Maximising profitable pork via AI

by Dr Grant Walling, JSR Genetics Ltd, Southburn, Driffield, East Yorkshire, YO25 9ED, UK.

Few, if any, technologies have had the impact on commercial pig production that has been achieved through artificial insemination (AI). Japanese workers first advocated AI of pigs in 1947, however, regular use was not adopted until the 1980s to allow the regular movement of genetics across greater distances.

The 1990s saw the rise of pig breeding companies and with that the establishment of a majority of the technified (not backyard) commercial producers switching from natural matings to purchasing semen. In the 21st Century this is further complemented with large producers establishing their own boar studs and smaller farms collecting semen from boars dispersed via AI into gilts and sows.

A technology that would have been considered alien at the start of the 1980s has become commonplace within 25 years and illustrates the high uptake of new technology in the agricultural sector across the world.

With the adoption of AI have come a number of opportunities but also pitfalls. Those that have integrated AI effectively into their business, whilst adequately planning for the potential pitfalls, have significantly profited from their integration of technology.

For the purposes of this article all examples will compare three different scenarios:

- **Scenario 1.** Natural mating. A 500 sow unit with one boar per 20 sows. Boars are replaced at 50% per annum at a cost of US$1200 (€850).
- **Scenario 2.** On farm AI. A 500 sow unit with one boar per 100 sows. Boars are replaced at 50% per annum at a cost of $2500 (€1785). Each sow receives two services per oestrus approximately 12 hours apart.
- **Scenario 3.** Purchased AI. A 500 sow unit purchases AI from a local boar stud at $6 (€4.30) per dose. Each sow receives two services per oestrus approximately 12 hours apart.

Genetic merit of boars

The genetic merit of boars used has a significant impact on the performance of the progeny. General commercial rules of supply and demand apply in pig breeding as with all industries. There is, therefore, a hierarchy in the quality of boars that are received by customers with those paying the most receiving the boars of highest genetic merit unless they specify otherwise. In front of these customers, breeding companies will always select the animals of highest genetic merit for their own use and for use in their own AI studs (Fig. 1).

Based on this hierarchical selling those purchasing in semen from the breeding company (Scenario 3) will achieve the best on farm performance, followed by Scenario 2 and Scenario 1. An example of the increased superiority of the two AI scenarios is given in Table 1.

Significant benefits from using boars of

	Scenarios 1	2	3
Days to 100kg	154	148	145
P2 backfat (mm)	11	10	9.4
Lean meat (%)	61.1	62.6	63.5

Table 1. Example of trait improvements achieved through the use of boars of higher genetic merit.

higher genetic merit are seen in both on farm performance and slaughter characteristics. Note that improvements are dependent on selection criteria and demand.

Whilst reducing backfat is desirable in Europe, pigmeat destined for Asian markets may prefer to increase level of backfat. Under these scenarios similar differentials to Scenario 1 can be achieved in the opposite direction.

Variation in progeny

The reduction in the numbers of boars required per sow provides further benefits to producers. Using fewer boars reduces the variation in progeny performance.

Under the natural mating scenario for 500 sows the required 28 services per week (assuming an 80% farrowing rate and 2.3 litters/sow/year) will require the use of approximately 10 boars of the 25 boars available. In contrast, those using AI can fulfil the service requirements from only two

Continued on page 9

Fig. 1. The distribution of genetic merit of nucleus animals and their selection destinations.

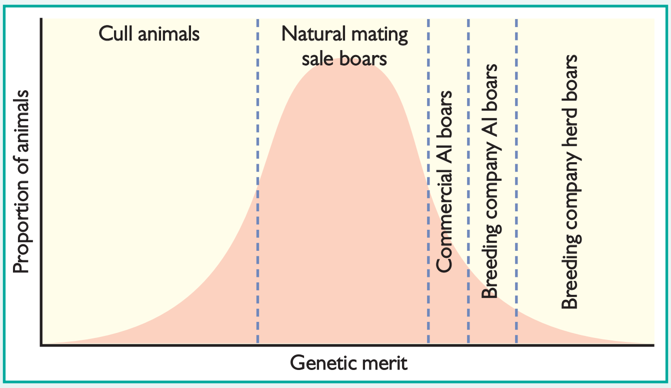
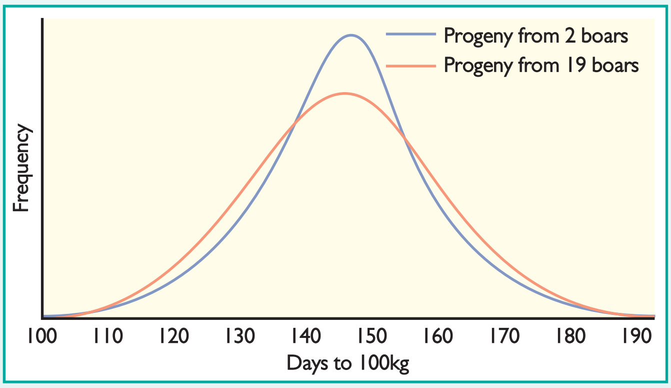


Fig. 2. Growth distribution of groups of animals bred from two (blue line) or nineteen (pink line) different boars.



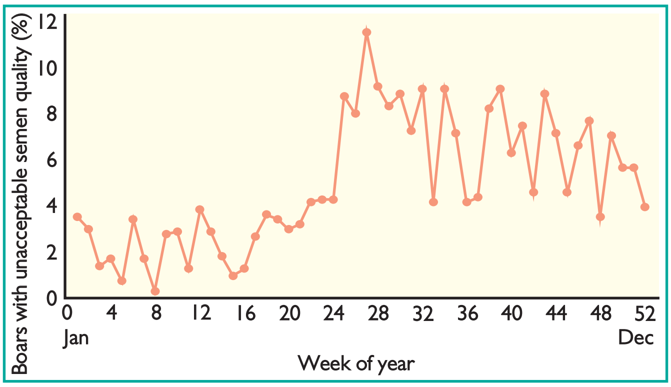


Fig. 3. percentage of boars with unacceptable semen quality across 350 boar stud places by week.

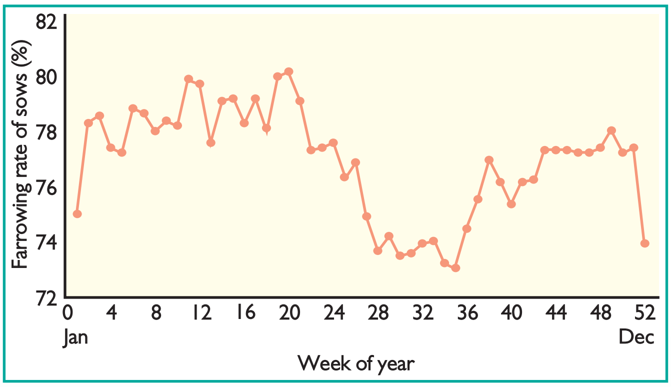


Fig. 4. Farrowing rate of sows served in different weeks of the year. The lower rate between weeks 28-36 corresponds to the peak in seen abnormalities in Fig. 3. The lower conception rate in weeks 1 and 52 highlights the likely poorer management of the animals due to seasonal celebration by production staff (Wiseman, Lewis & Williams 2006).

Continued from page 7
boars. The reduction in the number of boars used significantly decreases the variation in performance seen within a week's cohort of pigs (as demonstrated by the heavier tails of the normal distribution in Fig. 2).

This amounts to a 16% increase in the standard deviation of a trait such as days to 100kg. For producers with 'all in/out' finishing facilities the increase in variation leads to a greater weight spread in animals exiting facilities. For those on weight banded contracts this would lead to a 52% increase to 16.4% in animals falling outside of the weight band at 100kg with a 20kg weight spread (90-110kg). Similarly, other traits with optimal targets desiring low variation such as fat depth will also be affected. Whilst canonised selection may reduce variation ultimately within breed variation will mean that the use of larger numbers of sires will contribute to greater variation in the slaughter progeny.

Boar fertility

No business can maximise profitability without assessing the quality of the component parts. Pig production is no exception and a major component of the success or failure of a pig production enterprise is the fertility of both sows and boars. The only assessment of boar fertility available to those using natural service is the conception rate of gilts and sows. Even when conception rate is low it can be difficult to attribute this to individual boars if females have been naturally mated with multiple sires. When an individual boar is identified as having poor levels of fertility and semen quality a minimum of three weeks of sows and gilts may have already been missed by this boar. For those using AI additional checks can and should be made.

Upon collecting semen from the boar, studying a small diluted sample under the microscope can provide simple measures of both motility and abnormality. Collections with low motility scores (three or lower when scored on a one lowest to five highest scale) or high levels of abnormalities (>30% semen showing some abnormality) should be discarded rather than used for insemination. By discarding samples from the poorest performing boars conception and subsequent farrowing rates are significantly improved.

Specialist larger AI laboratories are able to justify investment in more sophisticated analysis technologies and larger more powerful microscopes. With such systems all semen can be rigorously analysed prior to dispatch so customers purchasing such semen can do so with the confidence that the product they are purchasing will achieve its intended role.

Such detailed collation of data on large numbers of boars highlights some of the challenges in maintaining boar fertility. Fig. 3 demonstrates the significantly larger proportion of boars with low motility or high abnormality rates to be a seasonal effect occurring after the warmer months of late spring and summer in the northern hemisphere. This is typically caused by heat stress affecting the process of spermatogenesis.

The full process of spermatogenesis is an eight week process and hence the onset of the effects can take up to two months to be rectified even if addressed as soon as is seen in the boar. This seasonal affect on boar infertility is likely to be a component in seasonal infertility that has been identified on farms around the world (demonstrated in Fig. 4) and demonstrates the importance of climatic control if the performance of the animal is to be maximised.

Table 2. Fatty acid composition of mammalian sperm.

	Fatty acid			
	18:2n6	20:4n6	22:5n6	22:6n3
Boar	2.1	3.2	27.9	32.7
Bull	3.0	3.3	6.9	55.4
Ram	1.7	4.5	1.0	61.4
Man	1.8	2.5	-	58.7

Boar nutrition

In contrast to natural service boars that are routinely kept with groups of sows for servicing and catching animals returning to oestrus, boars kept in specialist AI facilities can be fed differently to the sows. Typical sow diets are low in long chain omega 3 fatty acids (typically undetectable in most commercial sow diets) but such fatty acids are an essential component of mammalian sperm. Data suggests boars to be deficient of this component (Table 2).

Supplementing boar diets with DHA omega 3 fatty acids along with an organic source of selenium and an antioxidant such as vitamin E, therefore, significantly improves total sperm number, the number of viable sperm, progressive motility and reduces semen abnormality (Table 3).

Hence the ability to manage the diet of boars separately from sows has a significant benefit to both semen quality and quantity, a significant advantage to maintain high levels of sow productivity.

Flexibility

Producers purchasing semen from a centralised stud will typically be on a rolling weekly ordering system.

However, at any point such producers have the immediate power to change terminal sire breed, breeding company or source of their terminal sire boar. This allows them to quickly address issues of different reward systems being offered by packers and processors, poorly performing genetic lines or poor customer service from their current supplier. The result of such a change would appear in the progeny at birth within 115 days and in the slaughter pigs in 260 days.
Continued on page 11

Continued from page 9

For those using boars either naturally or within their own stud it would take two years for these animals to be fully replaced. It would then take a further 260 days before the progeny of these animals started to appear in the slaughterhouse. Those using AI can, therefore, be far more responsive to change, a critical factor in a rapidly evolving industry.

Pitfalls

Whilst there are considerable benefits of adopting AI into pig production systems there are also a number of issues that are less complementary. Artificial Insemination, as its name suggests, is not a natural process and hence is unable to benefit from some of the natural adaptation that has occurred through the process of evolution.

Evolution has delivered an animal with an effective immune system – one that actually hinders the pig producer during mating. The importance of this reaction is apparent when considering the number and propensity of sexually transmitted diseases.

When semen is therefore deposited into the reproductive tract, a number of molecular and cellular changes occur that are very similar to a standard immune response.

Within hours after mating, leukocyte infiltration occurs in the endometrium of the sow. Such a response can have a negative effect on semen and embryonic survival rates, but reduces disease risk to the sow.

In conventional mating, co-evolution has delivered the presence of seminal plasma – an essential component in regulating uterine immune reactions post-mating.

It is the dilution and changes made to semen through AI processing that changes the levels of seminal plasma away from its optimised norm.

Knowing which of the components of the seminal plasma is operational is the key to being able to replicate this effect. Rhodes et al. in 2005 tried using TGF-ß but failed to improve live foetuses per litter, implantation rate, foetal survival or percentage of corpora lutea.

Table 3. Improved performance from DHA supplemented diet (Rooke et al. 2001).

	Control	DHA supplemented diet
Sperm number (x10^{10})	6.8	12.1
Viable sperm (%)	71.3	80.4
Progressive motility (%)	72.0	76.6
Normal acrosome (%)	44.6	53.7
Abnormal morphology (%)	7.7	3.3

There is also compelling evidence that seminal fluid has a major change on the pH of the vaginal environment changing it from 3.5-4.0 before intromission rising to a more semen friendly ~7 due to the buffering effect of the fluid after ejaculation.

Seminal fluid is also implicated in the role of inducing contractions in the female reproductive tract, facilitating semen transport toward the site of fertilisation.

Given the role of seminal fluid in improving the environment of the sow reproductive tract, a combination of strategies such as a boar service followed by an AI service can be more successful. In this way, the AI dose benefits from improved sperm survival due to the site improvements provided by the boar's seminal fluids.

Various products are now being developed using different components of this seminal plasma to try to replicate the suppression of the sow immune response and the induction of contractions in the reproductive tract. Successful development of these products may be able to reduce the challenges faced by those using AI when encountering the immune response of the sow shortly after insemination.

One other pitfall worthy of mentioning is the training of skilled staff. The process of insemination is a specialised skill. The further development of ever more sophisticated catheters delivering semen deeper into the vaginal tract means that if conducted incorrectly significant damage can be done internally to the sow.

Ultimately, this could lead to sows being left infertile due to poor AI technique. It is, therefore, vital that all staff are properly trained in the AI process that has moved significantly further forward from its 'poke and hope' beginnings. Those performing semen collection and insemination should not rush either process and be given appropriate facilities to simplify the various processes.

Conclusions

AI when adopted appropriately with trained staff in pig production business models represents a significant improvement in pig profitability. The use of fewer, higher quality boars leads to improvements in performance and a decrease in variability, both important aspects of a successful pig enterprise.

The additional attention over fertility and nutrition that can be given to these animals significantly improves conception and farrowing rates, numbers born alive and overall profitability of a pig enterprise.

Those using AI are more flexible to changing market conditions and newer developments arising from improved understanding of reproductive biology are likely to further improve the success of this technology.

Pig producers adopting the latest AI technologies will be the most profitable during a challenging climate in the industry over the next decade. ■