Hams or hearts?

Dr Grant Walling, research and genetics director

Whilst most of us are familiar with the production of slaughter pigs for meat, the outcome of a meeting recently organised by the World Health Organis-ation (WHO) in Changsha, Hunan province, China may also mean the production of pigs for organs to be used in transplants.

The meeting resulted in the Changsha Communique, a document that should lead to global regulation of xenotransplants.

Barriers overcome

Many readers will be wondering why this is new, as over a decade ago the idea of pigs producing human organs had been widely discussed, however a numbers of barriers present at the time prevented further progress. These issues have now largely been overcome.

In particular retroviruses, dormant viral DNA in the pig genome, were of specific concern for human recipients.

The pig is able to control these viruses and keep them in the dormant stage however the concern was whether, once transplanted into humans, such viruses would no longer be able to be suppressed.

This issue is now managed by genetically engineering the pig to lack porcine retroviruses or carry interference molecules to prevent them from becoming active.

Treating human illness

So what tissues are we likely to see being donated from pigs to humans?

Despite what many of us may think, it is unlikely to be a whole organ but instead a treatment to a very common global condition – diabetes.

For this they will only need insulin producing islet cells from the pancreas.

Previous studies at the University of Minnesota have injected pig islet cells into the livers of diabetic monkeys along with immunosuppressive drugs.

The results of the work were that the monkeys were able to complete the 100 day experiment without further insulin injections.

For more information see Nature Medicine, Volume 12, p301.

Experiment in humans

The group at Minnesota are now looking to start a similar experiment in humans. The path of progress however is not totally clear.

Significant work is needed in addressing the issue of the recipient rejecting the im-planted cells.

To achieve this it is necessary to try and prevent the immune system from recognising these new cells.

Various strategies have been applied to achieve this including mixing donor cells with a special group of cells (Sertoli cells) from the pigs testes and encapsulating the cells in a substance (alginate) derived from seaweed.

Weakened defences

Despite all these weird and wonderful techniques to try and deceive the immune system the recipient still needs powerful immunosuppressant drugs which in itself is risky as this weakens the body's defence systems to other possible invaders, that could cause significant damage (including cancer).

So where are these pigs likely to be sourced from? Well processors should not worry.

An important clause in the Changsha Communique is that all source animals should be kept in closed populations free from pathogens so despite the great efforts most pig producers make in the area of biosecurity it is unlikely any animals will be sourced from commercial pig farms.

However producers should remember that one day the pig might just save their life. ■

Modern measurement technology

Dr Grant Walling, research and genetics director

One of the intrinsic problems of the pig and pork industry is that much of the research and development is done on the live animal – however the desired product is pigmeat on the resultant carcase.

One of the greatest challenges is finding measurements that can be taken on the live animal that are indicative of qualities on the slaughtered carcase.

Previously, this column has highlighted some of the techniques used by JSR – from the simplistic ultrasonic measurement of backfat, the image analysis software that has allowed the ultrasonic measurement of muscle depth, through to the impressive measurements from computerised tomography (CT) allowing calculation of specific muscle volumes and weights.

Time:cost variations

These measures vary considerably in time and cost, with the ultrasonic measures relatively quick and cheap to collect but with a lower level of accuracy than the more expensive and slower CT scanning.

The challenge is to find a technique with the accuracy of CT scanning and the speed and cost of the ultrasonic techniques.

I recently had a phone call from a student at the University of Leeds in the UK who may actually have produced this intermediate technology from a technique that has been around since the 1980s. This technology is electrical impedance.

Electrical impedance works on the basis of opposition to the flow of an electrical current through the body tissues which allows the estimation of the total water content within the animal.

Given that muscle has a significantly higher water content than fat it is possible to estimate the proportion of fat free body mass and hence if we know the body weight of the pig it is possible to estimate total body fat.

So, if the technology has been available for 25 years why has it taken so long to be adopted by the industry? One factor is reliability.

New improvements

Earlier studies demonstrated that the electrical impedance method was variable however newer developments with this technology, such as direct segmental electrical impedance, offer significant improvements.

This technology uses eight points of electrodes and multiple frequencies of currents through the body.

The higher frequencies above 100 kHz are particularly useful as these allow the discrimination between intracellular and extracellular water.

The older technologies had only ever been able to identify extracellular water.

The accuracy of these more sophisticated developments of the technology have now achieved levels of 96-98% when compared to carcase dissection or hydrostatic weighing.

The next step

So what are the next steps to realising this new improved technology?

Interestingly the student that had called needed to calibrate their electrical impedance equipment and to do this required a reliable measure with which to compare their readings.

The most dependable way to achieve this was to compare the results to those from a CT scanner or from full carcase dissection.

Based on this, it seems that the existing technology is still going to be reliable for those that have always set the gold standard.

The previous dream of being able to move away from these more expensive technologies may not be as close as previously hoped. ■

Be afraid of the dark

Dr Grant Walling, research and genetics director

A scientific paper recently highlighted to me by a colleague has started a significant debate within the scientific community in the immunology field.

The paper from Journal of Animal Science (85:93-100) by Niekamp et al. found that animals weaned into buildings with 16 hours of light per day grew approximately 60g/day faster up to 10 weeks of age than those weaned into buildings with only eight hours of light per day (both figures were at 250 Lux).

Immune response

Perhaps more interesting was the difference in the immune responses in the two groups of animals and an inverse relationship between growth and immune status.

This is not the first time that we have seen these type of results. We have known for some time that the immune system uses a significant amount of the energy and resources provided through nutrition.

Some estimates have suggested this figure to be as high as 20%.

Three strategies

Based on this result animals undergoing an immune challenge have three strategies:

● **Strategy 1:**
Eat more to provide the additional 20% required by the immune system with the subsequent negative affects on efficiency.

● **Strategy 2:**
Eat the same amount but divert 20% into fuelling the immune system with the subsequent negative affects on growth rate.

● **Strategy 3:**
Do not divert resources into the immune system with the risk of higher levels of illness or mortality depending on the disease.

There has been some evidence that lines and breeds that cope best with a PMWS challenge are those with higher feed intakes and hence follow strategy one, however with the large availability and uptake of wasting vaccines, where such genetics remain on farm, the feed inefficiencies of these animals remain despite the significantly lower disease challenge.

Under such circumstances and lower disease challenges, producers would be better advised moving to lines that follow strategy three where resources are concentrated on animal growth rather than an active immune system.

Perhaps one of the most curious findings from the scientific paper is the difference seen in growth and immune function with longer photoperiod (day length).

Importance of light

Producers will be familiar with the importance of light for sow and gilt fertility however this work also suggests a role of light for the growing pig. It is this result that has baffled scientific colleagues.

Explaining the additional growth rate is relatively easy as other work has demonstrated that longer periods of light per day have resulted in an increased number of feeding bouts and hence higher feed intakes.

It is the link between photoperiod and activated immune status that is more problematic for scientists to explain.

A simple message

Regardless of the underlying reasons there is a simple message for pig producers.

Animals should not be kept in the dark and whilst genetics will continue to improve growth rates, an immediate investment that can be made on farm to improve days to slaughter is to put lights on timers to ensure animals get 16 hours of light per day. ■

Best to be robust? Bones or born alive?

Dr Grant Walling, research and genetics director

The recent pig breeders round table meeting in Canterbury, UK again proved to be very thought provoking and illustrated the benefits of smaller focused scientific meetings with a good international audience.

One of the very noticeable changes in the meeting has been the switch in emphasis of much of the novel research from production type traits to longevity and functional traits, such as bone strength and structure.

Why has this change occurred? One of the main reasons has been some of the negative consequences of increasing more traditional production traits.

Significant increases in numbers born alive in Danish herds have been accompanied by an increase in sow mortality reaching 15% in the 2008 annual report from Danish Pig Production.

Global data has demonstrated an increase in sow mortality is typically related to leg problems or higher levels of reproductive failure.

Other data outside of Denmark has demonstrated leaner animals experiencing greater leg problems and higher performing animals having a less active immune system, a subject this column has covered several times over previous issues.

Why does this conflict occur? This basically comes down to how the animal allocates the resources it receives through nutrition.

Often increased performance is due to an animal allocating the available resource into the trait under selection, such as more piglets born alive or lean tissue growth rate, rather than using the resource for its own skeletal structure.

Examples are available of this in other species, one of the most familiar being oesteochondrosis in poultry, sheep and human populations where calcium and phosphorus is diverted into egg production rather than bone structure.

It is therefore not surprising that many of the genes that are being studied are associated with calcium regulation and use inside the pig's body.

Are producers going to have to accept low levels of performance if they want more robust animals? The answer to this question is not as easy.

Some of the candidate genes under investigation are clearly associated with conventional performance traits such as Apolipoprotein E (APOE) responsible for the movement of fat around the body and Gonadotrophin releasing hormone receptor (GNRHR) responsible for the activation of the main hormones responsible for the reproductive cycle.

Selection of alternative allele variants of these genes may increase fatness or decrease reproductive function respectively.

In contrast, there are a number of genes included without any obvious negative consequences on production traits, such as Indian Hedgehog Homologue involved in cartilage development.

Identification of a role of this gene in reducing leg problems in sows may allow an improvement in sow survival without compromising performance.

So what does this change in research focus mean for a pig producer?

Given the time required to complete and implement research findings it is likely to be at least five years before any changes reach producers.

At this point the emphasis should have changed onto the productive lifetime performance of the sow rather than pigs per sow per annum.

The reason for this was also explained at the meeting.

A sow does not recover her investment cost until parity three so a high producing herd achieving 30 pigs weaned per annum may not be profitable if the majority of animals struggle to survive past their second parity.

In our disposable society the disposable sow is not here to stay. ■

Embryo transfer: spanning the species

Dr Grant Walling, research and genetics director

Whilst the pig industry is very innovative, developing many valuable new technologies, it is always worthwhile monitoring techniques and advances contributed by other species.

Recently JSR were implanting stabiliser cattle embryos, imported frozen from Canada, into their herd of beef cattle.

The process was quick, simple and easily implemented on a standard farm without the need for specialist equipment, facilities or procedures.

Most importantly, the process was completed trans-vaginally and hence did not use any surgical techniques.

Success rate from the technique is generally 50-80% from frozen embryos and even higher from fresh embryos.

Embryo transfer

Embryo transfer would be very attractive for use in pig populations, allowing the movement of large quantities of pig genetics without the need for bulky and expensive haulage.

Using embryo washing, disease challenge to the recipient herd is minimal and significantly lower than when involving live animals.

Embryo sexing would allow the selection of gilts or boars and it would be easier to modify breeds as the recipient sow would not be contributing 50% of her genetics to the resultant progeny.

Future opportunities

The technology would also provide opportunities to investigate other new advances reliant on embryo transfer such as cloning and genetic modification.

In fact, the arguments for embryo transfer make it difficult to understand why everyone isn't already using it.

Slow adoption of the technology, however, is mainly due to the difficulty in getting it to work reliably and cost effectively on a standard commercial farm.

The relatively limited success to date has mainly come from surgical implantation of embryos and requires facilities unavailable on most farms.

Overcoming hurdles

The difficulty with trans-vaginal implantation in sows is in navigating the more complex shaped cervix, in trying to replicate more natural mating conditions to create a successful pregnancy and in trying to get sufficient embryos to implant allowing the sow to hold to full gestation and farrowing.

As with many reproductive technologies, these hurdles are sizeable and difficult to overcome.

The solution, however, may come from another species – humans. JSR's pioneering work with a University spin out Biotech company working with human embryology brings together JSR pig specialists and reproductive technologies and embryologists normally dedicating their efforts to assist human couples struggling to produce offspring.

In vitro fertilisation

The two organisations have already been able to achieve in vitro fertilisation of eggs collected from the ovaries of sows and have been able to mature them to the blastocyst stage of development.

After some preparation of the sow, using modifications to the design of the standard deep insemination catheter, it has been possible to introduce the blastocysts through a traditional trans-vaginal route rather than the invasive surgical methods.

Further success could see the technology being more widely adapted and utilised across the industry. ■

Highlighting herd diversity

Dr Grant Walling, research and genetics director

With the human genome project demonstrating that despite our race, religion, ethnicity or sexual orientation all humans share in excess of 99% of their genetic code, supporters of equality thought this to be a significant step forward against racism and discrimination.Sadly for these groups, most scientific research has focused on the less than 1% that explains the differences prompting some fears of a step backwards towards the eugenics movement.

Thankfully the issues of discriminating between different animals on the same farm do not carry the same ethical concerns to those working with human populations. Despite this it is interesting to see how few producers discriminate between different genotypes on their farms. One obvious area where greater discrimination between animals would be advantageous would be for producers running grandparental (GP) animals in their herd for the production of herd replacements. The female progeny of the GP animals are destined for very different uses than other animals in the feeding herd and benefit from being managed differently. These animals must be identified and clearly marked at birth to prevent them being lost in larger groups of slaughter pigs. Their diet also needs to be adapted, especially once they have reached 60kg, moving them onto a gilt rearing ration that will slow the rate of lean tissue deposition in comparison to the slaughter generation. Additional attention should be focused on calcium and phosphorus levels and the ratio of these elements given their key role in reproductive functions. Finally, the animals need to be streamed differently when other animals go to slaughter. Gilt replacement populations have a significantly higher cost of production and hence should never be used to make up slaughter pigs.

Whilst most producers will be aware of the need to discriminate between damline and slaughter pigs, many producers do not exploit the differences between different sirelines.

Despite the fact many producers change their sireline, what is surprising is that the same producers do not make adjustments to other constituents of their production system. This lack of change can lead to producers failing to exploit the benefits of the new line, or even worse, suboptimal performance due to environmental constraints. Take the information on three sirelines grown on the same farm in Table 1 (below). Each set of progeny were fed the same diet. Given the differences in feed intake only one of the genotypes could be getting the correct formulation of feed.

If the quality of the ration was adjusted to be sire breed specific the performance of the Large White and Pietrain progeny would be likely to improve.

Other factors other than feed specifications may also need to be adjusted. Many Pietrain sired progeny are broader across the shoulders and producers may need to increase the feeder space to prevent excessive feed restriction or access to food.

By exploiting the 1% of genetic variation that creates differences within species, producers can optimise their production systems to be more genotype specific. Extending this application further leads to the area of nutrigenomics where each animal can, theoretically, be fed to its individual genetic code. Whilst this is perhaps a more distant extension of the technology, at least working on a breed or line basis should allow increased profitability from current pig production. ■

Table 1. Performance statistics of different sire line progeny between 82 and 167 days of age.

Sireline	Hampshire	Large White	Pietrain
Feed intake (g/day)	1970	1740	1780
Growth rate (g/day)	765	723	710
FCR	2.62	2.40	2.51

Variety is the spice of life?

Dr Grant Walling, research and genetics director

The genome sequence of Phytophthora Infestans, more commonly called potato blight and the pathogen responsible for the Irish potato famine of the nineteenth century, has been sequenced with interesting results (Nature 461: 393).

Blight is difficult to control because it adapts quickly to genetically resistant potato strains. It achieves this by a rapid turnover of the genome and by having a very large collection of potato destroying genes at its disposal, in fact the mould has the largest genome of any sequenced to date.

So does this insight into the host-pathogen genetic interaction tell us anything about controlling disease in pigs?

The first clear message is that pathogens are very quick to adapt to new environments. Keeping them out of the farm through strict biosecurity is the most important step. Once the pathogen has access, it is a question of when, not if, the disease breakdown will occur.

Secondly, the pathogen is very successful at evading a single resistance mechanism through the vast array of genes at its disposal. Therefore a variety of control mechanisms may be more effective than a reliance on one alone.

This may mean using more than one vaccine or chemical on the pig unit to maximise the effectiveness of the treatment and prevent the pathogen establishing resistance to one single defence strategy.

These are physical methods that all good pig producers should be implementing as standard. However, there are some considerations regarding the host genotype that may be worthwhile bearing in mind.

Pig producers' overall aim is to produce a consistent product in regard to yield, grading or quality. To achieve this, the genetics on the farm are often standardised to one breed, line or product. Hence many would use a Genepacker 90 F1 parent female and a Gc700 sire line boar to produce an efficient growing high yielding slaughter pig.

Whilst a combination of good biosecurity, veterinary monitoring and the resistance of the host may minimise the chances of a herd breaking down with any disease, the genome of the potato blight mould suggests that if the pathogen infiltrates the controls put in place then all the animals may quickly succumb, leading to a disease epidemic on the farm.

A high proportion of animals could therefore be affected at an early stage of disease breakdown. The genome study suggests that at this point the best strategy may be to change the defence mechanism of the host.

Whilst it may be difficult to make this change with existing on farm animals, it may be possible to introduce new genetic controls through changes in semen and herd replacement animals.

Changing the genotype of the sow or slaughter pig may be a more successful strategy as different genotypes have differing facets to their immune response – meaning the pathogen has to continue to adapt its mode of attack to the new genotypic response.

This strategy may explain why different countries saw varying levels of susceptibility to post weaning multisystemic wasting syndrome (PMWS) between breeds. Depending on the country, the Pietrain, Hampshire, Large White or Landrace were anecdotally all considered 'more susceptible' to the disease. It is quite possible that the causative pathogen simply adapted very successfully to the dominant genotype in the region. The successful solution to the problem was hence to change to a different genotype rather than any one specific breed or line.

The down side to this strategy is that changing genotype will change other qualities of the production system.

Many on fixed contracts to specific processors and packers may be limited in their options.

Whilst variation is not desirable from a product consistency viewpoint, at least when it comes to managing the risk posed by disease pathogens it seems that variety may be the very key to survival. ■

Successful service – timing is everything

Dr Grant Walling, research and genetics director

The timing of service is almost certainly the most critical parameter in achieving the best farrowing rates and litter sizes.

Ovulation in the sow occurs about two thirds of the way through the oestrus cycle and insemination must occur a few hours prior to this.

There is no perfect timing that suits all farms, or all sows, so each farm will need to develop its own insemination strategy.

It is therefore crucial to recognise the signs of heat and to act in accordance, preferably keeping detailed records of heat detection.

Those records will indicate if the herd has a two or three day standing heat and, in turn, can be used to plan an insemination routine on farm.

The heat is on

Accurate heat detection is essential for the correct timing of insemination. Ideally, heat should be detected twice daily and expected to start some 4-5 days after weaning.

A good practice is to detect first thing in the morning and early afternoon in the presence of a boar for optimal stimulation.

The main sign of heat is the standing reflex to back pressure.

Most sows weaned on the same day will typically be synchronised, but do allow for some females to come on heat at different times after weaning.

External factors such as seasonality (earlier oestrus in spring against later oestrus in autumn) will add to this variation.

The first insemination should be carried out 12 hours after the first standing reflex was detected (it may need to be a shorter or longer interval if the sow comes on heat later or earlier than four days post-weaning).

Semen volume and concentration

Breeding companies will use 2.5-3.0 billion spermatozoa per dose and a volume of 70-100ml.

This amount helps to achieve good fertility levels whilst coping with deficiencies due to inaccurate insemination timing, inferior technique or poor quality of the sows, whilst still ensuring semen is affordable.

New catheters, allowing semen delivery in the uterine horns rather than in the proximal cervix, have been increasingly used over the last few years.

Studies show that using such catheters produces similar farrowing rates and litter sizes compared to traditional AI, but require significantly lower volumes of semen.

Surgical techniques allow for even lower insemination doses (about one million sperm in 0.5 ml).

Studies have shown that surgical inseminations of synchronised gilts with as little as 10 million spermatozoa in 0.5ml deposited near the utero-tubal junction of each uterine horn achieved fertility levels comparable to that obtained by three billion spermatozoa with conventional AI techniques.

Insemination status

It is good practice to use coloured markers to identify the insemination status of a sow or gilt.

This provides a visual indication to other stockmen of the next action for that animal.

Optimal serving practices are easy to plan on farms with good records.

The following list gives an indication of important parameters to record for each female on the farm: tag or tattoo number, date and duration of oestrus, date and time (am/pm) of inseminations, ID of the semen inseminated, three week date, last return date(s), projected and actual farrowing dates, any other observations for example bleeding during/after inseminations, abortions etc.

In theory, if one could predict the exact time of ovulation, one insemination would be enough to obtain optimal fertility.

Since significant variation can occur within the herd, two inseminations is a strict minimum for a successful service (some producers prefer three inseminations am/pm/am or pm/am/pm).

Each dose should contain from 2.5-3.0 billion spermatozoa and follow strict standards for semen quality and have been correctly stored prior to use.

Semen storage

The key message, when it comes to maintaining semen quality, is to insist that it is treated correctly throughout the semen distribution chain.

On farm, producers should avoid fluctuations of temperature during storage; the semen should be kept in temperature controlled conditions at all times and should never be exposed to temperatures below 15°C as the damage caused to the spermatozoa is irreversible.

Once the sow or gilt has been identified as on heat, semen can be removed from its temperature controlled environment.

A question that is often raised in the pig industry concerns the re-warming of semen prior to insemination. There is no strong scientific evidence to suggest that one practice is better than another.

The most common and easiest practice is to inseminate cooled semen, which will then warm up during the insemination process.

This procedure has the advantage of avoiding the need for a thermostatically controlled water bath or incubator on farm and requires one less technical procedure (re-warming) to be carried out.

JSR has developed its Cool Chain service – a series of inter-connected quality links, to maintain the optimal environment for the boar semen from collection to conception.

For more information go to www.jsr.co.uk ■