days old) were utilised. Ninety-six gilts were from the 5th generation of a line selected for low residual feed intake (LRFI), and 96 gilts were from the 5th generation of a randomly selected control line (CRFI). Gilt activity and exit behaviour were scored on the weigh scale. The activity score was taken at two time points, namely, $t = 0$ (immediately on the back gate closing on the weight scale) and $t = 15$ (15 s later). Activity was assessed using a 5-point scoring system (1 = calm, minimal movement; 5 = continuous rapid movement and an escape attempt), and exit score was assessed using a 3-point scoring system (1 = no encouragement needed, full exit; 3 = encouragement needed). Gilts were weighed once every 2 weeks (each weighing considered a testing round) for a maximum of eight scores per gilt. Statistical differences were identified in all rounds for activity between genetic lines, except Rounds 2, 4 and 5. For both lines, gilt-activity scores decreased over rounds. The LRFI line began with a lower activity score (2.31 vs 2.65 ± 0.13), but did not experience as great of a drop in average score over rounds as did the CRFI gilts (0.62 vs 1.21). By the end of the trial, the CRFI gilts scored lower than the LRFI gilts. Activity was greater at $t = 15$ than at $t = 0$. Although timing affected the score, the pattern was similar, and so consistency will be more important than timing procedure. For exit scores, in Rounds 5 and 7, the LRFI line scored lower than the CRFI line, and there was a trend for the LRFI line to score lower in Round 6. Across all gilts, the mean exit score increased slowly throughout the trial. In conclusion, selection for lower RFI in purebred Yorkshires has an effect on activity score but this relationship is complex and warrants further research. The observation that gilts become habituated to the process of weighing supports the conclusion that the process is not aversive.

Keywords

scale-activity scoring, swine, temperament

Disciplines

Agriculture | Animal Sciences | Meat Science

Comments

This is a manuscript of an article in *Animal Production Science* (2015): 1, doi:10.1071/AN14849. Posted with permission.

Authors

Larry J. Sadler, Anna Johnson, Dan Nettleton Dr., C. R. G. Lewis, J. M. Young, Steven M. Lonergan, and Jack C. Dekkers

The effect of selection for residual feed intake on scale activity and exit score in Yorkshire gilts

L. J. Sadler[A], A. K. Johnson[A], D. Nettleton[B], C. R. G. Lewis[C], J. M. Young[A], S. M. Lonergan[A] and J. C. M. Dekkers[A]

[A]Department of Animal Science, Iowa State University, Ames, IA 50011, USA

[B]Department of Statistics, Iowa State University, Ames, IA 50011, USA

[C]PIC Europe, Alpha Building, London Road, Nantwich, CW5 7JW, UK

[D]Corresponding author. Email: Larry.Sadler@KraftFoods.com

Summary text for the table of contents

Selection for lower residual feed intake in purebred Yorkshires has an effect on temperament, as measured by a scale activity score, but this relationship is complex and warrants further research. The observation that gilts become habituated to the process of weighing supports the conclusion that the process is not aversive.

The objectives of this study were to use scale activity and exit scores to 1) determine the extent to which selection for improved residual feed intake (RFI) correlates with individual gilt temperament, 2) determine if the timing of assessment affects the scores, and 3) determine if gilts habituate to the process of weighing. To achieve these objectives, 192 grow-finish purebred Yorkshire gilts (39.7 ± 5.7 kg; 98 ± 6 days old) were utilized. Ninety-six gilts were from the 5^{th} generation of a line selected for low residual feed intake (**LRFI**), and 96 gilts were from the 5^{th} generation of a randomly selected control line (**CRFI**). Gilt activity and exit behavior was scored on the weigh scale. The activity score was taken at two time points: **T=0** (immediately upon the back gate closing on the weight scale) and **T=15** (15 seconds later). Activity was assessed using a 5 point scoring system (1 = calm, minimal movement; 5 = continuous rapid movement and an escape attempt), and exit score was assessed using a 3 point scoring system (1 = no encouragement needed, full exit; 3 = encouragement needed). Gilts were weighed once every 2 weeks (each weighing considered a testing round) for a maximum of 8 scores per gilt. Statistical differences were identified in all rounds for activity between genetic lines except rounds 2, 4 and 5. For both lines, gilt activity scores decreased over rounds. The LRFI line began with a lower activity score (2.31 vs 2.65 ± 0.13), but did not experience as great of a drop in average score over rounds as the CRFI gilts (0.62 vs 1.21). By the end of the trial, the CRFI gilts scored lower than the LRFI gilts. Activity was greater at T=15 than at T=0. Though timing affected the score, the pattern was similar, and so consistency will be more important than timing procedure. For exit scores, in rounds 5 and 7 the LRFI line scored lower than the CRFI line, and there was a trend for the LRFI line to score lower in round 6. Across all gilts, the mean exit score increased slowly throughout the trial. In conclusion, selection for lower RFI in purebred Yorkshires has an effect on activity score but this relationship is complex and warrants further research. The observation that gilts become habituated to the process of weighing supports the conclusion that the process is not aversive.

Additional keywords: residual feed intake, scale activity scoring, swine, temperament

Introduction

Feed intake alone does not explain variation in growth and composition of livestock. A portion of variation in growth performance is due to differences in efficiency independent of growth and composition and this variation is referred to as residual feed intake (**RFI**; Koch, *et al.* 1963). Animals that consume less feed than expected based on their growth rate and composition have a lower RFI and are more feed efficient and therefore economically better for protein production. Cai *et al.* (2008) found that RFI can account for 34% of differences in efficiency between pigs and that RFI is a moderately heritable trait ($h^2 = 0.29 \pm 0.07$).

Factors that contribute to variation in RFI include activity (in the context of energy usage), digestion, metabolism (anabolism and catabolism), and thermoregulation (Herd *et al*. 2004; Sadler *et al.* 2011). Another trait that has been studied in several species, but has not yet been examined in relation to RFI, is temperament. Temperament is used to describe a “calm” versus an “excitable” animal (Voisinet *et al.* 1997a). Temperament has been described using a variety of behavioral measures and is often assessed when an animal is individually confined within a chute or scale. For example, some temperament measures previously evaluated include “calm” or “rapid movement”, vocalizing, and escape attempt (Voisinet *et al.* 1997a, King *et al.* 2006, Rempel *et al*. 2009). These behaviors have been implemented into subjective scoring systems, which have been successfully utilized to describe cattle temperament for more than 20 years (Burrow 1997). Such scoring systems have been utilized to assess scale activity and scale exit scores and successfully utilized to describe cattle temperament, for more than 20 years (Grandin 1993). Voisinet *et al.* (1997a, b) and King *et al.* (2006) reported a relationship between scale activity and exit velocity scores with performance and meat quality in cattle. More recently, scale activity has been utilized to assess temperament in swine, with correlations observed with performance (Crump, 2004; Holl *et al.* 2010; Yoder *et al*. 2011). However, because this is a relatively new practice in swine, best practices for how to assess pig scale activity have not yet been described. In particular, no studies have evaluated the effect of the timing (latency) in which the behavior is scored and how this time may influence results. Additionally, a suitable method comparable to exit scoring for cattle has not yet been identified in pigs. Although temperament is heritable in swine (Turner *et al.* 2006; D'Eath *et al.* 2009), the extent to which RFI selection affects swine temperament has not been described. Therefore, the objectives of this study were to use scale activity and exit scores to 1) determine the extent to which selection for improved residual feed intake (RFI) correlates with individual gilt temperament, 2) determine if the timing of assessment affects the scores, and 3) determine if gilts habituate to the weighing process.

Materials and methods

Experimental design

The Iowa State University Institutional Animal Care and Use Committee approved the protocol for this experiment, which was conducted from 15 April 2008 to 14 August 2008. Animals (n=192) came from 2 Yorkshire pig lines that were created at Iowa State University. Starting from a common base population of purebred Yorkshire pigs,one line (from which 96 pigs for this trial were derived) had been selected for low residual feed intake (**LRFI**) and the other line (n=96 for this trial) had been randomly selected (**CRFI**). The breeding and selection process for the development of these lines has been described previously by Cai *et al*. (2008). The gilts used in this trial were from generation 5 of the selection experiment. The experimental design for this study utilized a randomized complete block design, with pen as the block. The experimental unit was the individual gilt.

Animals

Gilts originated from 69 litters and were put on trial in 2 starting groups; this was done to minimize variation in starting age and body weight. Group 1 began the trial on April 15, 2008. Gilts were allocated to pens 1 through 6 based on their litter and genetic line, distributing litters among the pens and ensuring there were 8 gilts from each genetic line per pen, for a total of 16 gilts per pen. These gilts were on average 104±3 d old at the start of the trial and weighed 41.7±5.6 kg. Group 2 gilts were put on trial 14 d later and were allocated to pens 7 through 12 using the previously described method. Group 2 gilts started the trial at 92±8 d of age and weighed 37.6±5.8 kg. Six gilts, 3 from each treatment, were removed due to health issues; therefore 186 gilts completed the trial (LRFI = 93 and CRFI = 93). Data from these 6 gilts were included in the analysis up to the point at which they were removed, as their exclusion did not statistically affect the results.

On day of placement, 4 trained caretakers randomly selected and removed gilts from their nursery pens, using sort boards, for placement into finisher pens. Gilts were moved (320 m) to the conventional grow-finish barn using a height adjustable livestock trailer (Hydraulic Walk-On Livestock Trailer, Roose Manufacturing Company, Pella, IA) in groups of 15 to 18. Gilts were individually moved through a weigh scale (Electronic Weighing Systems, Rite Weigh, Robert E Spencer Enterprises, Ackley, IA), where they received an ear tag and transponder in the right ear for identification. Each gilt was then moved into a grow-finish pen for the duration of the trial. Gilts were not assigned a scale or exit score at initial placement, which included this first pass through the weigh scale.

Housing and feeding

A conventional grow-finish barn at the Iowa State University Lauren Christian Swine Research Center housed the gilts in 1 room. The room consisted of 12 pens, each with fully slatted concrete flooring. Each pen was 5.6 m long by 2.3 m wide (0.82 m^2/gilt) and pens were separated with steel rod gates. The barn was naturally ventilated with curtain sides providing natural lighting cycles. Two florescent light fixtures, each with 1 bulb, were on continuously. Each pen contained a 2-nipple-type water drinker (Edstrom, Waterford, WI), providing ad libitum access. A single-space electronic feeder (FIRE®, Osborne Industries, Inc., Osborne, KS) provided ad libitum access to a standard finishing diet that was formulated to meet or exceed the nutritional requirements for growing pigs (NRC, 1998).

Indoor environmental measurements

The room was equipped with 4 electronic environmental recording devices (HOBO; Hobo Pro series, Janesville, WI). The electronic recording devices were affixed 1.3 m above the floor. Ambient temperature (°C) and relative humidity (RH, %) were recorded in 10-min intervals for the entire trial. Environmental parameters were averaged to determine maximum, minimum, and average values for each weighing session of this trial. Over the 4 months of the trial, average temperature ranged from 20.2 °C for month 1 up to 25.2 °C for month 4. Average relative humidity ranged from 60.9% during month 1 up to 79.2% by month 4 (Table 1 and Table 2) (insert Table 1 and Table 2).

Activity and exit scoring

One week after placement, beginning at 0700 h, all gilts in a pen were moved from their home pen to a central holding area using a sort board (0.9 wide x 1.2 m high) by 2 trained persons that had previous experience moving swine. The pen closest to the central holding area was 4.5 m away, whilst the farthest pen was 18.3 m away. The holding area was 5.93 m^2, providing a space allowance of 0.38 m^2 per pig. This holding area had the same flooring as the home pen and alleyway. Curtains were not in this area and thus opening doors located on the north and south side of the area provided ventilation. Lighting was similar to the main room.

Activity scoring occurred every 2 weeks until the first gilts completed the trial, at which point average gilt weight was 104 ± 12.1 kg. Activity scores were collected over 9 sessions; with only group 1 being scored during session 1 and only group 2 being scored during sessions 8 and 9 due to: (1) group 1 starting at a heavier weight and (2) groups 1 and 2 being put on trial on 2 separate dates. For analysis purposes, gilts were scored on 7 or 8 rounds (group 1 and 2 respectively), where round is the number of times a gilt was exposed to the process. Round is distinct from session, with each session corresponding to a date at which the technicians collected data. Therefore during the first session only gilts in group 1 were scored. In the second session, gilts in group 1 were scored for their second round, while gilts in group 2 were scored for their first round.

Once in the holding area, gilts were individually moved onto the weigh scale. The scale was a freestanding self-sustained flow through unit. The weigh scale was of steel construction with waved fiberglass sides and metal woven flooring with rebar spaced 0.30 m to help aid against slipping. The gates, located on both the entrance and exit of the scale, were 1.9 cm angle iron spaced 10.2 cm on center. The inside dimensions of the weigh scale were 0.41 m wide by 1.24 m long by 0.76 m high. Once all gilts from a pen had received their scores, they were moved back as a group to their assigned pen. All gilts over all pens were scored by 1200 h.

For the process of activity and exit scoring, each gilt was scored for activity by 2 observers and then was allocated a scale exit score by 1 observer. Individual gilts were identified by the ear tag number and therefore observers were blind to genetic line. Activity score was assigned using a subjective scale of 1 to 5 that was modified from Rempel *et al.* (2009), including the use of only whole numbers (Table 3). Each observer scored the gilt immediately upon her entering the scale and the back gate being closed (T=0) and 15 seconds after the gate had been closed (T=15).

(insert Table 3)

Each gilt received a scale exit score using a subjective scale of 1 to 3 scale; with 1 defined as a gilt exiting the scale on her own; 2 defined as a gilt exiting part of the way on her own and needing encouragement to finish exiting the scale, and a score of 3 defined as a gilt needing full encouragement to exit the scale. Encouragement entailed any interaction with the pig, outside of opening the door, and included acts such as clapping behind the pig, patting the rump or physically pushing the pig forward with a single hand on the rump.

Statistical analysis

Activity score: The scores of the 2 technicians were averaged to create a single score for each time (T=0, T=15) for each pig and used for analysis. The Mixed Procedure of SAS (SAS Inst. Inc., Cary, NC) was used to carry out a repeated measures analysis of the data. The model included fixed effects for line, round, time and all their interactions. Random effects of litter, group, and pen were also included. The covariance matrix for modeling correlations among the errors for any particular animal was modeled as the Kronecker product of an unstructured covariance matrix for the covariance between scores at T=0 and T=15 within each round and a first-order autoregressive structure for covariance between rounds within each time. Weight at the time of scoring, average temperature during scoring, and average Temperature-Humidity Index during scoring were included as covariates but were not found to be significant (P = 0.43, P = 0.33, P = 0.21, respectively) and were removed from the final model.

Exit score: A repeated measures analysis of the exit scores was conducted using the Mixed Procedure of SAS, with a model similar to activity scores. This model included the fixed effects of line, round and line by round interactions. Age of the gilt, at the time of placement, was used as a covariate. Random effects of litter, group and pen were also included in this model. A common first-order autoregressive covariate-structure was applied for each gilt. For significance testing, SAS's implementation of the method of Kenward and Roger (1997) was used to obtain approximate F-tests and denominator degrees of freedom when necessary. P-values when appropriate are presented both raw and with a Bonferroni adjustment.

Results and discussion

The current study examined if selection for lower RFI, compared to randomly selected control gilts altered gilt temperament as measured by activity and exit score. Temperament can be considered as the individual animal's reaction to a given set of prescribed circumstances. Some individuals may act agitated and excited when interacting with humans, and could be classified as having an excitable temperament and in turn reduced welfare. A second group of animals, experiencing the same animal-human interaction, may be calm in holding equipment, exit the equipment slowly, walk quietly and show no obvious outward signs of distress. These animals could be classified as displaying a calm temperament and having improved welfare (Grandin 1993; Matthews 2008). Earlier work in the area of production animal temperament was completed using cattle as the model. These models assessed both cattle activity in a chute and the flight speed when exiting the chute. Burrow and Dillion (1997) concluded that cattle with better temperaments defined as slower flight speeds when exiting the chute had greater rates of gain.

Building on this work, temperament seems to be a trait with a component of genetic control that relates to both production and final meat quality attributes (Burrow and Dillon 1997; Fell *et al*. 1999; Petherick *et al*. 2002; Vann *et al.* 2006).

Voisinet *et al.* (1997a) identified differences in temperament between Brahman cross- and non-Brahman breed cattle. The authors reported that cattle with excitable temperaments (a higher activity score) had lower average daily gains (0.20 ± 0.04 kg/d). In additional work by this team, Voisinet *et al.* (1997b) reported that cattle with worse temperaments defined as 4 versus 1 on a scale temperament score had a higher shear force (less tender) and were more likely to be a dark- or borderline dark cutter (25% vs. 6.7% for 4 vs 1, respectively).

More recently, to assess temperament in pigs, the use of behavior while in the scale and exit speed from the scale have been applied. Crump (2004) found flight time had a low heritability ($h^2 = 0.21 \pm 0.05$) but noted that this could be due to the difficulty of assessing temperament of pigs using flight time. Though this method has been successful in cattle, the way these 2 species typically exit the scale is quite different. In the same study, Crump also assessed scale activity of the pigs, as an indicator of temperament, using biometric sensors on the weigh scale and estimated heritability of this trait to be 0.12 ± 0.04. In addition, correlations relative to daily gain were observed with flight time (0.33 ± 0.17) and with activity (-0.35 ± 0.21), indicating a link between temperament and production traits. Yoder *et al.* (2011) examined scale activity scores of Chester White, Duroc, Landrace and Yorkshire boars and gilts, using a 5-point scoring system similar to the one utilized in the current study. Yoder *et al.* (2011) found Landrace were the most likely to have a high scale score (indicating increased excitement), with an increased probability relative to Chester Whites (2.37), Durocs (3.94), and Yorkshires (2.46). Chester Whites had increased odds of having a higher scale score relative to Durocs (1.87) and Yorkshires (1.42). In this same study, Yoder *et al.* (2011) concluded pigs with lower temperament scale activity scores (calmer temperament) were fatter, had greater loin depth, and grew faster relative to pigs with higher scale activity scores (more excitable temperament). Sadler *et al.* (2011), using the same pigs as used here, reported that gilts selected for lower RFI were less active.

Therefore, with both the bovine and porcine models indicating a link between temperament and production and final meat quality attributes, it may be possible for RFI selection to influence the pig towards better or worse temperaments during animal-human interactions and in turn results in worse or improved welfare. Additionally, establishing an individual pig’s RFI is relatively expensive and hence cost prohibitive on-farm; therefore, if an association was found between RFI and scale activity, assessment of scale activity may prove to be a cost effective tool to aid in selection of RFI. Holl *et al*. (2010) and Rohrer *et al.* (2013) found that scale activity score of the pig was heritable (h^2 ~ 0.15), with a negative genetic correlation to backfat concluding, "...selection for more docile animals would be expected to result in faster growing fatter pigs." The gilts utilized in the current study with a lower RFI generally had less back fat, a greater loin depth, and grew slower (Smith *et al.* 2011). This does not provide a clear prediction for what the effects of RFI selection might be on temperament; however, it could be hypothesized that less fat and slower growth may indicate selection for low RFI will produce a more excitable animal. The genetic component of temperament justifies an evaluation of how temperament may in turn be linked to RFI.

Effect of genetic line on temperament scores as assessed by activity

When assessing activity over the entire study (8 rounds), differences were not observed between LRFI and CRFI gilts (1.89±0.11 vs. 1.81±0.11; $P = 0.14$) at either time points, T=0 and T=15. However, differences were observed when comparing genetic lines within individual rounds over both time points. During round 1, the LRFI line had a lower mean activity score than the CRFI line (2.31 vs. 2.65; $P < 0.001$). For all other rounds, if a Bonferroni adjustment was applied, there were no genetic line effects ($P > 0.10$). However, if left unadjusted, differences between lines were found in all rounds $P < 0.05$ except 2, 4 and 5 (Table 4). For both genetic lines, activity scores decreased from round 1 to round 8 ($P < 0.001$), but the LRFI line did not experience as large a decrease (Table 4). The LRFI line had lower scores (2.31 ± 0.13) than the CRFI

(2.65 ± 0.13) line in the first round, but by the last round, this relationship had reversed (1.69 vs. 1.44 ± 0.13). Scores of 1 and 2 indicated a calm pig. Throughout the trial, gilts from both genetic lines were classified as “calm”, and by round 4, both lines had a mean score below 2. In the current study, we found the LRFI line had a calmer temperament than the CRFI line in earlier rounds, which was contrary to our prediction. However, in later rounds, the LRFI gilts were found to have a slightly more excitable temperament relative to gilts from the CRFI line. The lack of conclusive findings and the observed switch in temperament between lines over time may be due to both lines in the later rounds being calm, and thus, temperament not being of relevance to production differences in this population.

(insert Table 4)

Effect of round on temperament scores as assessed by activity

Temperament scores were assigned over several rounds, which made it possible to determine individual gilt response to the process. Examining the time (T=0 and T=15) by line (LRFI and CRFI) interaction, there were no differences ($P > 0.05$) between genetic lines over all rounds, nor were there differences ($P > 0.05$) for the time by line interaction within rounds at time zero (T=0) versus 15 seconds later (T=15; data not shown).

The mean activity score across lines was 2.48 ± 0.12 during round 1 but dropped in each successive round, reaching 1.51 ± 0.12 in round 5, at which point it stabilized and did not change ($P < 0.05$) during the remaining rounds. Many animals find unfamiliarity to be a stressful event (Grandin 1997; Lewis *et* *al.* 2008). If an animal finds the event to be aversive, the level of displayed agitation should increase with each subsequent exposure until a threshold is reached (Grandin *et al.* 1986; Poscoe 1986). However if the animal does not perceive the stimulus to be extremely aversive, the displayed level of agitation should decrease (Phillips *et al*. 1998). For example, Waynert *et al.* (1999) noted that cattle become acclimated to the sounds of people yelling and metal clanking on metal. The results of the current study indicate gilts, regardless of selection line, display decreased activity, indicating they did not find to this common handling practice highly aversive

(insert Fig1).

Effect of T0 versus T15 on temperament scores as assessed by activity

Mean activity over all rounds and both lines at T=0 was 1.68 ± 0.11, which was lower than the mean activity at T=15 of 2.02 ± 0.11 ($P < 0.001$). This suggests that gilt agitation increased with length of time in the scale. The time by round interaction was significant ($P < 0.001$), with the T=0 score lower than T=15 for each round but with a decreasing difference between the 2 time points (Table 4). During round 1, the mean score was 1.98 ± 0.13 for T=0 and 2.98 ± 0.13 for T=15. In round 8, this difference had dropped to a mean score of 1.49 ± 0.13 for T=0 and 1.64 ± 0.13 for T=15. Previous research assessing scale activity has not described the timing methodology. In this study, the timings were chosen for convenience, with a latency more than 15s potentially delaying the processes. Additional studies would be needed to assess if a longer latency would be beneficial. As such, when assessing pig temperament with an activity score, it would be advisable to not assess immediately upon entering the scale. Perhaps of greater importance, these results highlight the importance of consistency, i.e. always collecting at the same time point.

Effect of gilt temperament as assessed by scale exit score

Due to the difficulty and potential inaccuracy in utilizing flight time in assessing temperament of pigs (Crump 2004), a novel subjective assessment score for exiting was created and tested. After Bonferroni adjustment, differences (P = .03) between genetic lines are only observed in round 7, with the LRFI line scoring lower than the CRFI line. Without Bonferroni adjustment, the LRFI line also scored lower (P = .04) than the CRFI line in round 5 and there was a trend (P = .07) for the LRFI line to score lower in round 6 (Table 5). Differences in scale exit score were not observed in the early rounds, only in the later rounds. This may indicate this scoring system is only able to detect differences when gilts are calm or habituated to the process. Over the entire gilt population, the mean score was 1.14 ± 0.08 for round 1. This score increased through the trial, with a mean score of 1.89 ± 0.08 by round 7 (Fig. 2). This supports the findings from the activity, indicating the gilts acclimated to the process, becoming calmer as the number of times exposed to the process increased.

Finally, it should be considered that the mixed housing of the lines in this study (50% LRFI and 50% CRFI) could have influenced temperament of the animals. It has been previously demonstrated (Jones *et al.* 2011) that group behavioral characteristics can influence growth and backfat, so one could postulate that group composition could also influence behavioral traits. In the current study, perhaps temperament differences would have been observed between lines if they were housed separately; however, differences were observed between lines regarding performance data, suggesting temperament differences should have been observed if selection for RFI influenced this trait, thus it appears selection for RFI does not adversely affect temperament in pigs. (insert Table 5; insert Fig. 2)

Conclusions

Selection for low residual feed intake in purebred Yorkshires resulted in minor to moderate differences in temperament scores as assessed by scale activity and exit scores and the gilts did not seem to find the weighing process highly aversive.

Acknowledgements

This work was supported by the National Pork Board Project Number 07-161 and the Hatch Funds from the Department of Animal Science, Iowa State University. We are grateful to Allison Meiszberg, Jill Garvey, Weiguo Cai, John Newton and the staff at the Lauren Christian Swine Research Center, and Man-Yu for technical assistance.

References

Burrow HM, Dillon RD (1997) Relationships between temperament and growth in a feedlot and commercial carcass traits of Bos indicus crossbreds. *Australian Journal of Experimental Agriculture* 37:407-411.

Cai W, Casey DS, Dekkers JCM (2008) Selection response and genetic parameters for residual feed intake in Yorkshire swine. *Journal of Animal Science* 86:287-298.

Crump R (2004) Genetics of temperament: flight time and movement meter. Proceedings Animal Genetics and Breeding Unit Australia, Pig Genetic Workshop. November 17-18th.

D'Eath RB, Roehe R, Turner SP, Ison SH, Farish M, Jack MC, Lawrence AB (2009). Genetics of animal temperament: aggressive behaviour at mixing is genetically associated with the response to handling in pigs. *Animal* 11:1544-1554.

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

Grandin T, Curtis SE, Widowski TM, Thurmon JC (1986) Electro-immobilization versus mechanical restraint in an avoid-avoid choice test for ewes. *Journal of Animal Science* 62:1469-1480.

Grandin T (1993) Behavioral agitation during handling of cattle is persistent over time. *Applied Animal Behaviour Science* 36:1-9.

Grandin T (1997) Assessment of stress during handling and transport. *Journal of Animal Science* 75:249-257.

Herd RM, Oddy VH, Richardson EC (2004) Biological basis for variation in residual feed intake in beef cattle. 1. Review of potential mechanisms. *Australian Journal of Experimental Agriculture* 44:423-430.

Holl JW, Rohrer GA, Brown-Brandl TM (2010) Estimates of genetic parameters among scale activity scores, growth, and fatness in pigs. *Journal of Animal Science* 88:455-459.

Jones RM, Crump RE, Hermesch S (2011) Group characteristics influence growth rate and backfat of commercially raised grower pigs. *Animal Production Science* 51:191-197.

Kenward MG, Roger JH (1997) Small sample inference for fixed effects from restricted maximum likelihood. *Biometrics*. 53:983-997.

King DA, Pfeiffer CES, Randel RD, Welsh TH, Oliphint RA, Baird BE, Curley KO, Vann RC, Hale DS, Savell JW (2006) Influence of animal temperament and stress responsiveness on the carcass quality and beef tenderness of feedlot cattle. *Meat Science* 74:546-556.

Koch RM, Swiger LA, Chambers D, Gregory KE (1963) Efficiency of feed use in beef cattle. *Journal of Animal Science* 22:486-494.

Lewis CRG, Hulbert LE, McGlone JJ (2008) Novelty causes elevated heart rate and immune changes in pigs exposed to handling, alleys, and ramps. *Livestock Science*, 116:338-341.

Matthews LR (2008) Animal behavior and welfare. *Australian Journal of Experimental Agriculture* 48(7):1014-1021.

NRC (1998). National Research Council *Nutrient Requirements of Swine. 10th ed*. National Academies Press, Washington, DC, USA.

Petherick JC, Holroyd RG, Doogan VJ, Venus BK (2002) Productivity, carcass and meat quality of lot-fed Bos indicus cross steers grouped according to temperament. *Australian Journal of Experimental Agriculture* 42:389-398.

Phillips M, Grandin T, Graffam W, Irlbeck NA, Cambre RC (1998) Crate conditioning of bongo (*Tragelaphus eurycerus*) for veterinary and husbandry procedures at the Denver zoological gardens. *Zoo Biology* 17:25-32.

Poscoe PJ (1986) Humaneness of an electroimmobilization unit for cattle. *American Journal of Veterinary Research* 47:2252-2256.

Rempel LA, Rohrer GA, Brown-Brandl TM (2009) Prepubertal scoring of scale activity in gilts and its potential relationship to subsequent fertility and reproduction performance in Landrace-Duroc-Yorkshire cross females. Proceedings of VIIIth *International Conference on Pig Reproduction,* Banff, Alberta, Canada. 177.

Rohrer GA, Brown-Brandl TM, Rempel LA, Schneider JF, Holl JW (2013) Genetic analysis of behavior traits in swine production. *Livestock Science* 157:28-37.

Sadler LJ, Johnson AK, Lonergan SM, Nettleton D, Dekkers JCM (2011) The effect of selection for residual feed intake on general behavioral activity and the occurrence of lesions in Yorkshire gilts. *Journal of Animal Science* 89:258-266.

Smith RM, Gabler NK, Young JM, Cai W, Boddicker NJ, Anderson MJ, Huff-Lonergan E, Dekkers, JCM, Lonergan SM (2011) Effects of selection for decreased residual feed intake on composition and quality of fresh pork *Journal of Animal Science* 89:192-200.

Turner SP, White IMS, Brotherstone S, Farnworth MJ, Knap PW, Penny P, Mendl M, Lawrence AB (2006) Heritability of post-mixing aggressiveness in grower-stage pigs and its relationship with production traits. *Animal Science* 82:615-620.

Vann RC, Randel RD, Welsh TH Jr, Willard ST, Carroll JA, Brown MS, Lawrence TE (2006) Influence of breed type and temperament on feedlot growth and carcass characteristics of beef steers. *Journal of Animal Science* 84, Suppl 1, 396.

Voisinet B, Grandin T, Tatum J, O'Connor S and Struthers J (1997a) Feedlot cattle with calm temperaments have higher average daily gains than cattle with excitable temperaments. *Journal of Animal Science* 75:892-896.

Voisinet B D, Grandin T, O'Connor S F, Tatum J D, Dessing M J (1997b) Bos Indicus-Cross feedlot cattle with excitable temperaments have tougher meat and higher incidence of borderline dark cutters. *Meat Science* 46:367-377.

Waynert DF, Stookey JM, Schwartzkopf-Genswein KS, Watts JM, Waltz CS (1999) The response of beef cattle to noise during handling. *Applied Animal Behaviour Science* 62:27-42.

Yoder CL, Maltecca C., Cassady JP, Flowers WL, Price S, See MT (2011) Breed differences in pig temperament scores during a performance test and their phenotypic relationship with performance *Livestock Science* 136:93-101.

Table 1. Descriptive statistics for temperature and relative humidity in the production room by month during the trial 15 April to 14 August 2008

Parameter	**Month[E]**			
	15 April – 14 May	**15 May - 14 June**	**15 June – 14 July**	**15 July – 14 Aug**
Air temperature, °C				
Minimum[A]	12.4	13.0	16.4	17.1
Maximum[B]	27.8	31.3	32.6	33.2
Average	20.2	22.9	24.8	25.2
Relative humidity, %				
Minimum[C]	26.8	30.5	32.9	48.3
Maximum[D]	100.0	97.4	98.9	99.8
Average	60.9	62.8	69.3	79.2

[A]Average minimum weekly temperature

[B]Average maximum weekly temperature

[C]Average minimum relative humidty

[D]Average maximum relative humidy

[E]A month began at the beginning for the trial running from the 15 of the calendar month to the 14 of the following calendar month

Table 2. Descriptive statistics for temperature and relative humidity on data collection days

Parameter	**Data collection session[5]**								
	1[A,B]	**2[C]**	**3**	**4**	**5**	**6**	**7**	**8[D]**	**9[D]**
Air temperature, C°									
Minimum	16.1	18.7	18.7	11.0	19.0	19.4	24.4	21.1	22.6
Maximum	22.5	28.5	22.1	17.1	26.8	26.5	30.8	24.7	27.9
Average	19.4	24.1	20.5	14.5	23.2	23.7	27.9	23.0	25.2
Relative humidity, %									
Minimum	63.3	40.2	52.0	70.9	70.3	44.7	66.9	81.2	70.0
Maximum	85.6	72.5	65.8	85.8	99.9	85.6	95.1	98.8	99.8
Average	76.3	55.1	59.0	77.1	88.7	60.4	85.5	90.8	84.1

[A]Only group 1 gilts were scored during this session

[B]Round 1 data collected for group 1 gilts following in sequence

[C]Round 2 data collected for group 1 gilts and round 1 data collected for group 2 gilts following in sequence

[D]Only group 2 gilts were scored during these sessions

[E]temperature and relative humidity data is from 0700 h until 1200 h during the day of data collection

Table 3. Activity scoring system adapted from Rempel *et al*. (2009)

Score	Temperament description
1	Calm. Weight shifting but little movement
2	Some walking forward and backward at a slow pace
3	Continuous fast movement, that included walking forward and backward
4	Continuous rapid movement and vocalizing
5	Continuous rapid movement and an escape attempt

Table 4. Least square means and standard errors of gilt scale activity score by line (LRFI and CRFI) and time of score (T=0 and T=15 seconds) for 8 rounds of evaluation

Round	Least Square Means (s.e).				Significance	Adjusted Significance[A]
	LRFI line[B]		**CRFI line[C]**			
1	2.31	(0.13)	2.65	(0.13)	**< 0.001**	**< 0.001**
2	2.33	(0.13)	2.44	(0.13)	0.20	1.00
3	2.21	(0.13)	2.01	(0.13)	**0.03**	0.24
4	1.73	(0.13)	1.65	(0.13)	0.40	1.00
5	1.58	(0.13)	1.44	(0.13)	0.12	0.96
6	1.65	(0.13)	1.47	(0.13)	**0.04**	0.32
7	1.60	(0.13)	1.41	(0.13)	**0.05**	0.37
8[D]	1.69	(0.13)	1.44	(0.13)	**0.01**	0.11
	T=0[E]		**T=15[E]**			
1	1.98	(0.12)	2.98	(0.12)	**< 0.001**	**< 0.001**
2	2.14	(0.12)	2.62	(0.12)	**< 0.001**	**< 0.001**
3	1.97	(0.12)	2.25	(0.12)	**< 0.001**	**< 0.001**
4	1.56	(0.12)	1.82	(0.12)	**< 0.001**	**< 0.001**
5	1.45	(0.12)	1.56	(0.12)	**0.007**	0.056
6	1.42	(0.12)	1.69	(0.12)	**< 0.001**	**< 0.001**
7[D]	1.43	(0.12)	1.58	(0.12)	**< 0.001**	**0.003**
8[D]	1.49	(0.12)	1.64	(0.12)	**0.001**	**0.009**

[A]Bonferroni adjustment of *P-value*

[B]Low residual feed intake line (n = 96)

[C]Control residual feed intake line (n = 96)

[D]Analysis only included data from Group 2 pigs

[E]Low residual feed intake line and control residual feed intake line (n = 192)

Table 5. Least square means (s.e.) of exit score of gilts by line at 8 rounds of evaluation

Round	LRFI [A]		CRFI [B]		*P*-value	Adjusted *P*-value[C]
1	1.17	(0.08)	1.11	(0.08)	0.61	1.00
2	1.03	(0.08)	1.04	(0.08)	0.95	1.00
3	1.30	(0.08)	1.27	(0.08)	0.82	1.00
4	1.54	(0.08)	1.43	(0.08)	0.32	1.00
5	1.35	(0.08)	1.58	(0.08)	0.04	0.30
6	1.49	(0.08)	1.69	(0.08)	0.07	0.59
7[D]	1.72	(0.08)	2.05	(0.08)	<0.01	0.03
8[D]	1.64	(0.08)	1.84	(0.08)	0.11	0.89

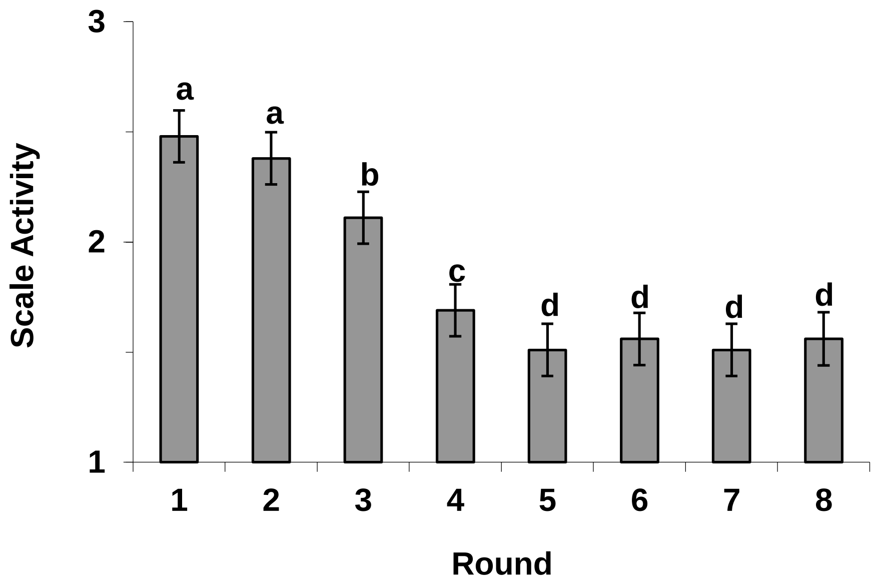
[A]Low residual feed intake line (n = 96)

[B]Control residual feed intake line (n = 96)

[C]Bonferroni adjustment of *P-value*

[D]Analysis only included data from Group 2 pigs

Figure 1. Least square means (±SE) of scale activity scores by round over the entire population of gilts[A].

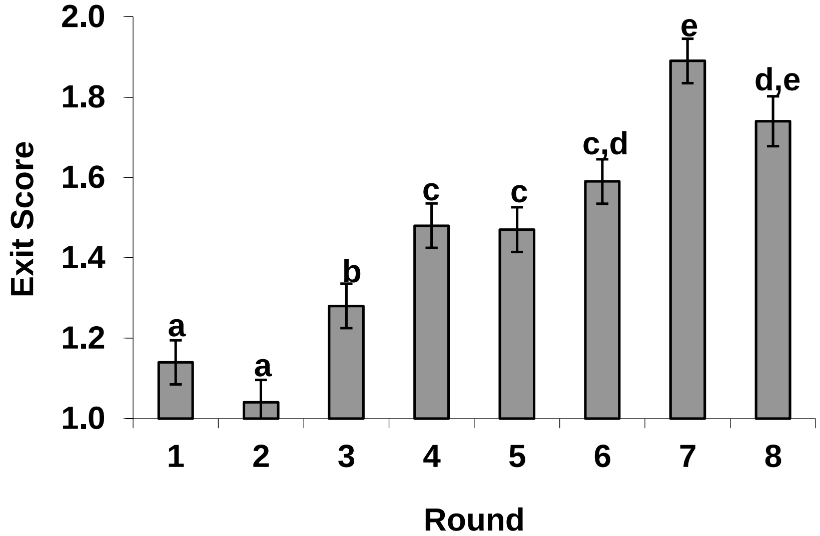


[A]Low residual feed intake gilts and control residual feed intake gilts (n = 192).

[a,b,c,d]Means with different superscripts are significantly different (*P* < 0.05)

Scale activity scored 1 (calm, little or no movement) to 5 (continuous rapid movement and an escape attempt)

Figure 2. Least square means (±SE) of scale exit score over the entire population of gilts[A]. Superscripts indicate differences at *P-value* < 0.05



[A]Low residual feed intake gilts and control residual feed intake gilts (n = 192).

[a,b,c,d,e]Means within columns with different superscripts are significantly different ($P < 0.05$)

Exit score: 1 (gilt exited the scale on her own) to 3 (gilt needed encouragement to exit the scale)