Adoption of further traits to increase genetic gain in the $Index

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Background

Genetic improvement of pig performance was summarised for 28 Australian pig populations at the previous AGBU pig genetics workshop (Hermesch, 2006). The average genetic trend was $1.06 per pig each year. In comparison, the top 25% of populations had achieved $1.92 per pig each year. During subsequent discussions at the workshop, breeders set a target of an annual genetic gain of $3 per pig. In order to achieve this ambitious target, breeders have to increase genetic gains in the traits of the breeding objective ($Index). This paper outlines factors that affect the economic importance of performance traits and highlights strategies for improved genetic gain in economically important traits.

Definition of the $Index

The annual genetic gain in the $Index presented by Hermesch (2006) was based on economic weights derived by Cameron and Crump (2001). However, a number of factors influence the economic importance of individual traits. Using the profit function implemented in PIGBLUP, Graser and Henzell (1997) evaluated the effect of changes to economic, production and marketing inputs on derived economic weights for growth rate, backfat, feed conversion ratio and litter size. The input parameters that most influence economic weights for each trait are shown in Table 1 for illustration purposes. Breeders may find this illustration useful when deriving the $Index most relevant to their own pig breeding program.

Changes to non-feed costs per day and average daily gain until market affected economic weights for growth rate. As daily non-feed costs increase economic weights for growth rate become larger. The number of days to a fixed market weight is larger for slower growing pigs, which explains the higher economic weights for lower average daily gains.

Economic weights for backfat depend on the mean backfat relative to the payment scheme. Due to the price grid used in the example by Graser and Henzell (1997), the importance of backfat changed only above a mean backfat of 14 mm. Overall, breeders have made substantial genetic gain in backfat reducing the economic importance of further reductions in this trait. Therefore, other carcase measurements have to be developed that better capture the economic importance of improving lean meat content in valuable cuts of the carcase.

The economic importance of feed conversion ratio increases with higher feed prices. Given the increasing demands world wide for food, feed and bio-fuel (Ratcliff, 2008), it is likely that feed prices will remain high increasing the importance of feed conversion ratio. Australian pig producers are experiencing feed prices at the highest level used in the example outlined in Table 1.

Usually, litter size is only considered in breeding objectives of dam lines. This aspect is mimicked in the PIGBLUP profit function by changing marketing input variables, which affected economic weights for litter size the most.

Table 1. Impact of changes to the economic, production and marketing data on the economic weights of different traits ($/litter) in the $Index of PIGBLUP (Graser and Henzell, 1997)

	Average daily gain (ADG)				
Non-feed costs per day ($/pig/day)	0.10	0.15	0.20	0.25	0.30
Economic weights - ADG	*0.20*	*0.30*	*0.41*	*0.51*	*0.61*
Average daily gain until market	520	560	600	640	680
Economic weights - ADG	*0.41*	*0.35*	*0.30*	*0.27*	*0.24*
	Backfat (BF)				
Mean fat depth (mm)	10	12	14	16	18
Economic weights - BF	*-0.06*	*-0.06*	*-1.60*	*-10.5*	*-15.1*
	Feed conversion ratio (FCR)				
Cost of feed ($/kg)	0.20	0.24	0.28	0.32	0.36
Economic weights - FCR	*-149*	*-179*	*-209*	*-239*	*-269*
Number of piglets born alive	9.0	9.5	10.0	10.5	11.0
Economic weights - FCR	*-154*	*-162*	*-171*	*-179*	*-188*
	Litter size (LS)				
% sires used as Terminal, Maternal or Slaughter pigs	0/60/40	20/40/40	40/20/0	60/0/40	100/0/0
Economic weights - LS	*47.8*	*41.0*	*34.3*	*27.5*	*20.8*
Non-feed costs per day ($/pig/day)	0.10	0.15	0.20	0.25	0.30
Economic weights - LS	*30.5*	*27.5*	*24.6*	*21.6*	*18.7*

Expressing economic values per genetic standard deviation of each trait makes a comparison across traits possible (Table 2). The values presented by Cameron and Crump (2001) were derived for the Australian market in comparison to values derived by Knap (2005) for a ‘typical Western market’.

In the Australian market, the economic value for growth rate was the lowest in comparison to the other three traits. It was derived for a fixed slaughter weight. Economic values for this trait are higher if it is assumed that the improvement in growth rate is accompanied by a higher slaughter weight.

The economic values for pre- and post-weaning survival as well as sow longevity were of similar magnitude per genetic standard deviation as performance traits traditionally used in pig breeding programs (Knap, 2005). These economic values demonstrate that these traits deserve consideration in pig breeding programs.

Table 2. Economic values of pig breeding goal traits (Money/pig)

	Cameron and Crump (2001)		Knap (2005)	
	A$/trait unit	A$/genetic standard deviation	Money/trait unit	Money/genetic standard deviation
Backfat depth (mm)	-2.05	-2.91		
Carcase lean content (%)			+1.49	+3.45
Average daily gain (g/day)	0.05	1.69		
Days to slaughter weight (days)			-0.50	-4.31
Feed conversion ratio	-21.1	-3.16		
Average daily feed intake (kg/day)			-29.4	-3.89
Litter size at farrowing (piglets/litter)	3.56	3.18	+2.27	+2.16
Pre-weaning piglet survival rate (proportion)			+0.28	+1.08
Grower pig survival rate (proportion)			+0.44	+2.21
Sow reproductive lifetime (parities/sows)			+25.8	+3.01

Uptake of further traits

Additional traits need to be included in selection decisions to improve genetic gain in the $Index. A number of traits have been researched extensively and sufficient information is available for adoption by breeders. Avenues to improve selection for feed conversion ratio, pre-weaning survival and sow longevity as well as carcase composition and meat quality are outlined. Further information about these traits is available from previous workshops notes which are available at the AGBU web pages http://agbu.une.edu.au/pigs/pigblup/work.php.

1. Selection for feed conversion ratio

Most pig breeders in Australia are not able to record feed intake and rely on indirect selection criteria for genetic improvement of feed conversion ratio. The use of juvenile Insulin-like Growth Factor-1 (IGF1) in pig breeding programs has been researched extensively in Australia demonstrating the genetic relationship between feed conversion ratio and juvenile IGF1 (Bunter *et al.*, 2005). The use of juvenile IGF1 in pig breeding programs that do not record feed conversation ratio was outlined by Bunter (2001), who provided some guidelines for the use of this trait:

- Each juvenile IGF1 test batch should include multiple sires. Breeders should not create juvenile IGF1 test groups with progeny from one sire only. (This principle applies to all performance traits.)

- When the number of tests is low, fewer progeny per litter should be tested to increase the number of litters tested per sire.

- The optimum number of pigs to test per litter for a fixed number of tests per batch depends on the number of sires producing progeny per batch. Testing up to four pigs per litter seemed adequate when progeny from two to five sires were tested concurrently.

- Initially, more extensive testing may be used to increase the accuracy of EBVs quickly. Breeders should aim to test at least 20 progeny per sire and/or progeny from at least 5 litters per sire.

- If a limited number of tests can be performed then pigs should be recorded in those breeds or lines with higher emphasis on feed conversion ratio in the breeding goal.

In addition, Bunter (2001) provided index calculations to evaluate response in the breeding objective for different recording scenarios. Using records on growth rate and backfat alone was the basis for comparison (=100). It was assumed that selection candidates had information from their parents, 4 full sibs and 20 half sibs available. Including juvenile IGF-1 information increased the response in the breeding objective by 7% (=107), which was comparable with the strategy to record feed conversion ratio on the selection candidate (=108).

The use of juvenile IGF-1 as a selection criterion for feed conversion ratio and lean meat growth has been demonstrated. It is likely that feed prices will remain high placing greater importance on feed conversion ratio in the breeding objective. Therefore, breeders should (re-)evaluate the optimal use of juvenile IGF-1 in their pig breeding program.

2. Selection for pre-weaning survival

Considerable genetic gain has been achieved for litter size in pig breeding programs. However, litter size has unfavourable genetic correlations with average piglet weight at birth and pre-weaning survival. Phenotypically, breeders have noted a decrease in these two traits when sows have large litters. Strategies to improve pre-weaning survival have been discussed during previous workshops recommending the use of average piglet weight at birth (Hermesch, 2001) or piglet survival (Knol and Bergsma, 2004). Different approaches were suggested since genetic associations between average piglet birth weight and pre-weaning survival differed between these studies. A higher average piglet weight at birth was genetically associated with improved pre-weaning survival in the Australian study only. The relationship between piglet weight and pre-weaning survival weakens with improved farrowing facilities and stockmanship (English, 1985), which may explain differences in genetic parameters and therefore selection strategies for pre-weaning survival between Australian and Dutch pig breeding programs.

Assuming equal economic weights for number of piglets born alive and pre-weaning piglet mortalities showed an increased response in the breeding objective of 86% when average piglet weight at birth was recorded in addition to litter size (Hermesch, 2001). It became evident that selection for litter size alone was not a sustainable breeding practice since mortality rates were increased by half a piglet with every one piglet increase in number of piglets born alive. Since then, a number of Australian breeders have incorporated average piglet weight at birth or at 21-days into their breeding program to genetically improve pre-weaning survival as well as piglet growth.

3. Selection for sow longevity

There is an economic incentive to increase the number of parities per sow as shown by Knap (2005) for example. A shorter weaning to conception interval after the first parity had favourable genetic relationships with a sow's ability to stay in the herd until the third or fourth parity (Tholen *et al.*, 1996). This trait seems to be more effective for shorter lactation lengths and where sows have several opportunities to rebreed, which is often the case after the first parity. Weaning to conception interval was not heritable after subsequent parities. Information for both traits, weaning to conception interval and the number of parities per sow, is readily available in herd recording systems and these traits should be incorporated in genetic evaluations.

4. Carcase and meat quality

The level of backfat has been decreased considerably which reduces the economic importance of this trait as outlined above. The retail value of the carcase depends on weight and composition of individual cuts with the middle usually achieving higher prices in Australia in comparison to the back leg and the shoulder (Green, 2008). Research is currently underway in Australia to explore alternative measures to describe the weight of primal cuts more accurately. However, muscle depth has already been shown to have moderate to high genetic correlations with loin and ham weight (Hermesch *et al.*, 2000; Knol and Pius, 2004). The response was increased by 64% when muscle depth was recorded in addition to backfat for a breeding objective that maximised boneless loin and ham weights (Knol and Pius, 2004).

Pork quality is not considered in payment schemes. However, an increased drip loss percentage represents a real cost to the processor. In addition, pork quality may be regarded as 'the costs of doing business'. Overall, pork quality will probably only be of significant importance in niche markets. Incorporating information about meat quality traits that were recorded in abattoirs into pig breeding programs may only be feasible for specific circumstances. Therefore, measurements recorded on the live animal are of interest. Flight time is heritable in pigs (Crump, 2004) and has genetic relationship with meat tenderness in cattle (Kadel *et al.*, 2006). However, so far no study is available in pigs to evaluate the genetic relationship between flight time and pork tenderness.

Adoption process

The adoption process includes a number of steps. Firstly, the breeding objective has to include all economically important traits. Changes in economic parameters and performance levels will affect the relative importance of traits. A comparison of the relative economic importance of traits is possible by expressing economic values per genetic standard deviation of each trait. Secondly, selection criteria need to be recorded routinely over a certain period of time. Therefore, recording procedures will have to be adapted and herd recording systems will have to be modified to accommodate changes. The potentially higher costs of an in-house herd recording system may be offset by the greater flexibility that in-house systems provide. It is often observed that recording *per* *se* highlights short comings and leads to improved performance, well before any genetic improvement has been achieved. Thirdly, data need to be incorporated into genetic evaluation systems and finally, response in individual traits needs to be monitored. For reproductive traits of sows this process may encompass a number of years. This whole adoption process takes about five to seven years in best case scenarios and may be enhanced if R&D is part of the adoption process. The current APL2133 project embraces this approach where Australian breeders actively collaborate in R&D projects.

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