Improving the efficiency of testing

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Introduction

In the face of an oversupplied world pig market only the most efficient producers will stay in business. By and large these will be the operations that are able to more successfully exploit the genetic potential of their animals. Similarly, only those breeders who are able to demonstrate sustained genetic improvement will sell stock to the smaller number of large producers who are left. Although smaller breeders may feel threatened by the few multinational companies who are investing heavily in molecular technologies, there is no reason why a smaller operation cannot make equally as much progress through attention to detail and greater efficiency. The key to this is to think carefully about what we are doing when measuring performance in pigs, in order to maximise the chances of selecting the genetically superior animal. This in turn will reduce non-genetic differences between pigs and help realise a greater rate of genetic improvement.

Testing has simple principles

The principles of genetic improvement through performance testing are simple and straightforward, but often overlooked. Pigs need to be given opportunity to grow under conditions which allow them to express their potential, but which are similar to those their progeny will meet in the real world. The rate of genetic progress in a trait such as days to market depends upon the selection intensity - how good replacement animals are relative to their contemporaries, the replacement rate, and the heritability of the trait. The heritability is primarily concerned with the degree to which observable differences in performance between animals are attributable to their genes. The ratio of genetic differences, or variation, to total observable differences (phenotypic variation) is referred to as the heritability, but this is not cast in stone. If we introduce other reasons why pigs might differ from each other, for example by mixing pigs of different health status, or by feeding animals in the same barn with different rations, then we increase the environmental variation. This leads to an increase in the total phenotypic variation, and consequently to a reduction in the heritability.

One of the aims of a good performance test is therefore to minimise controllable sources of environmental variation, and so to maximise the heritability. A further way of reducing non-genetic differences between animals is to pay greater attention to recording and measurement. All mistakes, whether human or machine-generated, help to inflate non-genetic variation between animals, and mask the underlying potential of stock. In addition, simple procedures such at taking repeated measures of weights and probe depths go a long way towards improving the accuracy of selection.

Testing and the commercial environment

A further consideration of a test is that it should reflect the marketplace into which pigs are being sold. Firstly, if pigs are being taken up to heavy slaughter-weights, then the weight range over which they are being tested should encompass at least this weight. Testing pigs to a greater end point has the added advantage that it is easier to distinguish between pigs which are gaining weight through lean as opposed to fat depositions. Equally, it allows pigs with extraordinary lean growth potential to be detected. Use of a test in which pigs are grown under something akin to commercial conditions also reduces the possibility of a Genotype x Environment interaction (GxE). The progeny of pigs which are tested in single pens may not necessarily rank in the same way as their parent when reared in a conventional competitive environment, for example. Depending on which part of the world one is operating in, measurement of performance on an ad libitum based, computerised wet feeding system may be a future challenge we need to think about.

Practical measures for improving efficiency

The object of this talk is not to dwell on objectives, but to look at how we might achieve better, and more repeatable performance in our stock. This covers a number of subjects, all of them addressing the question of reducing non-identifiable sources of variation.

Identification

One of the fundamental sources of error is recording, whether this is related to writing down the wrong ear number or weight in the first place, or transcribing this incorrectly when the data are put onto the computer. Electronic capture of data is one solution, which is more cost-effective than at first might appear. This is dealt with at length elsewhere in this meeting.

Basic identification of animals is fundamental to the breeding programme. The breeder can help himself greatly here by making sure that tattooing is done correctly and early. Simple details like ensuring that the pins used in tattooing pliers are sharp and intact, and rubbing ink into both sides of the ear need to be checked. As soon as the pig is a bit bigger, it should be tagged (preferably prior to weaning), with a clear, legible identification number. This prevents errors creeping in from misreading of tattoos. Saving money on tags is a false economy, particularly as most pigs are likely to receive one later, anyway. Use of different colours and sequences of numbers for each breed helps to keep tag errors to a minimum.

Health

A particular concern to the measurement of all types of performance is the health status of pigs on test. A number of experiments performed at Iowa State University in the last few years have clearly demonstrated that animals which are immunologically challenged suffer from poorer performance. For example, pigs from a Medicated Early Weaning (MEW) background ate 6% more food, grew 20% faster and showed a 14% improvement in feed efficiency from 6-112 kg, than those with a 'normal9 health status

(Table 1). Furthermore the MEW pigs were better able to respond to an increasing amount of lysine in the diet, and had advantages in both their ability to digest and assimilate nutrients. On many nucleus herds, the general burden of disease organisms has built up over the years, to the stage where it is limiting performance. This effectively means that it is difficult to distinguish between pigs which have genuinely got a genetic advantage in growth and those which merely have a higher level of immunocompetence (not necessarily a bad thing, but confusing to the selection process!).

Table 1. Impact of immune system (IS) activation on feed intake, body growth rate and gain: feed ratios of pigs fed from 6 to 112 kg body weight (from Williams, 1998)

Item	IS	Pig growth phase, kg		
	Activation	6-27	27-112	6-112
Feed Intake, kg/d	LOW	0.977	2.630	2.215
	HIGH	0.907	2.520	2.095
Daily Gain, kg/d	LOW	0.677	0.951	0.864
	HIGH	0.531	0.793	0.720
Gain: Feed	LOW	0.696	0.362	0.391
	HIGH	0.587	0.315	0.244

The best practical solution for improving health status is, unfortunately, the most expensive one of depopulation and restocking. This is often not a viable option to the smaller breeder, nor is the development of separate site production. Both these options should be considered, however. Two site production is often a feasible alternative, which allows expansion of the breeding herd. This allows disease breaks to be introduced so that cycles cannot be developed. MEW programmes allow pigs to be moved whilst still benefiting from a degree of maternal immunity, whilst simultaneously being vaccinated against any diseases of economic importance they are likely to encounter. A key feature of separate site production is all-in all-out movement of pigs. On a more modest scale, operation of rooms within a farm on an all-in all-out basis may lead to improvements in health status which can only benefit test performance. Rearrangement of the stock flow on farms can often achieve this. All-in, all-out systems must be policed rigorously, however. In order to be successful it is no good doing part-clean outs, or moving older, poor growing pigs in amongst younger pigs. This applies equally in the farrowing house, where back fostering often makes a nonsense of the weaning weights.

The guiding principles of health control are to reduce the level of stress, in all its forms, to the pigs so that conditions are not favourable for the development of disease (i.e. the immune system of the pig is able to cope). A number of environmental stressors are likely to exacerbate disease situations. These include raised levels of dust, ammonia from deep-pit slurry storage, inadequate ventilation, poor water supply or delivery and over-stocking. Danish results have clearly shown that growth rates are further depressed and the severity of a disease increases when the level of ammonia is increased (Table 2.). Although these are perhaps aspects more usually thought of as features of commercial pig production, they can nevertheless have a devastating effect on nucleus performance. An environmental audit is well worth carrying out to assess what improvements can be made cost-effectively on your farm.

Table 2. Response of pigs exposed to ammonia and challenged with *Pasturella multicoda* (Andreason *et al*., 1994)

NH_3 (ppm)	Pneumonia Frequency	Pneumonia Extent	Cough Index**	Daily Gain g/day
5	13/17	0.036	6.3	641
10	9/10	0.075	7.9	590
100	9/10	0.065	10.7	609

* Proportion of surface with consolidation
** Number coughing per day / number of pigs in group

Feeding

It is important that the correct feed is offered to pigs in the nucleus environment, and that this is appropriate to each genotype. For terminal sire lines, much denser test rations are now being used with grams of lysine to MJ DE ratios increasing to over 0.9 whilst pigs are on test. This represents total lysine levels of 13g/kg and 14.0 MJ DE. Obviously this sort of ration is not suitable for all stock. Indeed we are beginning to face a dilemma between maximising performance, particularly of gilts, and preparing them for breeding condition afterwards. For maternal lines, in particular, where the main emphasis of selection may not be on growth, gilt developer rations, designed to maximise breeding success (through addition of energy reserves), may be more important.

Standard management practices should apply even more so to nucleus pig production. Diets should use good quality raw materials, be offered as fresh as possible, and regular checks carried out for anti-nutritive factors which might impair appetite. Readily available sources of protein, such as fishmeal or blood plasma will help to raise performance, and should be cost-effective if used properly. Ideally, a fixed formulation ration should be offered, to reduce a further source of variation in performance over time, and practically to make results more comparable over time.

Feed delivery systems are also very important. Even in the case of ad-libitum feeding, without measurement of intake, how the food is offered may affect performance, and so bias evaluations. The pig is a social animal, and greater feed intakes can often be achieved through allowing more than one pig to feed at once. If this is the case hopper design should minimise wastage, and prevent fouling. The latest generation of nudge bar feeders are very effective in this way, allowing pigs to eat little and often with little opportunity for waste. Similarly, water availability is very important for appetite. There should be an adequate number of water sources per pen (typically a minimum of one nipple to 10 test pigs), these should be adjusted to the correct height and angle on a regular basis, and flow rates checked daily.

If measuring feed, the usual choice is now to go for electronic recording systems, such as FIRE. These can and do work very well but require a lot of maintenance, particularly in checking figures daily to ensure that they are operating correctly and that all pigs are actually feeding. Often the operator is left to make his own decisions about which 'poor' records should be edited out. Regular adjustment of crate widths and use of a suitable training period is vital to correct functioning. This type of feeder

cannot be supplied with an integral water system, so use of meal feeds may well limit intake, and pellets should be considered. There is a lot to be said for the traditional crate system of individually feeding pigs, if food is offered on a scale feed to both boars and gilts. Work over an extended period of time from the Roslin Institute clearly demonstrates that selection on a restricted ration can increase both lean growth and efficiency relative to selection on ad libitum systems. The labour involved in such systems is often high, however, and a number of steps must be taken to ensure that feed weigh is as accurate as possible. These include development of semi-automated weigh-back systems, use of coloured buckets and ear tags, and periodic checking of weighs.

Stock Flow / Pig Movement

Adoption of all-in, all-out principles has already been discussed, with respect to health. I would argue though, that a review of pig flow on most nucleus units would be an interesting exercise. Whilst pigs are on test, conditions should be standardised as far as possible. Pigs should be tested in pens of exact number as far as possible, and offered the same conditions as far as possible with respect to pen size, stocking density, feed and water supply, and length of test. Less visible perhaps, is how pigs are treated prior to going on to a performance test per se. Lifetime gain is a key trait in the PIGBLUP $INDEX. This is obviously influenced by a number of factors prior to a traditional 40-90 kg performance test, and so standardisation of procedures prior to test is also vital for evaluation of animals.

An important part of this is the degree of mixing which takes place. Each time pigs are mixed they fight, and precious energy resources are diverted away from eating and growing. If a pen of 40 kg boars are mixed onto test it may take more than two weeks for them to recover from the inevitable growth check which is imposed. Work at the University of Illinois in the US has shown that pigs which are not mixed grow up to 20% faster than those which are over the finishing period. Unmixed pigs achieved growth rates of 866g a day, while pigs mixed for up to two weeks with others achieved just 720g a day. Furthermore, Dutch work has shown that pigs grow better if kept in mixed groups of temperament, rather than placing all pigs of one type together, either aggressive or submissive. Stock flow should be designed to minimise mixing and moving of pigs as far as possible.

The ultimate goal of this type of testing system is the cohort test, in which weekly groups of pigs of the same age are placed onto test without having been mixed from weaning. This means that social groupings are not disturbed and that pigs do not suffer any unwelcome growth checks. The heaviest pigs at the end of test are always the ones which have grown fastest, therefore. A modification of the cohort test is to test in large groups, as pioneered by one UK breeding company. One week's weaning is split into large pens of 60 to 80 pigs, and then the whole group is then transferred again into finishing accommodation. This reflects a particular type of rearing system ('Big Pen'), which although environmentally sound, can be difficult to manage in practice.

Off-Test procedures

1. Use of Multiple Measurements

The repeatability of a trait tells us about the degree to which multiple records on a trait agree with each other, and is the intraclass correlation of records measured between and within animals. If the repeatability is low then the residual (error) variance of a trait is high. The repeatability essentially represents the upper limit to heritability. If several records are taken on an animal, however, the residual variance is reduced, and the heritability is increased as a consequence of lower phenotypic variance.

The table below gives an indication of the relative improvement in response $[R(n)/R]^2$, for different repeatabilities and numbers of records. This shows that there is more benefit to taking repeated measures when the repeatability of the trait is low.

Repeatability	Observations		
	2	5	10
0.10	1.8	3.3	5.3
0.25	1.6	2.5	3.1
0.50	1.3	1.7	1.8
0.75	1.1	1.2	1.3

It is essential that measurements taken at the end of test are as accurate as possible. This is particularly pertinent to pig weights. A difference of as little as 1 kg in end weight can lead to a poor estimation of breeding value, and cause a pig to be ranked incorrectly. This can make the difference between selection for breeding or rejection. It is interesting to take repeat weights, even within a few minutes of each other. These can differ by as much as 4 or 5 kg, particularly if the pig empties its bladder or bowels. If the repeatability is low (and weights probably have a value of 40-60%), then more than one measurement needs to be taken, so that the performance is not judged off a single record. At least two weights are therefore required. Careful design of the selection area so that pigs are weighed both on entry and exit can help to achieve this without a huge loss in time. Likewise, litter size has a low repeatability (15-20%), and therefore at least 3 litter records are recommended before a sensible selection decision can be made on an individual animal. Ultrasound measurements have a higher repeatability, but are easily measured. It costs little to take repeat measurements on each flank, and therefore this should be considered to prevent 'rogue' values from being recorded.

There is also a need to attempt to assess the soundness of the pig more objectively. All breeders look at the physical structure of their pigs, but few record this other than as a straight 'keep' or 'cull' code. Technology may be borrowed from the cattle industry, however, in the form of linear type scores. A number of traits are scored according to a predetermined scale, with low values reflecting poor conformation and high values good type. Traits such as meatiness and leg strength can be recorded onto data loggers to aid in this process. These values can then be analysed and Estimated Breeding Values produced for each pig, which take into account the integrity of its relatives' conformation, not just the individual's own scores.

Measurement of Reproductive Traits

With reproductive traits, the measurements are fairly easy to obtain, but the definitions have to be precise. Therefore, numbers born alive should be defined to include alive pigs only, but this includes pigs which were alive at birth but subsequently died. This can be something that stockmen are reluctant to record, particularly where bonuses may be at stake. Similarly, litter weights should be defined as either including or excluding dead pigs, depending on whether born alive or total born figures are used.

Litter weight reared is one of the most complex traits, not least in PIGBLUP, because of the need to take account of management practices such as fostering, early weaning and extra suckling. I have yet to see a farm on which piglet movements were recorded completely and adequately. Even if this were the case then one should recognise that smaller pigs are often placed on good milking sows to give them a boost. The weaning record is therefore likely to underestimate the sow's true milking potential, as she will have been shown to have reared piglets with a poor aggregate record. Similarly, if early or split weaning is used then the litter has received a different treatment from its contemporaries, and therefore breeding values for that sow may be biased. The way round this is to standardise procedures and as far as possible, stop fostering. The majority of fostering takes place in the first couple of days anyway, so it is possible to impose a management system with no fostering after 48 or even 24 hours (without any detriment to the litters). Litter weighing should as far as possible take place every day, (or second day at worst) so that an 'exact' 21 day weight (for example) is recorded. This reduces any errors which may creep in through having to regress the mean litter weight according to age at weighing. In instances where circumstances dictate that litters have to be moved or sows weaned off early, the weaning part of the data should either be deleted from the database or the adjusted so that the sow is not credited with any litter weight.

Stockmen and Other Miscellaneous Subjects

Stockmen perform better under good working conditions. This is good for pig performance both because a contented work force is likely to do a better job of managing them, and secondly because if the environment is comfortable for a man it is also likely to be comfortable for the pigs. There are a number of factors which come into account, in order to make life simpler and improve efficiency:

- General hygiene, reduction of odours, particularly ammonia
- Dust levels
- Ease of doing routine tasks, such as feeding and cleaning
- Use of clear tags, and timely insertion
- Use of a clearly defined off-test/selection area, with good lighting, and preferably an inspection pit
- Designed layout so that pig movement is logical and simple, passageways not too wide or narrow, and easily gated
- Good load-out facilities, no sudden comers or distractions.

Use of PIGBLUP and Adequate Prediction and Monitoring

PIGBLUP is a very powerful tool for providing information with which to make selection decisions. Any system of evaluation is based around an analytical model which tries to explain differences in performance according to information provided on the pedigree of the animals and how they were reared. Although some corrections are performed on data (for example backfats are adjusted for weight at weighing) in order to make a fair comparison, assumptions have to be made about the general environment of the pigs within each defined management group. If pigs within a management group are not treated the same then these assumptions are violated. Similarly, although regression equations are used to adjust data according to the mean performance, it is quite possible that this under or over-estimates the potential of individual pigs. At the wider level if there are huge differences between management groups, for example different farms with completely different management schemes, then it is difficult to take account of these differences statistically, and therefore it becomes increasingly difficult to compare breeding values of animals from each of the two farms. The key to all this is once you have decided on a regime, to try and standardise conditions both within and across farms as far as possible.

The next point is then to use the information provided by PIGBLUP as efficiently as possible to monitor how successful you are being at selection, and respond accordingly. This is a big subject, which will only be touched on here, but key areas that may well be being neglected are:

- Environmental trends
- Achieved and potential selection intensities
- Inbreeding coefficients
- Numbers of sires and dams contributing to each generation
- Actual generation intervals

Conclusions

It is important to recognise that there are always improvements in efficiency to be made. Although some of the suggestions here apply equally well to commercial pig production, the degree to which they are implemented has a potentially larger impact on selection efficiency in a nucleus. A periodic review of management procedures is recommended which takes account of physical aspects of the selection process, as well as 'traditional' aspects of selection monitoring. These need not be too expensive and any improvements in performance should result in direct savings in the cost of production. The breeder also needs to be in a position to consider new technologies to achieve this.

With standardisation of the environment through health control, stocking density, feeding, minimising disruption and collecting data electronically, it is hoped that a 10-20% gain in efficiency can be made. This can be translated into a similar gain in the rate of genetic improvement. You therefore stand to improve your competitive position as well as your profits.

References

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