National Hog Farmer

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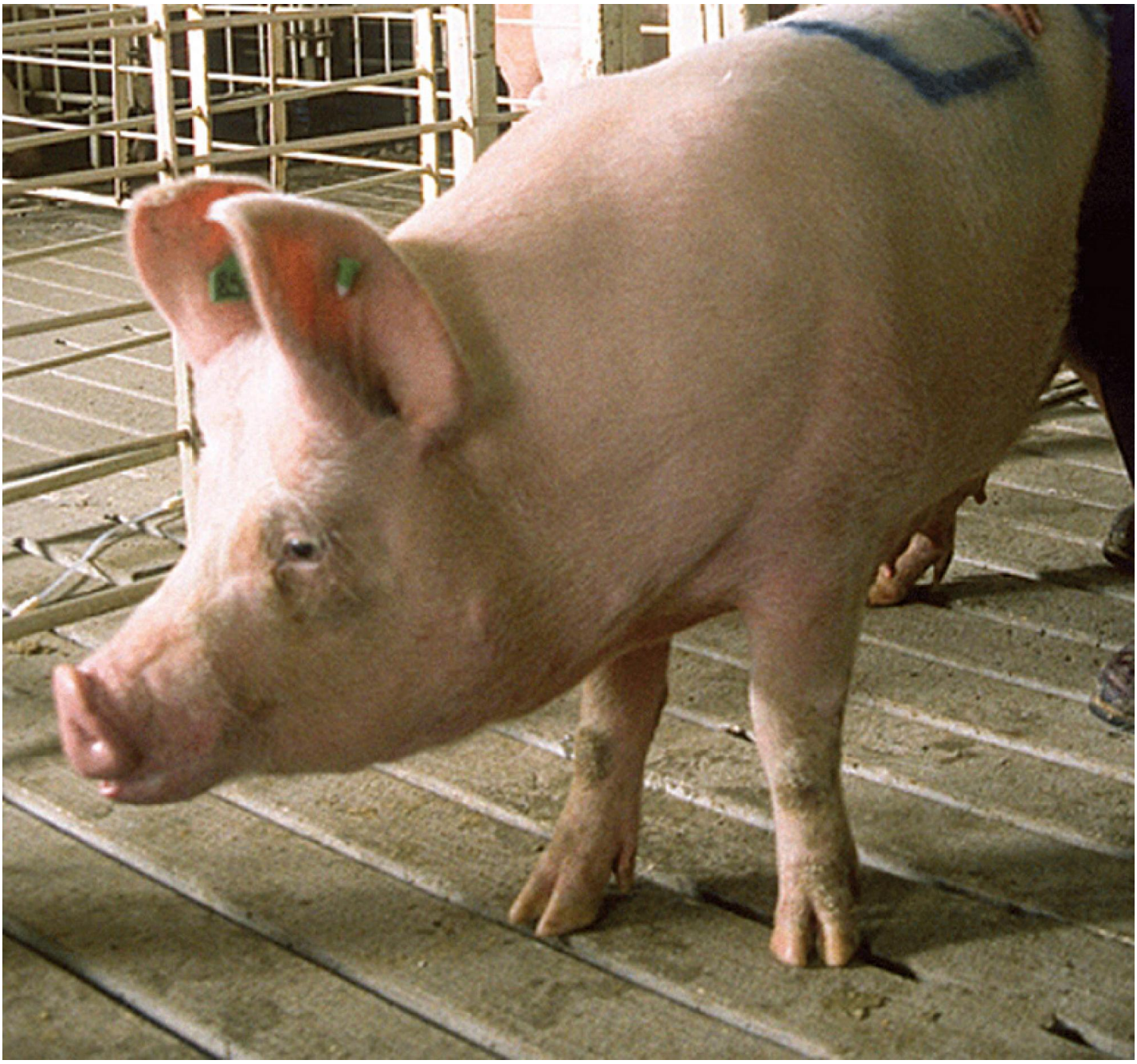

Blueprint: Selection for feed efficiency helps pigs adapt to stressors

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Feed is the largest cost in pork production; therefore, improving feed efficiency can increase producer profitability. Furthermore, improved feed efficiency can support industry competitiveness, decrease the demand on global feed resources and complement environmental sustainability.

Enormous strides have been made to improve feed efficiency during the grow-finish period by selecting for pigs that grow faster and that have less backfat. Recently, selection for feed efficiency has been accelerated by directly measuring feed intake and, therefore, feed efficiency on animals in nucleus breeding populations. The question whether selection for feed efficiency results in pigs that are less robust and that may be less able to cope with physiological and behavioral stress is, however, often raised. After all, mounting an immune response and coping with stress requires substantial amounts of energy, and pigs that are very efficient may not have the resources to mount an effective response to cope.

In addition, there are concerns that pigs from maternal lines that are selected for feed efficiency during the grow-finish period may not be able to withstand the challenges of breeding, gestation and lactation. In particular, lactation puts high demands on energy resources, which a sow from a line that has been selected for efficiency may not have available.

To address these and other questions, in 2001, we started divergent selection lines for high versus low feed efficiency in a population of purebred Yorkshire pigs at the Lauren Christian Swine Research Center in Madrid, Iowa. The specific measure of feed efficiency that we selected for was residual feed intake during the grow-finish period. Against this background, the objectives of this article are:

■ to explain the concept of residual feed intake as a measure of feed efficiency and its importance

■ to discuss how selection for feed efficiency based on RFI impacts the grow-finish pig's ability to cope with physiological and behavioral stress

■ to discuss the impact of selection for efficiency during the grow-finish period on a sow's reproductive performance

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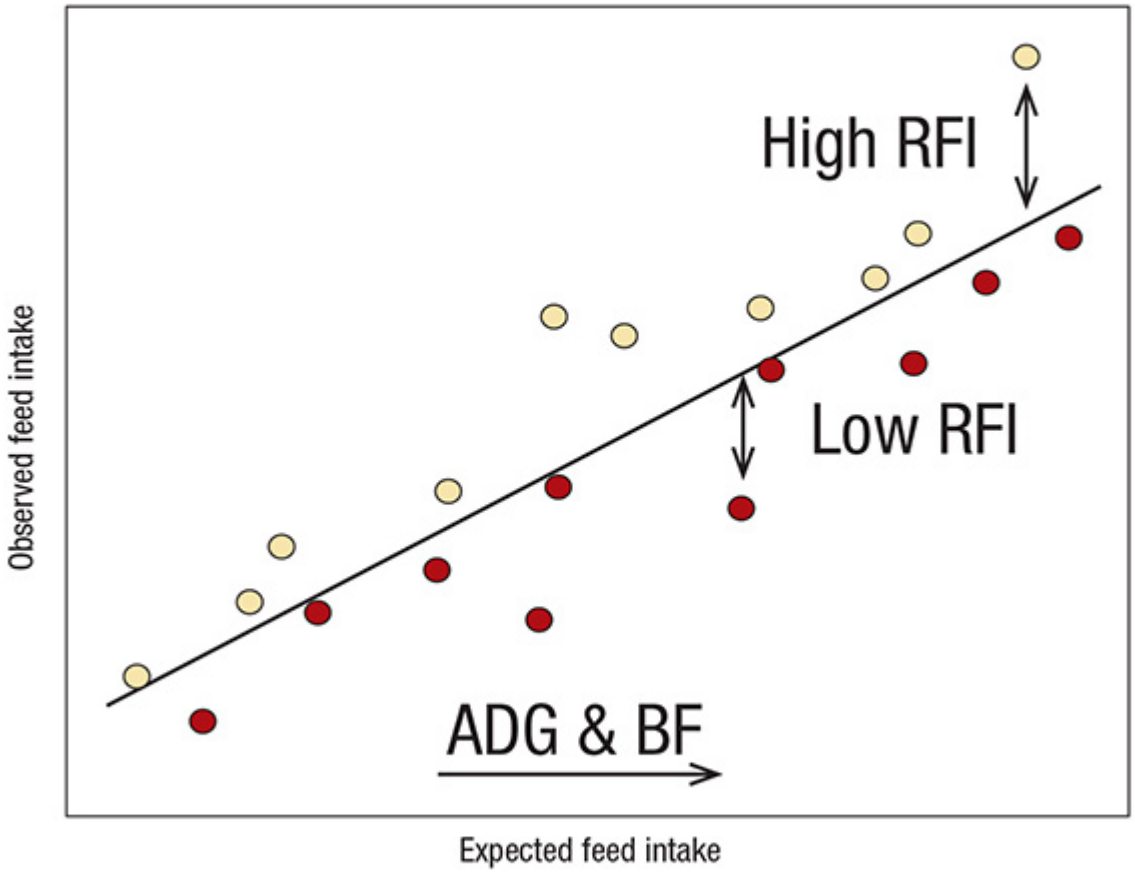
What is residual feed intake?

Residual feed intake is one method of measuring feed efficiency, defined as the difference between a pig's observed and expected feed intake. Expected feed intake is determined for each pig based on its growth rate and backfat thickness. Pigs that consume less feed than expected have a lower RFI, are more feed efficient, and they are, therefore, economically better for lean production compared to pigs with high RFI (Figure 1). A nice feature of RFI as a measure of feed efficiency is that it is independent of growth and backfat, i.e., we can find pigs that fall above or below the line among pigs that have high growth rate and low backfat thickness (pigs on the right side of the graph in Figure 1), as well as among pigs that have a low growth rate and high backfat thickness (left side

of the graph).

Figure 1. Schematic of residual feed intake as the difference between observed and expected feed intake



The line represents expected feed intake based on the pig's average daily gain (ADG) and backfat (BF). Pigs that are above the line have high RFI and are less efficient. Pigs below the line have low RFI and are more efficient.

In our research, we have found that more than 30% of the variation in feed intake between pigs can be attributed to RFI, with the remaining approximately 70% resulting from differences in growth rate and backfat thickness. This 70% is obviously an important contributor to feed efficiency because, although pigs that grow faster eat more per day, they reach market weight sooner and, therefore, require less feed to reach market weight. Selection for increased growth rate and reduced backfat thickness effectively taps into this 70%, and the industry has been very effective in capitalizing on this. Getting at the remaining 30% that is represented by RFI, however, requires actual recording of feed intake.

The take-home message here is that RFI captures differences in feed efficiency that are not captured by differences in growth rate and backfat thickness.

Factors that contribute to variation in RFI include body composition (beyond backfat), energy used during activity, efficiency of digestion, metabolic balance, thermoregulation and temperament.

Using RFI over the past 15 years, two selection lines of purebred Yorkshire pigs have been developed at Iowa State University: an efficient line that has been selected for low RFI over 10 generations and an inefficient line that was randomly selected for the first five generations and then selected for high RFI for another five generations. Now in their 10th generation, pigs from the low-RFI line require 12% to 15% less feed to reach market weight than pigs from the high-RFI line, while having a similar growth rate. The pig with low RFI does have slightly lower backfat thickness, but this only explains a small proportion of the differences in feed intake. These lines are a unique resource to investigate the 30% of differences in feed efficiency that are not explained by differences in growth rate and backfat thickness and to understand what the consequences of selecting for increased feed efficiency based on RFI are for robustness.

At the same time, similar selection lines for high and low RFI were initiated in a population of European Yorkshire pigs at INRA in France. Results from our lines have been compared to those obtained on the INRA lines where possible.

Physiological stress response

Grubbs and colleagues (2013) investigated the protein profile of mitochondria from liver, semitendinosus (red portion), semitendinosus (white portion) and longissimus dorsi to determine the differences between the HRFI and LRFI lines. More feed-efficient (LRFI) pigs indicated an increase in antioxidant defenses and potential modifications of metabolic pathways leading to oxidative stress, metabolism and cellular repair. Results indicated that pigs selected for LRFI may be less prone to muscular oxidative stress, and their livers may have a greater metabolic capacity when compared to their less feed-efficient (HRFI) contemporaries. Here the take-home message is that metabolic inefficiencies at the mitochondria may translate to increased tissue stress that antagonizes lean tissue accretion.

Colpoys (2015) investigated how selecting for RFI may impact the pig's ability to cope with stress.

Do more feed-efficient pigs have lower baseline stress?

Do more feed-efficient pigs have lower response to a stress challenge?

Naturally, following a stressful event, pigs secrete adrenocorticotropic hormone from the anterior pituitary gland, which then stimulates the secretion of cortisol from the adrenal cortex. Therefore, ACTH can be exogenously administered to induce a stress response, and the pig's responsiveness can be measured through cortisol. Cortisol is important for reacting to a stressor, as it prepares the body for a fight or flight response and, therefore, influences animal welfare. Colpoys (2015) evaluated the physiological stress response of gilts from the two RFI lines by administering ACTH and measuring the stress response through cortisol concentrations. The results showed that gilts from the more efficient LRFI line tended to have lower baseline cortisol and had lower cortisol concentrations in response to the ACTH stimulation compared to HRFI gilts.

Pigs selected for improved feed efficiency were better able to cope with a physiological stressor. Therefore, we predict that in a production environment, these pigs would be more robust when exposed to physiological stressors.

Immunological stress

Dunkelberger and colleagues (2015) assessed the effect of infection with porcine reproductive and respiratory syndrome virus on pigs from the two RFI lines. One hundred weaner piglets from each line were infected at Kansas State University (R.R.R. Rowland) and followed for 42 days.

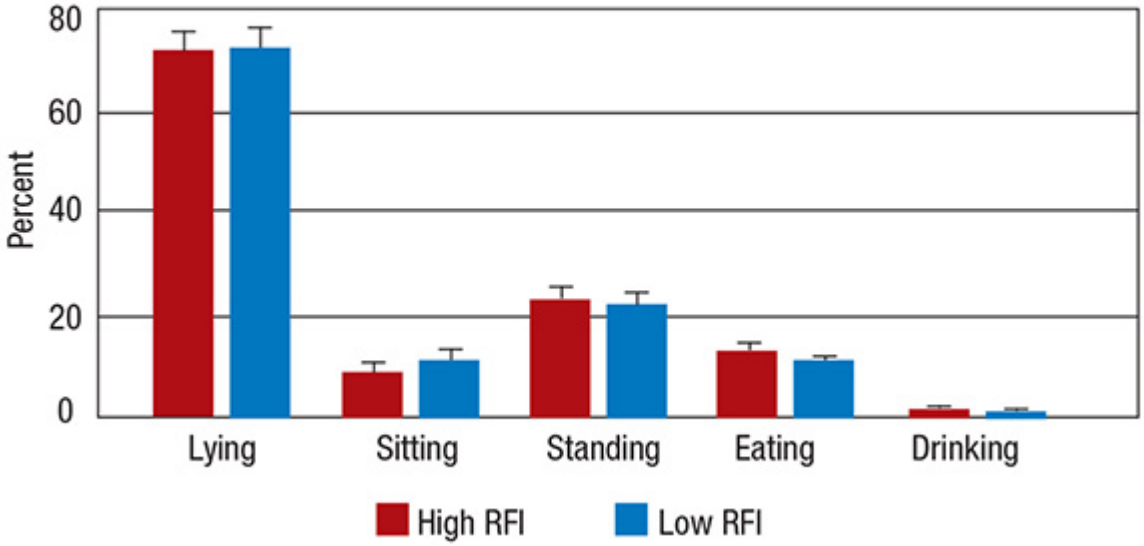
There was a tendency for pigs from the LRFI line to have lower levels of PRRS viremia in blood following infection, to have a faster antibody response, and the growth rate of the LRFI pigs was less affected by infection than that of pigs from the HRFI line.

Pigs selected for increased efficiency based on RFI were less affected by PRRSV infection and inflammatory challenge and responded better to the disease.

A lipopolysaccharide challenge can also be used to determine whether selection for improved feed efficiency impacts sickness behavior expression. A study by Azarpajouh and colleagues (2015) using gilts from the RFI lines did not show differences in sickness behaviors in response to a

lipopolysaccharide challenge (Figure 2).

Figure 2. Sickness behaviors in RFI gilts



Genetic selection for improved feed efficiency did not affect the sickness behaviors expressed by gilts in response to a lipopolysaccharide challenge.

Rakhshandeh and colleagues (2012) evaluated the impact of lipopolysaccharide challenge on apparent ileal digestibility and apparent fecal digestibility of nutrients for the two RFI lines and on intestinal nutrient active transport and barrier function. The immune system stimulation decreased apparent ileal digestibility of nutrients. The reduction in apparent fecal digestibility of crude protein as a result of immune system stimulation was greater in the LRFI line than for the HRFI line. Genetic selection for LRFI increased the apparent fecal digestibility but had no effect on apparent ileal digestibility of nutrients. It also reduced the total tract digestive capacity of growing pigs during immune system stimulation. The immune system stimulation affected both apparent ileal digestibility and apparent fecal digestibility of dietary crude protein.

Behavioral stress response

Sadler and colleagues (2011) evaluated the extent to which RFI selection impacts behavior and presence of lesions using the RFI selection lines.

On the day of placement in their grow-finish pens, there were no postural, behavior or general activity differences between the two lines, but over subsequent rounds, behavioral differences were

observed, with LRFI gilts becoming less active. Gilts from the LRFI line also had lower lesion scores on the day after placement. However, over subsequent rounds there were no differences in lesion scores between the two lines.

Genetic selection for improved feed efficiency resulted in a better lesion score in gilts on the day of placement.

Novel object- and human-approach tests are commonly used to test a pig's behavioral response to fear-eliciting stimuli, as pigs are innately neophobic. Research conducted by Colpoys and colleagues (2014) compared behavioral reactions of barrows from the two RFI lines. Barrows were evaluated using a human-approach (HAT) and novel object-approach test (NOT). During both HAT and NOT, LRFI barrows expressed fewer fear behaviors than HRFI barrows.

Genetic selection for improved feed efficiency resulted in fewer fear behaviors in barrows. Therefore, we predict that when producers walk grow-finish pens, more feed-efficient barrows will be less likely to touch the producer but will also be less stressed with the producer in their pen.

Reproductive performance

Young and colleagues (2016) investigated the impact of selection for feed efficiency in grow-finish based on RFI on subsequent reproductive performance. Contrary to what we expected, sows from the more efficient LRFI line had 1.3 more piglets born alive and 1.6 more piglets weaned, with similar piglet weights at birth and weaning. Thus, LRFI sows on average provided more energy to their piglets during gestation and lactation. However, LRFI sows consumed 18% less feed during lactation.

To provide this extra energy to their piglets and make up for their lower feed intake, the LRFI sows mobilized substantially more body reserves: They lost nearly 22 pounds more body weight during lactation, including nearly 0.8 inch more backfat.

In terms of their performance during lactation, the LRFI sows behaved like a dairy cow, milking the fat of their backs, while the HRFI sows were like a beef cow, being more worried about their own condition than that of their offspring. Similar results were observed in the INRA RFI lines.

Genetic selection for improved feed efficiency during the grow-finish period based on RFI does not negatively affect reproductive performance. In contrast, sows selected for increased efficiency had larger litters and were better mothers.

An outstanding question, however, is whether the greater negative energy balance that the efficient sows experience during lactation affects rebreeding performance. This could not be evaluated in the ISU RFI lines, but results from the INRA lines indicated no difference in rebreeding performance between their high- and low-RFI lines.

Summary

This research conducted on the RFI lines is encouraging as it relates to physiological, immunological and behavioral responses and reproductive performance of pigs that have been selected for improved feed efficiency. Overall, results demonstrate that selection for feed efficiency during the grow-finish period based on RFI does not reduce their ability to respond to immunological and behavioral stressors. To the contrary, pigs selected for feed efficiency based on RFI were better able to cope with these stressors.

In addition, pigs from the efficient low-RFI line were better able to cope with the stresses of gestation and lactation. Although the exact mechanisms behind these findings are unknown, our hypothesis is that the more efficient low-RFI pigs are better able to direct resources where they are needed, deal with the challenge and then go back to performing. To further ascertain the robustness of the low-RFI pigs, more work is needed to evaluate their performance in commercial situations.

This content is in part based on a factsheet at the Pig Information Gateway .