Commercial needs and the delivery of genetic improvement - success or failure?

J. R. Walters

UPB Europe Ltd.

Introduction

At the last Pig Genetics Workshop two papers described aspects of the lost potential in pig production at the commercial level. Black (2000) estimated that slower growth, reduced efficiency of feed use and fatter carcases decreased the profitability of pig enterprises by as much as 25%. Walters (2000) estimated that successful progress had been achieved in backfat reduction but that there were shortfalls of 58% in lean growth, 47% in feed conversion and 67% in litter size against the achieved progress in research selection programmes. It was also shown that there had been a significant decline in feed intake. Use of these latter data together with a simple economic model (see Appendix One) indicates that the gains through genetic progress are valued at some A$2.01 per pig per year while the loss in performance potential is worth at least A$1.61. These data suggest that the delivery of genetic improvement has been both a success story and a failure.

Using the latest world slaughtering estimates from four selected countries (see Appendix Two) allows the estimation of the annual benefits from genetic progress and the cost of the 'lost' potential in the commercial pig industries:

	Genetic Progress A$million	'Lost' Potential A$million
USA	239.2	191.6
Germany	103.7	83.1
UK	23.9	19.2
Australia	9.4	7.6

Depending on one's view, these data may be interpreted in two ways:

- That the value of genetic improvement has been considerable and is a significant success story.
- That the cost of 'lost' potential, at more than 44% of that considered achievable, is also considerable and should be viewed as a significant failure of delivery.

This paper reviews briefly some of the main reasons for this failure to deliver genetic improvement and practical options for better on-farm delivery.

Reasons for the failure to deliver

1) Health

Although genetics is considered the first limiting factor in pig production health status is also a very important component in improving production efficiency. Despite the introduction of high-health breeding pyramids, split-site farms and all-in/all-out health strategies, health remains far from optimal in most commercial operations. When pigs are subjected to disease burden, the immune system is challenged and there is an associated loss of appetite and reduced performance because of the immune response:

	Health Status	
	High	**Low**
Daily Feed Intake (kg/day)	2.22	2.00
Daily Gain (gpd)	830	720
Feed conversion Efficiency	2.53	2.92
Backfat (mm)	25	31
Estimated muscle (%)	57.0	52.3

Weight range - 5 to 113kg

(Source : Stahly, 1995)

Research has also shown that there are important interactions between genotype and health status. The result is that the negative aspects of an immune response are most marked in pigs with high lean potential:

	Lean Potential	**Health Status**	
		High	Low
Feed Intake (kg/day)	Low	2.69	2.58
	High	2.54	2.22
Daily Gain (gpd)	Low	680	599
	High	826	625
Feed Conversion Efficiency	Low	3.98	4.28
	High	3.02	3.60

(Source : Stahly, 1995)

In the above, and several other trials, the pigs with the highest genetic potential out-performed the low potential pigs. However, when the immune system was activated because of disease challenge there was a much greater reduction in the performance of the genetically superior pigs.

Since appetite and lean growth have a large impact on ration specification it may be advisable to adjust diet specifications where disease is likely to influence these factors. In particular, higher lysine levels can be exploited in high health pigs whereas in low status pigs there is both inefficient usage and an energy cost associated with de-animation and elimination of the excess protein.

Another important health component in the 'loss' of genetic progress has been the concentration of production in large units and the emergence of 'new' diseases. For example, PRRS has been a major problem in many countries with increasing evidence of 'waves' of infection, extensive mutation (particularly in the American strain) and variation in virulence levels between strains. Of even greater current concern is the rapid spread of PMWS (Post-weaning Multi-systemic Wasting Disease) and PDNS (Porcine Dermatits Nephropathy Syndrome) worldwide. Unfortunately, despite typical mortality levels of over 20%, relatively little is known about the disease. A common virus is implicated (Porcine Circovirus-2) but various 'trigger' factors, as yet poorly understood, are also involved.

2) Expectations from research

Many of the calculations on genetic gains have come from the research database. Unfortunately, these are often divorced from the commercial world. For example, selection pressure may be exerted on a small number of traits, often in an ideal environment with specialist management, or work undertaken on a genotype that has little place in commercial production. It is hardly surprising, therefore, that extrapolation of such work suggests that commercial exploitation of genetic improvement is failing somewhat.

What is needed increasingly is more of the Bunge scenario where large-scale commercial enterprises are used for practical research. Certainly, the worldwide reputation of Australian genetic research is, in part, due to the magnificent database available - it is to be hoped that the new owners of Bunge continue the current policy!

Another problem arising from research expectations is that the scientists are constantly competing for future funding. The result, all too often, is that the commercial producer is promised rapid advancement years ahead of practical delivery. This has no direct effect on the commercial genetic 'gap' but partially explains the mistrust of research and research data by many producers. The result of this is that producers often fail to exploit viable new developments. A prime case of hightened expectations is in the new biotechnologies. For example, the advances expected from semen-sexing are long and well rehearsed but still appear to be several years away. At the same time, molecular genetics has been slow to realise benefits in commercial production since the 'start' in 1991 with the identification of the halothane mutation. Since then much has been promised but there has been virtual zero delivery, and there remain several problems to be resolved:

- Markers are often inconsistent between breeds and between lines (in some cases even between families).

- There is a chance of the identification of 'false positives'.
- There may be possible unknown adverse correlated effects.
- There could be a relaxation in other economically more important traits.

3) Failure to achieve the full benefits of sire and dam-line breeding

Maximum genetic progress is achieved with separate sire and dam line breeding (and is utilised in PigBlup via the marketing inputs). However, many breeders of purebred Large White/Yorkshire, Landrace and Duroc pigs appear to believe that the breeds are best suited as dual-purpose animals. As these breeds make up the vast majority of the genes in global commercial females it would appear more appropriate to concentrate selection on dam-line traits to achieve greater genetic potential in sow traits.

4) Reliance on simple breed substitution

Partial inefficiency has resulted from the use of simple breed substitution in an attempt to obtain a genetic 'lift' in a limited number of traits. The Table below summarises differences between major breeds for a sample of some of the more important traits:

	Large White/ Yorkshire	Landrace	Duroc	Hampshire	Pietrain	Meishan
Numbers born	=	+ / =	-	- -	- -	+ + +
Weaning-service	=	+ / =	-	-	-	+ +
Growth	=	– / =	+ / =	-	- -	- - -
Feed conversion	=	+ /–	-	+ /–	+ / =	- - -
Backfat	=	=	+	-	- -	+ + +
Lean	=	=	-	+	+ +	- - -
Killing-out	=	– / =	– / =	+ / =	+ +	- - -
pH_1	=	=	=	=	- -	=
pHu	=	=	– / =	- -	-	=
'Marbling'	=	=	+ +	=	- - -	+ + +
Tenderness	=	=	+ /–	+	-	+
Juciness	=	=	+ /–	+	-	+ +

(Adapted from Sellier, 1998 and others)

The two breeds that have been used most extensively for breed substitution are the Meishan and the Duroc.

In the case of the Meishan there is evidence of an increase in litter size in Chinese synthetics of about 1.10 pigs born alive (Mercer, 1994). However, despite this palpable advantage there are real economic disadvantages. As well as significantly higher levels of tainted meat, data from the UK Meat and Livestock Commission (1998) indicated that Meishan synthetics had the following disadvantages compared with 'white' hybrids:

Lean growth rate (gpd)	-23
Killing-out %	**-0.8**
Backfat (P_2) mm	+1.5
Lean %	-1.3

When the economic loss from these traits is balanced against the increase in litter size there is a substantial disadvantage to the Meishan synthetic.

In the case of the Duroc, among the main 'positive' and 'negative' features of the breed are:

Positive	Negative
Increased fat firmness	More fat
Higher 'marbling' fat	Less lean
Increased tenderness	Poorer feed conversion
Increased juiciness	Deep-seated hair
More bone	More bone
Higher haem (red) content	Higher saturated fat profile

Primarily, the breed has been used in 'quality' markets to give a boost to meat and eating characteristics, particularly to increase the level of 'marbling' fat. However, some excellent large-scale research (eg. Cameron, 1990 and Berger, 1994) has indicated that 'marbling' has little effect on eating quality. It would now appear that the advantage in quality assessments made on Durocs may be due to variation in muscle-fibre type (MLC, 1999). Despite this advantage, there is evidence (MLC, 1992) that more than 50% of the genes in the slaughter generation must be Duroc to give any real measurable advantage in tenderness and juciness. In many Duroc markets this level is not achieved. Together with the added costs of production it is clear that the slaughter product must command a premium or displace other pigmeat to 'pay for itself'.

5) Failure to use an integrated approach

Until relatively recently there has been a tendency for the scientific disciplines to work independently of each other so that geneticists have had little involvement with veterinarians, nutritionalists and production specialists. The result has often been poor targeting of priorities and the failure to use integrated models of production systems. In particular, there has been a failure to match nutrition to genetic potential across the range of sexes of different genotypes at different growth stages which can be achieved by growth modelling. A key feature of growth modelling allows the forecasting of future requirements with continuing genetic progress. As an example, the projected performance of pigs which grew last year from 40 - 110kg at 950gm per day with an annual progress of 15gm per day are modelled below for fifteen years:

Year	Growth	Lean Growth	Fat
2000	950	431	11.9
2005	1025	471	11.3
2010	1100	513	10.7
2015	1175	554	10.1

Note the increase in lean growth and the reduction in fat. The model predicts that animals will be leaner at a given weight and less mature at that weight. In combination with the increased growth the result will be an increase in mature size and a resulting change in the nutrient requirements:

Year	Energy MJ DE/day	Lysine g/day	FCR*	Feed Intake*
2000	31.2	26.2	2.50	2.37
2005	32.1	28.1	2.38	2.44
2010	32.9	30.1	2.28	2.51
2015	33.7	32.1	2.18	2.57

* Assumes 5% wastage ; 13.89 MJ/DE diet

Note that the model predicts an increase in daily energy and lysine to support the genetic potential for lean growth. The result is an on-going requirement for increased daily feed intake. As there is currently a considerable shortfall between genetic potential and commercial performance in this trait there is growing awareness that this is an area requiring considerable emphasis for the immediate future.

6) Failure to use available technology on-farm

Production management from the service house to delivery at the abattoir is sub-optimal. For example, in the growth complex, weaning weight is of prime importance but is often poorly targeted. It has only recently received the attention of geneticists - bravo to PigBlup for including litter weaning weight as a trait some time ago! The higher the weaning weight the greater is the subsequent growth rate (on average, each 1.0 kg increase in weight at weaning reduces the time to slaughter by 10 days). A suitable target is 7.0kg at 23 days, equating to a typical litter growth rate of 2.4kg/day supported by a sow milk yield of 10litres per day. Note that at these milking levels the sow is as efficient as the dairy cow on a weight for weight basis!

Weaning weight is also influenced by birth weight – each 0.5kg at birth equates to 1.0kg at weaning. Birth weight is partially governed by the level and type of diet fed in the last 14 days of pregnancy during which the foetal pig gains some 40% of its birth weight. Increasingly, management regimes involve high sow feed intakes (3.5 to 4.0kg) on high energy diets, such as lactation rations, during this vital period. At the same time the programme must ensure that sows are not over-fed during the rest of the gestation period, particularly after mating.

Growth post weaning is also of vital importance – each 50gpd increase in this period also equates to a 10 day reduction in the days to slaughter. Below is a table of typical targets through the growth curve:

Age	Weight	Growth	FCR	Feed Intake (gpd)
21-35	7.0-10.5	300	1.10	330
35-49	10.5-17.0	450	1.35	610
49-70	17.0-30.0	600	1.66	1000
70-83	30.0-40.0	750	2.00	1500
83-106	40.0-60.0	850	2.20	1850
106-128	60.0-80.0	920	2.60	2400
128-148	80.0-100.0	1000	2.90	2900
148-169	100.0-120.0	950	3.50	3300

(Source : Close and Cole,2000)

These targets are all achievable in modern genotypes with precise nutritional targeting. Ideally, phase feeding should be used together with *ad lib* supply of high quality water (the 'forgotten nutrient'). The idea behind phase-feeding is to support lean growth at least cost through the growth curve – to do this the amount of protein relative to energy is reduced with increasing liveweight. Even if true phase-feeding is nof feasible there are several options available which take feed strategy in the direction of matching target requirements.

Returning to the sow, it is vital to remember that the potential for increasing litter size will require both improved management and higher feed intake capacity of the sow. For example, Eissen (1999) recently published data showing that modern sows could 'cope' with up to 11 piglets – however, larger litter sizes resulted in high weight loss, large backfat loss and poorer litter growth due to inadequate feed intake:

	11 pigs	14 pigs
Feed intake (kg/day)	5.0	4.7
Backfat loss (mm) day10-28	2.5	3.8
Weight loss (kg) 10-28	18.8	24.0
Litter growth (kg) 10-28	42.4	44.8
Piglet growth (kg) 10-28	3.85	3.20

Again, feed intake is a recurring theme!

The Future

It can be seen that a range of strategies will be needed to improve the uptake of genetic potential across the range of improved traits. Within this scenario the pig industries worldwide will need to look carefully at the potential strategic structures that are developing currently. As an example, other than for backfat reduction (and its correlated effect on leaness) there has been very little direct selection for meat and eating quality traits to date. The main reason is that there has been no economic incentive for producers to improve these traits. However, it is now clear that pig producers have been slow to come to terms with the globalisation of pork production. Globalisation means there are fewer and fewer real decision makers – furthermore these are all in the slaughtering and retail sectors. In other words we are breeding pigs for a market of buyers, not producers! The policies pursued by the likes of Ahold, Wal-mart, McDonald's and Pepsi will have crucial impact on supply chain relationships. In some markets dedicated supply chains will become the norm. Ensuring you are part of a surviving supply chain will be a major strategic objective. The competitiveness of pig meat against competitor meats and the growth in global pig consumption may increasingly drive pig production toward in-built genetic advances in meat and eating quality. At the same time there will be increased urgency to deliver these benefits commercially. Together with improved biological efficiency it is to be hoped that genetic improvement will be delivered more effectively and successfully in the future.

References

A full list of references may be obtained by the author.

Appendix One : Economic Model of Genetic Progress

a) Genetic Progress

Trait	Genetic Progress % Possible*	Achievable*	Actual*	Shortfall
Litter size	+1.4	+1.11	+0.46	0.65
Growth rate	+1.7	+1.34	+0.41	0.93
Feed conversion	-1.3	-1.03	-0.69	0.34
Backfat	-2.1	-1.66	-1.66	-

* See Walters (2000)

Assume 79% achievable, as per backfat

b) Valued of Achieved Progress

Trait	Actual Progress	MLC 2001 Herd average	Annual Progress	Value A$
Litter size	+0.46	22.35	0.10	0.31
Growth rate	+0.41	657	2.7	0.37
Feed conversion	-0.69	2.62	0.018	0.59
Backfat	-1.66	11.0	0.18	0.74
	Tot	Total per pig per year		**2.01**

c) Value of 'Lost' Progress

Trait	Progress Shortfall	MLC 2001 Herd average	Annual Progress	Value A$
Litter size	0.65	22.35	0.15	0.45
Growth rate	0.93	657	6.1	0.86
Feed conversion	0.34	2.62	0.009	0.30
Backfat	-	11.0	-	-
	Tot	Total per pig per year		**1.61**

d) Economic Values (based on various MLC estimates)

Trait	Value A$
Litter size	68.75 per pig[1]
Growth rate	0.1375 per g
Feed conversion	3.30 per 0.1
Backfat	4.13 per mm

[1] Value is divided by 22.35 to give value per pig produced per year

Appendix Two : Industry Values of 'Lost' Progress in Selected Countries

	Annual Production*	Genetic Progress A$million[1]	'Lost' Potential A$million[2]
USA	119.0	239.2	191.6
Germany	51.6	103.7	83.1
UK	11.9	23.9	19.2
Australia	4.7	9.4	7.6

* (x'000) – 2001 data from FAO (Food and Agricultural Organisation) and FAPRI (Food and Agricultural Policy Research Unit)

[1] Value per pig of annual genetic progress = A$2.01 (see Appendix One)

[2] Value of 'lost' progress per pig per year = A$1.61 (see Appendix One)