



# Testing strategies of pigs for measurement of feed efficiency: relative improvement in feed efficiency from relying solely on indirect selection compared to indirect selection for faster growth rate and higher percent lean

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## ABSTRACT

The objective of this study was to compare different testing strategies of pigs involving direct measurement of feed efficiency in pig. Using simulated data software, we collected individual information for FCR and grouped trials into direct and indirect measurement. The direct FCR included measurement of FCR in both sexes (100M-100F), in boars only (100M), in 50% of boars and 50% of gilts (50M-50F) and in only 50% of boars (50M-0F). Direct measures of FCR (0M-0F) in indirect selection were not used. The highest and the lowest genetic regression responses in FCR were observed for 100M-100F and indirect selection scenarios (0M-0F). Among direct selection, the increase in genetic progress was directly related to the percent of pigs tested for FCR. Using FCRs records more than 50% (50M-50F or 100M) can raise response higher than 80%. Meanwhile, 0M-0F showed a loss in genetic gain more than 50% when compared with 100M-100F. These results suggest using direct measurements on at least 50% of all pigs for genetic evaluation in FCR.

**Key words:** Feed conversion ratio, Genetic response, Indirect selection.

## INTRODUCTION

Historically, to improve feed efficiency most genetic suppliers have relied on the genetic improvement that can be made from indirect selection for faster growth and higher percent lean. Previous research has shown that this indirect selection can improve feed efficiency in swine (Kuhlers *et al.*, 2003). Studies have shown that the genetic correlation between FCR and leanness was favorably significant (Saintilan *et al.*, 2011; Hoque *et al.*, 2007). There are also favorable genetic correlations between age (days) to market weight and feed efficiency (Hoque *et al.*, 2007), that should be used when evaluating and selecting for a combination of leanness and growth in pigs (Chen *et al.*, 2003). Therefore, selecting simultaneously for fast growth and high lean percentage should be favorably correlated to feed efficiency (Mabry, 2012). Over the past few years, the cost of feed has increased dramatically, making the genetic improvement of feed efficiency more important to the swine industry. However, it is a difficult trait in which to measure the phenotype of the individual pig, since pigs are housed and fed in pens of 20 or more animals eating from a common feeder. The equipment needed to measure feed intake on each individual pig while housed in a pen environment, commonly referred to as a FIRE (Feed Intake Recording Equipment) system (Sadler *et al.*, 2009), is used by some seed stock suppliers to directly measure feed intake. This allows for direct measurement of feed efficiency on the animal which could increase the rate of genetic

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improvement. However, there are several different testing strategies that could be used with the FIRE systems because it is quite expensive to purchase and maintain. Some genetic suppliers are testing only males, since it has been shown that with AI the male has the greatest potential for genetic improvement in the terminal progeny (Hoque *et al.*, 2007). Moreover, several suppliers are testing only a portion of the seed stock in an effort to minimize costs (Kuhlers *et al.*, 2003). Therefore, this study was conducted in order to compare different testing strategies of pigs for measurement of feed efficiency and the genetic responses in terminal line

index in pigs. This work was conducted using simulation software developed specifically for this project.

## MATERIALS AND METHODS

Phenotypic data on feed efficiency (FCR), percent lean (PCL) adjusted to 105 kg and days to market weight at 105 kg (DAY) were generated by multi-trait animal model simulation. The genetic relationship between traits were taken as genetic correlations (-0.29, 0.30 and 0.30 for FCR and PCL, FCR and DAY and PCL and DAY, respectively). The means of traits, (co)variance of additive variances, environment variances, litter variances, sex and contemporary group (CG) variances that were used in simulation to generate the phenotypes are shown in Table 1.

### Simulation techniques and conditions

In the first step in this simulation, all 50 boars and 150 gilts from base generation G0 (Effective number of population,  $N_e = 150$ ) were randomly mated to produce next generation (G1) offspring. The following conditions were used: 1) Five CG per generation. 2) Two genders were randomly assigned at 50% chance. 3) Number born alive per litter averaged eight piglets (range 5 to 11 piglets). 4) Fifteen percent random fallout rate (to simulate structural and reproductive unsoundness problems) was imposed for each generation. 5) Mating ratio was 1:3 (boar:sows). 6) Boars and gilts from current and previous generation (kept back only 1 generation) were eligible for selection based on terminal line index as equation (1) to produce next generation off spring.

$$I_1 = 100 - 30 * EBV_{(FCR)} + 2.0 * EBV_{(PCL)} - 1.75 * EBV_{(DAY)} \quad (1)$$

The mating plan was positive assortative mating from the best 50 boars and 150 sows to produce next generation offspring. Every mating pair was chosen using Mate/Selector program developed by Duangjinda (2013), which inbreeding coefficients were limited to less than 10% for any mating. Thirty replicates were conducted for each selection scenario.

There were two types of general selection scenarios, based on if FCR was measured. The first, direct selection using estimated breeding values from FCR records of all animals (100M-100F), FCR records on males only (100M), FCR records on 50% of boars and 50% of gilts (50M-50F), and FCR records on only 50% of boars (50M-0F). The second scenario was indirection selection for FCR where estimated breeding values (EBV) for FCR were based on

genetic correlations with PCL and DAY and is represented as 0M-0F.

### Statistical analyses

In simulation, gender (female and male) and contemporary groups were assigned as fixed effect while animals and common litter effects were considered as random effects. The variance components obtained by Restricted Maximum Likelihood (REML) using BLUPF90 software packages developed by Misztal *et al.* (2002) was used to estimate breeding value for each generation using equation (2) with multi-trait animal model analysis (3 traits):

$$y_i = X_i \beta_i + Z_i \alpha_i + W_i c_i \varepsilon_i \quad (2)$$

Where

$y_i$  is the vector of observations of traits 1 to 3,  $\beta$  is the vector of fixed effects,  $\alpha$  is the vector of additive genetic effects,  $c$  is the vector of litter effects,  $\varepsilon$  is vector of residuals,  $X_i$ ,  $Z_i$ ,  $W_i$  are the incidence matrices for fixed, random effects and litter effect for the traits  $i$ .

### Estimation of selection response

Data and pedigrees from six generations of simulation were used to estimate variance components and genetic parameters under tri-variate animal model (2) using AIREML. The averages EBV across generations were plotted to measure genetic trend.

## RESULTS AND DISCUSSION

### Genetic response based on direct and indirect selection

The genetic responses from simulation are shown in Fig 1. We found a lower genetic response of -0.26 kg feed per gain from indirect selection (0M-0F) compared to the direct selection types over six generations of selection. Among direct selection types, the increase in genetic progress was directly related to the per cent of pigs tested for FCR. 100% testing of males and females yielded the highest genetic gain of -0.51. Testing of half the pigs, either 100M-0F or 50M-50F yielded less genetic gain, -0.46 and -0.45 respectively. Testing lesser percentages of pigs, 50M-0F gave less genetic response at -0.42. The difference in response could be broken down into two comparisons: indirect vs direct selection (Fig 1a) and differences within the direct selection types (Fig 1b). 100% testing gave twice the response as indirect selection. Testing 50% of the females instead of no females increased response by < 10% or -0.03 (compare 50M-50F to 50M-0F). Testing 100% of males vs 50% of males increased response by < 10% or -0.04 (compare 100M-0F to 50M-0F). Therefore, the genetic

**Table 1:** Parameters used in simulation of phenotypic traits, including initial population mean, contemporary group variance ( $\sigma_{CG}^2$ ), sex variance ( $\sigma_{sex}^2$ ), additive variance ( $\sigma_a^2$ ), common litter variance ( $\sigma_c^2$ ), error variance ( $\sigma_e^2$ ).

Traits <sup>1</sup>	Mean	$\sigma_{CG}^2$	$\sigma_{sex}^2$	$\sigma_a^2$	$\sigma_c^2$	$\sigma_e^2$	$h^2$	$c^2$
FCR	3.000	0.010	0.017	0.028	0.005	0.050	0.31	0.06
PCL (%)	56.00	1.17	1.76	3.36	0.38	5.86	0.35	0.04
DAY (days)	170.00	35.00	52.00	56.00	40.00	103.00	0.28	0.20

<sup>1</sup>FCR= Feed conversion ratio, PCL= Per cent lean (%) and DAY = Day to market weight (days).

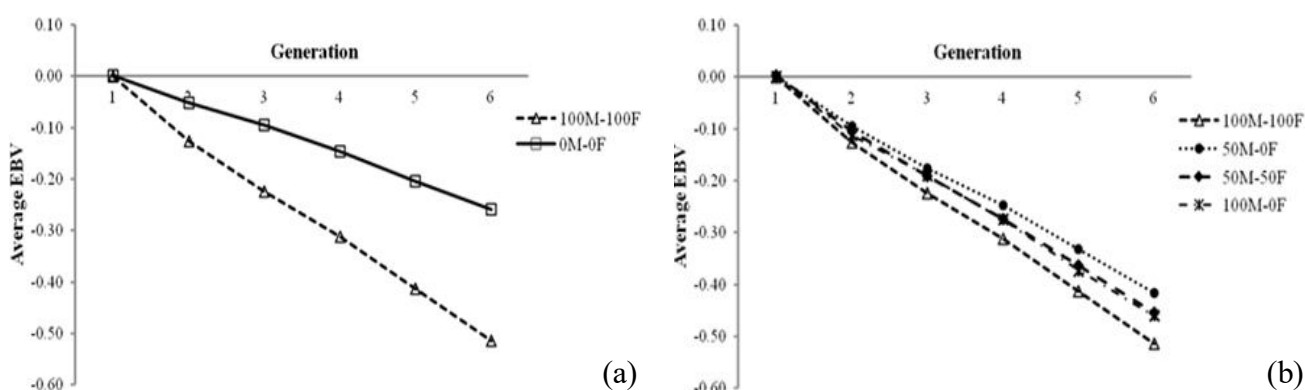
gain with any FCR testing exceeded the genetic gain from indirect selection only. This result implied that genetic improvement for FCR depended on how much FCR data was measured.

The highest and the lowest genetic regression responses in FCR were observed for 100M-100F and indirect selection scenarios (0M-0F), respectively (Table 2). The two estimates of rate of genetic improvement are different by more than double. These results should be applied to the relative improvements made in FCR across testing strategies. The magnitude of the genetic trend results in this simulation is not expected to be replicated in real life due to factors of genetic slippage for realized genetic response.

While, a testing only a portion of boars (50M-0F) was close the value reported by Hoque *et al.* (2007) who estimated genetic response per generation in FCR over six generations was small (-0.083 unit per generation) based

on improving growth and carcass traits. This study was larger than evaluated by Kuhlert *et al.* (2003) who observed decrease 0.038 kg feed per gain per generation where barrows were considered as well as boars and gilts.

The genetic progress of PCL in our study ranged from 0.05 to 0.20% per generation (Table 2) which slower than Nguyen and McPhee (2005) who report considering growth rate. We may deduce that the response of PCL depends in part on the FCR information as suggested by Hoque and Suzuki (2008) who mentioned that the backfat thickness may depend on residual feed intake information used. Moreover, FCR and PCL are negatively genetically correlated, perhaps making this situation more difficult to handle genetic change, which is in agreement to Nguyen and McPhee (2005) and Saintilan *et al.* (2011). Genetic regression response of direct selection traits improved for all selection scenarios were similar for DAY (Table 2).



**Fig 1:** The difference in genetic response over the six generations of feed conversion ratio into two comparisons; (a) indirect vs direct selection and (b) differences within the direct selection, based on mate selection.

**Table 2:** The genetic response and standard deviation of the estimates from 30 replicates (in parenthesis) over six generations simulated data for feed conversion ratio (FCR), per cent lean (PCL) and days to market weight (DAY) using positive assortative mating under different levels of FCR data measurement.

Selection scenarios <sup>1</sup>	No. records	Regression of EBV			Accuracy of selection <sup>2</sup>			% ΔG loss <sup>3</sup>
		FCR	PCL	DAY	FCR	PCL	DAY	
100 M-100F	5961	-0.11 (0.013)	0.20 (0.12)	-5.13 (0.50)	0.83 (0.03)	0.71 (0.02)	0.87 (0.01)	0.00
100 M-0F	2963	-0.09 (0.011)	0.12 (0.12)	-5.42 (0.58)	0.81 (0.02)	0.71 (0.02)	0.87 (0.01)	18.19
50 M-50F	2903	-0.09 (0.012)	0.11 (0.12)	-4.77 (0.80)	0.81 (0.03)	0.71 (0.03)	0.86 (0.02)	18.19
50 M-0F	1474	-0.08 (0.011)	0.08 (0.11)	-5.49 (0.76)	0.74 (0.03)	0.70 (0.02)	0.87 (0.01)	27.27
0 M-0F	0	-0.05 (0.007)	0.05 (0.12)	-5.23 (0.98)	0.42 (0.08)	0.70 (0.02)	0.87 (0.02)	54.54

<sup>1</sup>Direction selection based on EBVs from FCR records of all animals (100M-100F), involved FCR of male only (100M-0F), 50% of boars and 50% of gilts (50M-50F), only 50% of boars (50M-0F) and indirection selection of FCR (0M-0F).

<sup>2</sup>Accuracy of selection is correlation between true breeding value and estimated breeding value.

<sup>3</sup>Per cent ΔG loss of FCR calculated from % Loss =  $\left( \frac{R_{FCR} - CR_{FCR}}{R_{FCR}} \right) * 100$

## Selection efficiency

Selection efficiency is consistent with percent loss of genetic response of FCR. Per cent loss in selection response from indirect selection (0M-0F) on FCR was approximately 54.54% when compared with direct selection (100M-100F). On the other hand, using FCRs records at a level of more than 50% (50M-50F or 100M) can raise response higher than 80% (%loss was approximately 18%). Therefore, this result suggested that selection efficiency for FCR would not depend on source of records (boars or gilt). These results could be applied in some genetic suppliers use males only (100M) as, artificial insemination (AI) has the potential for genetic improvement in terminal progeny.

Improvement in genetic response will be dependent upon the amount of FCR measurement via to accuracy increase (Falconer and Mackay, 1996; Muir, 2000). The highest and the lowest of accuracy and genetic regression response in FCR were observed for 100M-100F and 0M-0F, respectively. On the contrary, the DAY in all mate selection schemes was more than 85% accurate. The accuracy of PCL in all mate schemes was less than 75% which was the lowest compared to other traits under 100M-100F scenario. Therefore, the genetic progress of PCL could be slow improved in this study.

## CONCLUSION

Selection for DAY and PCL caused desirable genetic change in FCR. Percent of regression response of indirect selection for FCR (0M-0F) when compared with direct selection (100M-100F) was approximately 54.54%. The accuracy of selection of FCR data measured differs based on data collected. Accuracy of DAY was similar in all selection schemes while the accuracy of PCL was below 75%. Improvement in genetic response will be dependent upon the amount of FCR measurement via to accuracy increased. We suggest using direct measure on at least 50% of all pigs (50M-50F or 100M-0F) as response of FCR did not differ largely among direct selection types also.

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