Key differences underlying top and bottom reproductive performers: analysis of management programme data

Final Report
APL Project 2013/022

April 2016

South Australian Research and Development Institute
Kate Plush, Pieter Langendijk, Roy Kirkwood, Graeme Pope, Sara Willis and John Riley
The University of Adelaide Roseworthy Campus
Roseworthy SA 5371

Acknowledgements

This project was supported by funding from Australian Pork Limited and the Department of Agriculture and Water Resources.

The investigators also wish to formally thank all the farm participants involved in the project for full access to performance records, staff and farms.

Executive Summary

A major area of reproductive wastage in sow herds is the premature culling of sows. It is commonly cited that a sow is required to farrow at least three litters in order to generate profit, resulting in a farm average retention of sows to parity three exceeding 70% of the herd inventory. Traditionally, main reasons for sow culling involved poor reproductive performance, lameness, and other health issues. The current self-imposed phase-out of gestation stalls, and subsequent move to group housing in the Australian pork industry may exacerbate or shift these reasons for sow culling. The aims of this project were to identify the reasons for low retention of mated gilts to parity three, identify on-farm management differences between herds with low and high retention rates, identify positive and negative influences that impact on sow longevity, develop key management practices to improve gilt and sow retention, and finally to produce case studies promoting key management practices which increase the retention of mated gilts to parity three.

Twenty-two farm participants were recruited to the project from South Australia (12 farms), Queensland (8 farms) and Victoria (2 farms). The first stage of the project involved an in-depth analysis of twelve months of farm performance records that reported on sow population dynamics (parity distribution, replacement rate, reasons for culling) as well as reproductive performance and gilt characteristics. During stage two, all farm participants were visited and a questionnaire designed to provide insight into specific aspects of farm management was populated. Finally, six farms (3 from SA and 3 from QLD) were selected based on data collated during stages one and two that showed these participants exhibited high sow retention rates as well as superior reproductive performance. These six farms formed the basis for case studies, showcasing the management of gilts, heat detection and mating strategies, and farrowing house procedures, which were presented during two workshops held in South Australia and Queensland. Additionally, a seventh case study was produced that included techniques identified by the investigators from published literature not yet taken up or adopted by the farm participants that may increase sow longevity and reproductive output.

Firstly, there were very few farms that achieved a farrowing rate of greater than 85% signifying that the reproductive performance of the farm participants was sub-optimal. Retention rate averaged 60% and therefore sow longevity may not be as big an issue as first anticipated. However, replacement rate was high suggesting young sows were being culled at a high rate. The most commonly cited reasons for the culling of young sows were of reproductive nature, and this should not occur in these young animals. A curvilinear relationship was identified between gilt age at first mating and retention to parity three, with a large number of farms falling outside the optimal 210-240 day window. Additionally, a large number of empty days and often unusual wean to service patterns were observed. Thus, the premature culling of young sows was most likely explained by poor gilt management, heat detection and mating strategies. In addition to this, farrowing house performance was low given the average total numbers of piglets born, however the design of this project did not allow for the identification of reasons for this poor performance.

In order to address high replacement rates, especially by reducing the premature culling of young sows, this project has identified that the management of gilts, heat detection and mating strategies for sows, detection of returns and farrowing house management should all be optimised with the goal of increasing the reproductive performance of Australian herds.

Table of Contents

List of Tables

List of Figures

Background to Research

Sow wastage in breeding herds in Australia has been of concern to the industry for many years. Premature loss from the breeding herd can be due to lameness, reproductive failure, injuries and high levels of mortality, adversely affecting potential herd productivity.

In response to community and consumer concerns, APL initiated a voluntary move from housing of gestating sows in stalls to group housing for continual sow welfare improvement. To realise the full benefits of the welfare initiative, it is necessary for producers to review management practices and develop strategies that will result in improved sow retention.

The detection of issues that underlie a given reproductive performance level can be achieved through a computer records management system. Similarly, a number of causes underlying particular problems can also be detected using the same management system. For example, does gilt introduction and breeding management impact on sow retention?

The APL Strategy Core Objective Two concentrates on improving the industry's international competitiveness. This project aimed to identify opportunities of maintaining a favourable herd parity distribution, with a target of 70% retention of mated gilts to parity three. It aimed to address the process efficiency of the selection and rearing of replacement gilts. Improving process efficiency will result in increased production and an improvement in feed use thereby increasing financial margins per unit of production. Main deliverables of the project were to identify key factors that contribute to a high replacement rate and subsequently building the skill of staff at all levels by producing case studies highlighting best practices to achieve the core objective.

The project was designed to analyse data from computer records management systems in combination with gathering data on farm about management practices to:

- Assess reproductive performance for individual operations and factors limiting production
- Identify the underlying causes of low retention rates with particular reference to lameness, reproductive performance and levels of mortality
- Identify key management practices that impact on performance
- Determine relationships between gilt management programs and sow longevity

Objectives of the Research Project

The project was designed to achieve the following outcomes:

1. Identify the reasons for low retention of mated gilts to parity three
2. Identify on-farm management differences between herds with low and high retention rates
3. Identify positive and negative influences that impact on sow longevity
4. Develop key management practices to improve gilt and sow retention
5. Produce case studies promoting key management practices which increase the retention of mated gilts to parity three.

Introductory Technical Information

Why is sow retention important? An extensive review by Stalder et al. (2004) noted that:

- Increasing sow longevity by a single parity is equivalent to a 0.5% improvement in lean pork percent in finishing pigs.
- Sows achieve optimal fertility (litter size, rebreeding performance) during their 3rd through 6th parities. The corollary of this is that herd fertility will be constrained when there are a high proportion of young sows (eg. due to high culling rates).
- The single greatest reason for sow removal is reproductive failure, which was more prevalent in younger sows.
- The benefit to herd performance was greater when the maximum parity increased from one to five than when it increased from five to ten. Again indicating the positive impact of retaining younger sows.
- If extremes are ignored, gilt age or body composition at breeding has little impact on longevity in research trials. However, in commercial practice there may be effects. This implies that the gilts *per* se are not the problem and possible farm-specific interactions with other aspects of management must be considered.

It is evident that for maximum return on investment sows should remain in the herd for at least six parities, but there is concern that the average herd age suggests this does not occur. The Australian Pig Annual states that during the 2011-2012 period, the average farm sow turn-over rate was 56.1%, a figure that is too high. There are many reasons for culling sows, with the most common reason being reproductive failure. Components of reproductive failure include failure to achieve puberty, post-pubertal anoestrus (stale gilts), post-weaning anoestrus, regular and irregular returns to service, and failure to farrow. Attempts at reducing the sow attrition rate must consider aetiologies of reproductive failure, and possible remedial actions to address these aetiologies. Since the parities at greatest risk for culling due to reproductive problems are gilts and primiparous sows (D'Allaire and Drolet 1999) it is these animals that should receive focus.

Gilt development

The ability to meet breeding targets will have the greatest impact on the numbers and variance of pigs produced (Dial et al. 1996). However, if the drive to hit the breeding target involves the breeding of inadequately developed gilts, subsequent culling rates will likely increase. If you accept that the purpose of gilts is to generate revenue, then the primary objective of gilt management is to cost effectively produce prolific and long-lived breeding females. A gilt management strategy should therefore aim to minimize entry-to-oestrus intervals and maximize subsequent reproductive performance but should not negatively affect sow longevity. Interestingly, it has been suggested that gilts that achieve an early puberty may be relatively more fertile (Nelson et al. 1990; Holder et al. 1995). This suggests that long-term performance may be enhanced by stimulating an early oestrus but, presumably, delaying breeding until second or third estrus. However, there is evidence that at weights greater than 110 kg, breeding at puberty results in fertility and longevity equivalent to those seen following second or third oestrus breeding (Young et al. 1990). The decision on when to breed gilts (in terms of age, weight, backfat depth, oestrus number) is likely farm-specific. The delayed breeding of young gilts will result in progressive increases in ovulation rate (cf. older gilts), and first litter size (Kirkwood and Thacker 1992). Whether delayed breeding enhances performance by improving gilt body condition is highly contentious. Challinor et al. (1996) reported an additional 7.2 pigs per lifetime for gilts bred with >18 mm backfat compared to those having <16 mm. However, this was a very small study and no actual data was provided. Others similarly note an advantage of increased fatness, but reviews of these studies indicate comparisons were with the very leanest gilts (see Kirkwood and Thacker 1992; Stalder et al. 2004).

A rational conclusion concerning gilt development is that some minimum backfat depth is required for successful long-term performance. However, the actual depth required will be farm/management specific, and beyond this backfat "requirement" performance and longevity will be minimally affected by body composition at the gilt breeding. This conclusion is supported by three large retrospective studies of commercial records (Schukken et al. 1994; Culbertson and Mabry 1995; Le Cozler et al. 1998). Each indicated no adverse effect of mating young gilts but consistently demonstrate an adverse effect of mating older gilts. The adverse effects of older age at farrowing on productivity may be a consequence of these being late maturing gilts and later maturity may be indicative of relatively poor fertility. The comparisons made by Le Cozler et al. (1998) were between French herds with managements dictating early, intermediate or later ages at first farrowing. Interestingly, data indicated that while the best overall performance was exhibited by herds having an intermediate age at first farrowing, within populations (early, intermediate or late), the best performance was observed by the sub-population of gilts with the youngest age at first farrowing.

Minimizing entry-to-estrus intervals

Having cyclic gilts provides predictability to the breeding program and this will aid the achievement of breeding targets. Note that the objective is to have gilts achieve an earlier puberty, not necessarily an earlier breeding. Two methods to stimulate an earlier onset of oestrous cycles are appropriate boar exposure and the injection of exogenous gonadotrophins.

Boar exposure is the most common practice for inducing early puberty. However, it is important to understand the difference between oestrus *stimulation* and oestrus *detection*. Adequate stimulation requires direct physical contact while detection only needs fence-line contact (although direct physical contact is better). The rules for appropriate boar exposure are:

- Gilts must be old enough; the usual advice is at least 160 days of age although more recent evidence suggests that 180 days may be better.
- Boars must be old enough (ie. at least 10 months of age).
- Gilts should be in physical contact with the boar for at least 15 minutes per day.
- Gilts should be taken to the boar and not vice versa.
- Twice daily exposure will improve the response.
- Provide adequate space (eg. >1.5 m^2 per gilt) since crowding may delay puberty and will make detection more difficult.
- House gilts at least 1 meter away from potential stimulus boars to prevent gilts becoming refractory to boar stimuli (a detection problem).

It is also important to remember that when boars are used to stimulate the achievement of the pubertal oestrus but gilts are not bred at this oestrus, boar exposure should continue (eg. at least 5 minutes every two to four days) in order to promote regular oestrous cycles. In the absence of continued boar exposure, many gilts exhibit irregular inter-oestrus intervals making subsequent oestrus detection problematic.

If appropriate boar exposure does not appear to be effective on a particular farm, for example as a reflection of seasonal infertility, an intervention strategy may be considered. Gonadotrophin treatment (eg. PG600) is effective for the induction of fertile oestrus in pre-pubertal gilts. However, before recommending the use of hormones you must be confident that the gilts are truly pre-pubertal. If hormones are administered to cyclic gilts then the predictability of oestrus will be lost (Kirkwood 1999). When PG600 is administered, research and clinical experience has shown that up to 30% of treated gilts may not exhibit behavioural oestrus and about 30% of those exhibiting behavioural oestrus may fail to cycle normally. The aetiology of unpredictable responses is possibly due to the hCG component of PG600 inducing an immediate ovulation or luteinization of large follicles, and the subsequent progesterone production then suppressing behavioural oestrus. Further, PG600 treatment may result in an initial oestrus and ovulation and then, because of the long half-lives of the constituent gonadotrophins, a new follicular wave may occur with the eventual production of accessory corpora lutea. The accessory corpora lutea would determine when the gilt returns to oestrus. Since predictability beyond the induced oestrus is not good, gilts should be bred at the induced oestrus.

We have shown oestrus detection rates during a three week period were 78% and 37.5% for PG600-treated and untreated gilts, respectively. For non-bred (skipped) and non-pregnant PG600-treated gilts, a 2:1 ratio of regular to irregular returns was observed, confirming the 70% incidence of normal oestrous cycles in hormone-stimulated gilts. The farrowing rate of hormone-induced gilts was lower but there was no adverse effect on long-term sow performance. This suggests that if the use of hormones is deemed necessary, such use need not adversely affect sow longevity.

In practice, a problem often encountered is that some proportion of incoming gilts (5 to 15%) fail to show oestrus within a reasonable time period after entry (eg. 28-days). It has been suggested that these gilts are either having silent oestrus (but confirm appropriate boar exposure was used) or are pre-pubertal but relatively infertile (late maturing gilts). In either case the gilts appear to be relatively infertile and probably should be culled. When culling pressure is to be reduced, an injection of PG600 should be given and the gilts bred at the induced oestrus. However, to avoid accumulating too many non-productive gilts, any gilt failing to exhibit oestrus by seven days after treatment, or failing to conceive to the service should be culled as infertile. Well-developed gilts failing to show natural oestrus and then not responding to gonadotrophic stimulation cannot be considered to be a reasonable candidate for becoming a productive and profitable sow.

Stimulating post-weaning oestrus

Prolonged wean-to-oestrus intervals (ie. >5 days) and post-weaning anoestrus (ie. WEI >14 days) are both associated with reduced sow performance and an increased likelihood of early culling (Tantasuparuk et al. 2001). Delayed oestrus and anoestrus are more likely in primiparous sows, especially as a component of seasonal infertility (Kirkwood 2003). A primary driver of prolonged wean-to-oestrus intervals and anoestrus is inadequate lactation nutrient intake. Primiparous sows have a lower appetite than older sows, and will thus also have a disproportional reproductive response to environmental factors that reduce sow appetite. Appropriate nutritional strategies for gestating and lactating sows have been described previously (eg. Soltwedel and Pettigrew 2003).

Where a records analysis indicates a problem of prolonged wean-to-oestrus intervals, or a too high incidence of anoestrus exists, the usual approach is the hormonal stimulation of oestrus. While various products exist for this purpose, the most commonly available product is PG600. The usual application of PG600 in sows is at weaning. Several studies have examined this and all agree that PG600-treatment results in a shorter and more synchronous onset of the post weaning oestrus (Hurtgen and Leman 1979; Kirkwood et al. 1995, 1998). The day of injection (ie. at weaning or next day) has no effect on the response obtained (Kirkwood and Giebelhaus 1998). A more cost-effective use of PG600 would be to inject only problem sows. To do this, treatment is limited to sows anoestrus on day 7 after weaning. Results from delayed treatment have shown both an improvement (Bracken et al. 2003) and no improvement (Tubbs et al. 1996), relative to controls. In all likelihood, the response obtained will depend on the accuracy of non-oestrus detection in weaned sows.

While PG600 is effective for induction of oestrus in weaned sows, occasionally depressions in farrowing rate and/or litter size may manifest. The reason for this is not known but may involve the timing of breeding relative to ovulation. Depending on semen quality, maximum fertility requires insemination within 12 hours or within 24 hours of ovulation. The duration of a hormone-induced oestrus is longer, which potentially develops a population of late ovulating sows making the timing of insemination relative to ovulation more difficult (Knox et al. 2001). However, this effect can be used to advantage since recent research has indicated 10 to 20% improvements in farrowing rate when sows were bred to a hormone-controlled ovulation (De Rensis et al. 2003; Casser et al. 2004). If time of ovulation is known, then timing of insemination is simple. Indeed, under conditions of controlled ovulation sow performance to a single insemination may equal that following multiple inseminations (Casser et al. 2005).

Suppressing post-weaning oestrus

An alternative to oestrus induction is oestrus suppression. The rationale for this is that the relatively poor metabolic status of primiparous sows at weaning will constrain their fertility. Therefore, the suppression of oestrus to allow for metabolic recovery should enhance fertility. To suppress oestrus, allyl trenbolone (Matrix, Intervet) can be fed to sows from weaning. Note that the first Matrix feeding must be on the day of weaning and most sows (>85%) will likely be oestrus 5 to 7 days after the last feeding. Although the synchronized wean-to-oestrus interval will be longer, it will be more predictable. Feeding Matrix for seven days after weaning improved litter size of primiparous sows (Kirkwood et. al. 1986). Presumably, the feeding of Matrix captured the effect of ‘skip-a-heat’ breeding but with fewer non-productive sow days. Further, where early weaning is practiced, delaying the post weaning oestrus with Matrix permits sows to have a longer recovery period and will likely improve fertility. There is very little data concerning the effect of Matrix feeding on subsequent farrowing rates, although Morrow et al. (1989) did note higher farrowing rates associated with Matrix feeding. A field trial is currently ongoing to examine whether a short period of oestrus suppression enhances primiparous sow fertility and longevity.

Conclusion

It is clear that sow retention is largely influenced by the reproductive output of sows, and some would argue, young sows and gilts. There are known strategies that improve reproduction in these younger parity, ‘at risk’ individuals but whether these published techniques have been adopted in the Australian pork industry remains to be understood. This project will identify whether previously reported links between reproduction and sow longevity exist, and showcase the strategies of farms where sow longevity and reproduction are high.

Research Methodology

This project was conducted in three stages: recruitment of, and analysis of performance records from, farm participants; a participant farm visit allowing for the population of a questionnaire by investigators to better understand animal and infrastructure management; a participant workshop involving the presentation of case studies showcasing the top performing participants with regards to sow retention and reproductive performance.

Stage 1

Twelve farms using Elite Herd software were recruited from SA, eight from QLD and two from VIC giving a total of 22 commercial participants in the project. The performance summary statistics from the participating farms can be found in Table 1.

Table 1. Reproductive performance summary from the 22 participating farms recruited to the project.

	Average	Range	Australian herd mean*	Accepted targets
Reproductive performance				
Farm size	765	277 to 3218		
Conception rate (d35)[a], %	89	75 to 98		>90
Farrowing rate, %	80	65 to 91	84.6	>85
Total born	11.9	11.1 to 12.9	12.3	>13
Born alive	10.8	9.9 to 11.7	11.2	>12.0
Stillborn, %	6.9	3.9 to 9.9	7.2	<6
Mummies, %	2.1	0.7 to 3.9		<2
Pre wean mort, %	10.5	5.6 to 21	11.3	<10
Weaned/litter	9.6	8.7 to 10.5	9.9	>10.5
Lactation length, d	21.7	18.9 to 26.6	23.9	
Litters/sow/yr	2.22	2.03 to 2.44	2.33	2.4
Weaned/sow/yr	21.5	18.4 to 24.3	23.0	>25
Retention and removal				
Gilt age at first service	237	199 to 274		210-240
Replacement rate[b], %	56	41 to 71	56.1	<50
% of gilts farrowing 3 litters	60	40 to 90		>70
% of gilts farrowing 6 litters	30	13 to 41		>30
Average parity	2.7	1.8 to 3.9		3.5-4.5
% sows removed for				
Age, %	23	0 to 42		
Reproductive performance, %	15	0 to 50		
NIP/return, %	14	0 to 36		
Leg problems, %	10	5 to 23		
Unidentified reason, %	17	4 to 41		

*Taken from Australian Pig Annual 2014.

[a]Sows considered pregnant after ultrasound testing prior to d35 of gestation.

[b]Number of gilts introduced to the herd as a percentage of total sow numbers.

The performance records for each of the participants were obtained and the previous 12 months were analysed by Dr Pieter Langendijk. This analysis included a performance summary (standardized output) for both gilt/first parity and multiparous sows that reported on:

- Sow replacement rate
- Reasons for replacement
    - Reproductive failure
    - Lameness
    - Age
    - Death or other health reason
    - Low litter size born or weaned, poor milking, poor progeny
    - Other or unknown
- Parity at removal
- Parity distribution
- Reproductive performance by parity
- Wean-mate interval
- Return interval distribution
- Gilt characteristics
    - Age/weight/oestrus cycle at first mating
    - Pregnancy rate at 1st mating
    - Proportion culled without producing a litter
    - Retention rate after 1st lactation
    - Time of return to oestrus at 1st parity

It is important to emphasize that this was not a benchmarking exercise. In addition to this standardized output, each report also involved a customized output and tailored recommendations based on this analysis. The analysis was conducted at a deeper level with the aim of finding underlying causes for specific shortcomings in reproductive performance. For example, a suboptimal litter size can have many causes. It may be related to parity distribution of a herd, which in turn may be related to a high culling rate. The analysis of data records was able to detect whether this was the case and what the causes for culling where, which was then combined with the information from the enquiries in Stage 2. An example of a farm report is attached to this report in Appendix 1.

Stage 2

A standardized farm questionnaire was devised and captured general farm characteristics as well as the management of gilt rearing and mating, of the farrowing shed, of sows around mating and through gestation, and farm culling policies. Specific details of the questionnaire can be found attached to this report in Appendix 2.

All farms recruited to the project were visited over a six month period. In some cases, there was a delay between Stages 1 and 2, and this delay resulted in significant management and production disparities. Where this occurred, new Elite Herd data for the twelve months immediately preceding the farm visit was obtained and Stage 1 analysis was conducted once more with the updated data being presented in Table 1. The aim of the visit was to verify the herd record analysis and populate the questionnaire on management practices that could not be derived from the herd records analysis in Stage 1, or that required an objective and standardized assessment.

The information collected during Stages 1 and 2 of the project was combined and a simple linear regression between two traits was conducted in Microsoft Excel with a P-value of less than 0.05 deemed as significant.

Stage 3

In total, six case studies were compiled from the 22 farm participants (three from SA and three from QLD) and farms were chosen based on their ranking within the data set for:

- Low replacement rates (average 48%, with range of 32-65%)
- High retention to parity three (average 69%, with range of 65-76%)
- Good reproductive performance with regards to W/S/Y (average 23.4, with range of 22.1 to 24.1)

A final seventh case study was written by the investigators. This final case study was compiled using 'best practice management' guidelines extracted from both observations during participant farm visits as well as information from current published literature. The investigators chose to do this as it was decided that whilst all case study farms were achieving good results with regards to gilt retention and reproductive output, there was no one farm that excelled across all management factors that were examined. The seven case studies are attached to this report in Appendix 3.

Two workshops were delivered in late 2015 to coincide with Dr Pieter Langendijk's visit to Australia. The first was held in Toowoomba in November 19th, with the second on November 27th in Murray Bridge. Originally, these workshops were to be delivered solely to the farm participants involved in the project but after consultation with those presenting case studies, the invitation was opened to the greater pork communities in both SA and QLD. The workshops were advertised in both press and radio format. In QLD, 25 attendees were present at the workshop, with six out of the eight participating farms represented. In SA, 12 attendees were present at the workshop, with four out of the 12 participating farms represented. The workshops were structured in the following way:

1. Background on farms
    a. Summary statistics of data provided to project
    b. The links between reproductive output within this data set
2. Value of high sow retention
    a. What do others say with regards to retention?
        i. Includes a link to an online calculator that identifies for each farms production statistics, the age at which a sow begins to generate profit
    b. The links between high retention and production within this data set
        i. Increase in retention improving farrowing rate
3. Producer presented case studies
    a. It was thought that producers will gain more out of listening to the case study report delivered by a farm representative rather than by the project investigators
    b. The investigators developed a presentation template and worked with the farm representatives to ensure case studies followed a similar format across farms and states
    c. The three South Australian case studies were presented in the SA workshop, and the three Queensland case studies in the QLD workshop
4. Final case study- ideal scenario
    a. The final inclusion in the compiled case study document was an ideal scenario based on the project investigators knowledge of gilt and sow management
    b. The investigators delivered this case study

5. Take home messages
    a. Importance of
        i. Selection
        ii. Puberty
        iii. Mating
        iv. Removal
        v. Farrowing

The final presentation from the SA workshop is attached to this report in Appendix 4. The workshop attendees were asked to fill out a feedback survey and 75% of attendee's rated the content of the workshop as excellent, 22% very good, 3% good and fair and poor received no votes. In addition to the two workshops, a presentation containing a summary of the main outcomes of the project was delivered by Dr Kate Plush at the South Australian Pig Day, 2016.

Results and Discussion

Reproductive performance

Two farms were disregarded from the analysis due to data integrity concerns. Majority of the farms (17/20) had a farrowing rate < 85% (see Table 1 in Research Methodology). The average conception rate (tested as pregnant at day 35) was 89%, however this was probably distorted by some farms that had a high conception rate relative to their pregnancy rate (assumed pregnant at day 70), suggesting poor detection of returns and sows not in pig (NIPs). Pregnancy rate at d70 was 85% on average (68% to 96%), with 15/20 farms having <90% pregnancy rate. Of the 17 farms with suboptimal farrowing rate, 14 also had a percentage of sows bred by 7d post weaning below 90%, which suggested that a majority of farms underperform with regards to heat detection, insemination strategies, or that lactation management impacts on post weaning performance. Mating strategy appeared to be a common aspect across farms that could and should be improved, based on the individual analysis reports (see Appendix 1). This conclusion was based on the above paragraph, and on mating data from individual farms in Elite Herd which showed overly rigid mating patterns, atypical wean-to-mating patterns, atypical return patterns, and incongruence between conception rates and farrowing rates. Farrowing rate was not related to litter size (Figure 1).

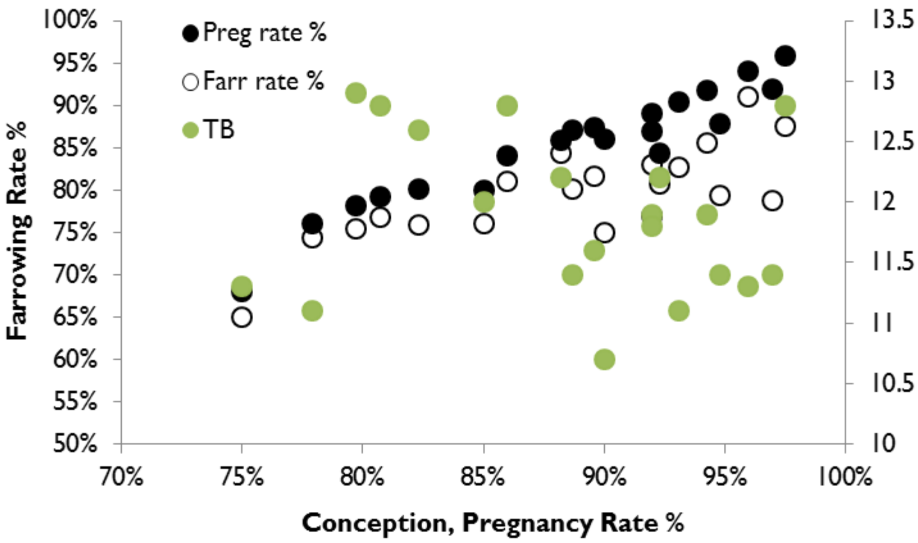

Figure 1. Relationships between conception rate and farrowing rate (open circles), pregnancy rate and farrowing rate (closed circles), and total number of piglets born and farrowing rate (green circles).

Even though one would expect so, farrowing rate was not strongly related to litters/sow/year (l/s/y; Figure 3). As a consequence, the farm farrowing rate was poorly related to the numbers weaned/sow/year (w/s/y; Figure 2). This was not surprising because a sensitivity analysis for the impact of farrowing rate on litters/sow/year, with assumed lactation length of 21d, lost days for a NIP between 21 and 42d, and wean to first service interval (WFSI) of 5d, revealed that a 10% change in farrowing rate only changes number of litters per year by 0.03 to 0.06, and hence the w/s/y by 0.3 to 0.6, which would have a minimal impact on total w/s/y. Apart from that, this lack of relationship also indicated that other management factors contribute to the variation in w/s/y between farms, possibly farrowing house management and litter size. Nevertheless, on individual farms an increase in farrowing rate should obviously lead to more w/s/y.

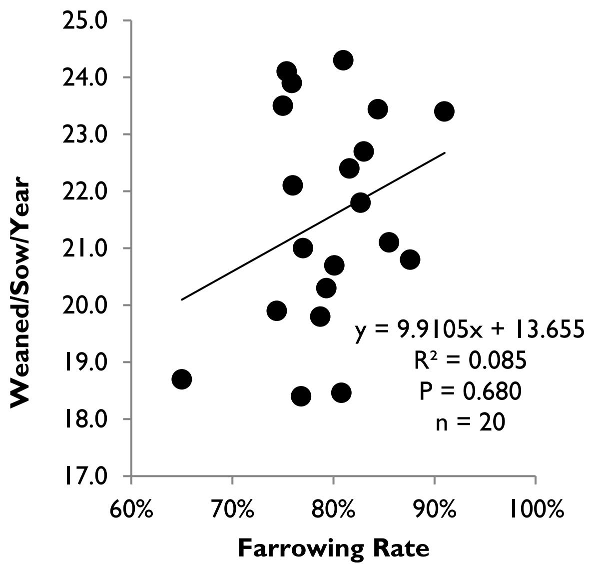

Figure 2. Relationship between number of pigs weaned/sow/year and farrowing rate %.

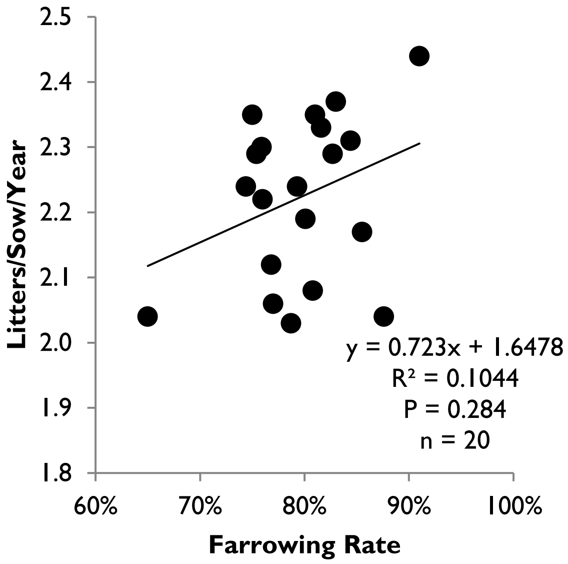

Figure 3. Relationship between the number of litters/sow/year and farrowing rate %.

Number of piglets weaned per litter exhibited the largest influence on w/s/y (Figure 4), more so than number of total born. There was, however, different ways of achieving a large number of weaned per litter across the farms examined. Some farms had a high number of total born and with average farrowing house management achieved a reasonable litter size at weaning. Some farms had an average total born but achieved reasonable litters at weaning through good farrowing house management. There was a spread of about two piglets between the farms in weaned per litter which, with an average of 2.2 litters per year, amounts to a 4.4 piglet spread in w/s/y. Technically, litter size has much more impact on w/s/y than farrowing rate, meaning that a 10% improvement in litter size impacts more on w/s/y than a 10% increase in farrowing rate. Pre-wean mortality was 10.5% on average, and ranged from 5.6 to 21% (Table 1). Considering the average litter size, the pre-wean mortality was high and reflects farrowing house accommodation and management.

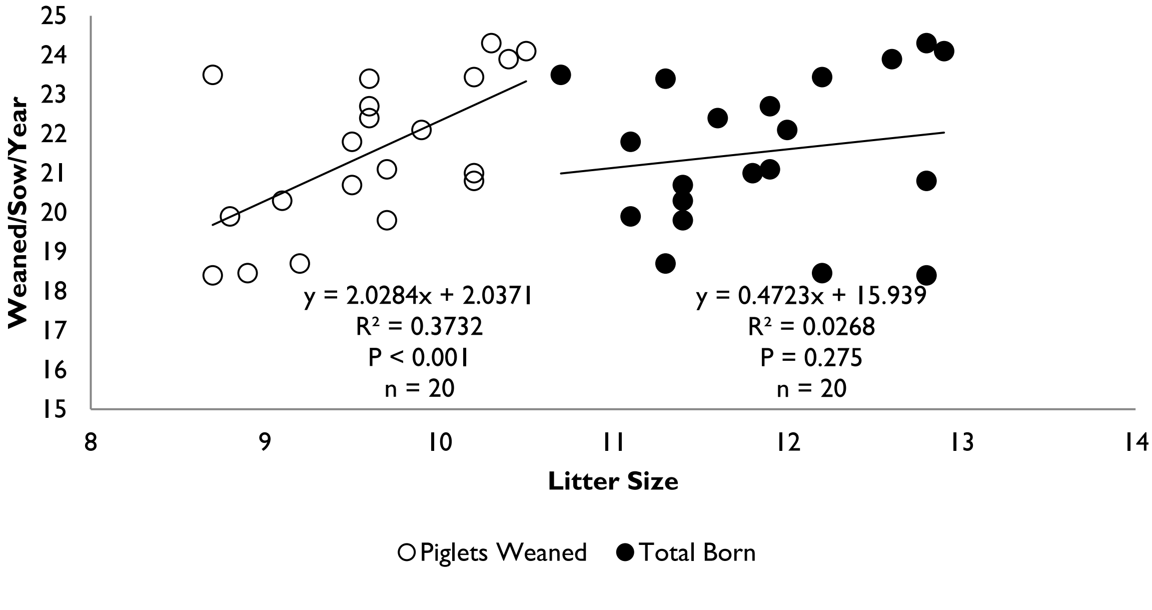

Figure 4. Relationship between total number of piglets born (closed circles) and number of piglets weaned/sow/year and number of piglets weaned (open circles) and number of piglets weaned/sow/year.

The relationship between the numbers of total/live born and number of piglets weaned per litter was not as strong as expected (Figure 5). This suggested that a number of farms were not getting the potential number of piglets weaned from the litters born, which is a farrowing house issue. Therefore, the farms with a high w/s/y are the farms that have a superior management in the area of their mating strategy as well as improved farrowing house management.

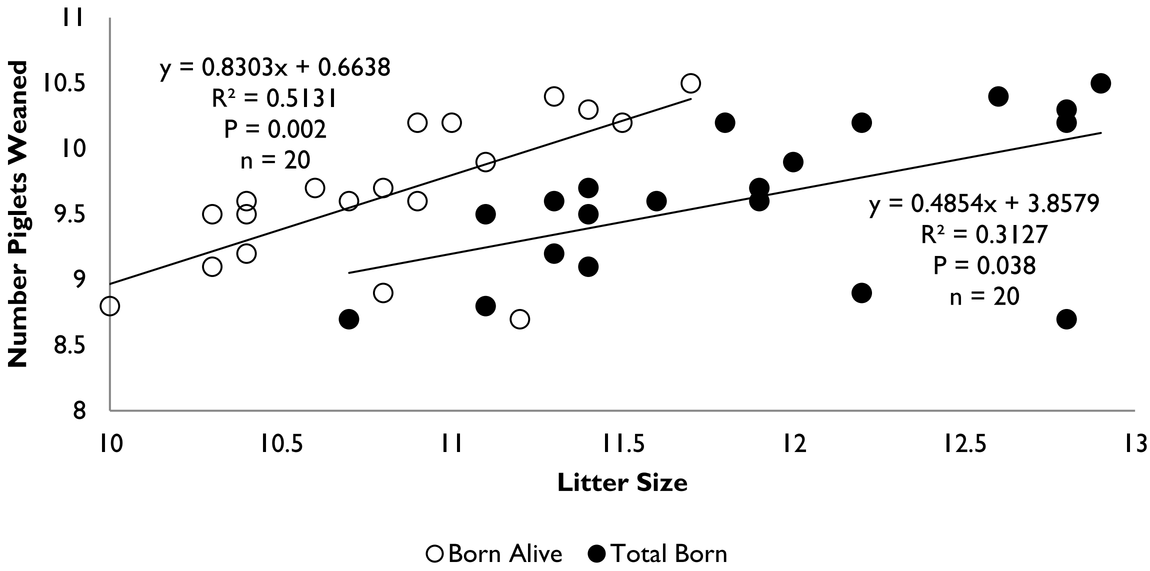

Figure 5. Relationship between total number of piglets born (closed circles) and number of piglets weaned per litter, and number of piglets born alive (open circles) and number of piglets weaned per litter.

Reproductive performance (w/s/y) was not increased for farms with a shorter lactation (Figure 6).

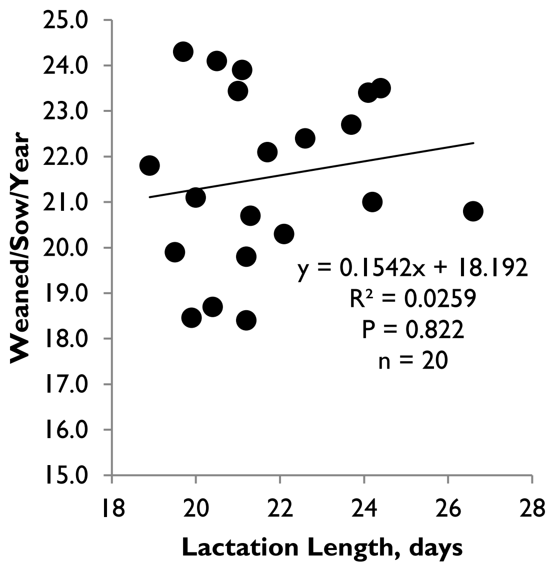

Figure 6. The relationship between number of piglets weaned/sow/year and lactation length (days).

Retention to third parity

Retention rate to third parity was 60% on average (Table 1). As an average this was reasonable, however, variation between farms (43 to 90%) was considerable. Excluding farms that were in some kind of transition affecting the retention rate (genetic turnover or herd expansion), there were three farms with clearly a low retention rate compared to other farms, with 43%, 54%, and 40% retention to P3 respectively.

- The first farm had reproductive performance (38%) and lameness (11%) as the main reasons for culling. Age at first mating on this farm was 274d, and for gilts, reproductive performance was a reason for 50% of culls; this presumably being for stales or returns.
- On the second farm NIP was the reason for 24% of the culls, and for 48% of the culled gilts. Age at first mating on this farm was 241d.
- The third farm had a high culling rate in general, and P0-P2 sows were amongst other reasons culled for "infertility".

Retention rate was related to the age at first mating in a curvilinear manner (Figure 7). Age at first mating varied from an average of 199 to 274d between farms, but should be between 210 and 240d for individual gilts (PE Hughes, personal communication). For individual gilts, the variation will be even greater than that reported for farm averages. This variation in age at first mating is considerable and will be reflected in reproductive performance of the gilts. Gilt introduction and management varied widely between farms in terms of age at mating, pregnancy rate, farrowing rate, and culling policies.

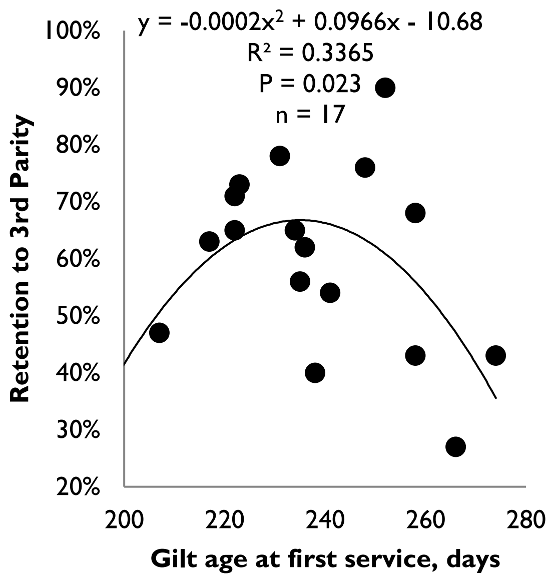

Figure 7. Relationship between age at first service (days) for gilts and retention to third parity.

Retention rate was related to farrowing rate (Figure 8) and replacement rate (Figure 9). Based on the individual reports and the presented data, it seems that these relationships are not only due to the causal relationship between culling and retention, but also that quality of management in general as reflected by farrowing rate and replacement rate influences retention to third parity. From this, retention rate is not a major problem across the farms investigated. Retention rate generally reflects overall quality of management. The inverse relationship between retention rate and replacement rate may seem obvious but not necessarily so. Theoretically, a farm could have high replacement but reasonable retention, as long as mainly old sows are replaced. Additionally, a farm could have low replacement and still have low retention as long as mainly young sows are replaced. To support this, the reports identified that farms with a low retention rate demonstrated excessive culling of young sows for reproduction reasons. Figure 9 suggests that on farms with low retention, mainly young sows are being replaced and at a high rate. That is a very important point.

There was no relationship between retention rate and reproductive performance (l/s/y and w/s/y). It would be expected that a higher removal rate would result in fewer l/s/y, but this was found not to be the case, suggesting that farms with high retention rate do not benefit from low removal rate. One explanation for this could be that farms with low removal are not necessarily doing a good job of keeping their young sows in the herd, and conversely, that farms with high removal are not removing the right sows for the right reasons. Additionally, this may reflect that removal strategies may not always have a solid basis.

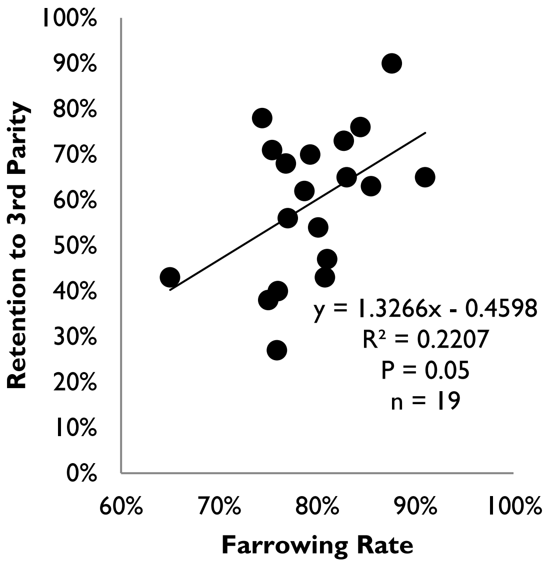

Figure 8. Relationship between farrowing rate % and sow retention to third parity %.

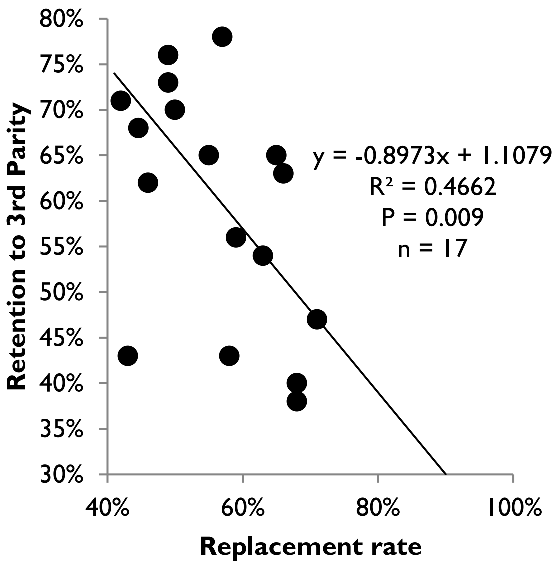

Figure 9. Relationship between farrowing rate % and sow retention to third parity %.

Replacement rate

There was considerable variation in the number of empty days per sow (65d average, range from 27 to 98d; Table 1), which was not related to replacement rate. Again, this was probably related to when and why sows were culled. A low farrowing rate contributes strongly to the number of empty days, and this shows the economic impact of farrowing rate on the costs of maintaining a non-productive sow, rather than its impact on w/s/y.

The policy with regard to picking up and mating of NIP's and returns was poor to very poor on some farms. There were very long delays in time to remate which suggested some sows cycled more than once before they were picked up and remated. Most farms did not have a structured heat check at 18-25 days to pick up regular returns. Those who did perform a structured heat check at d21 had reduced empty days, and tended have higher l/s/y and w/s/y (Table 2). If implemented, structured heat checks would pick up regular returns. Ultrasound at 25-28 days would then pick up irregular or late returns.

Table 2. The impact of type of heat check at day 21 on total number of empty days/mated female, litters per sow per year (l/s/y) and piglets weaned per sow per year (w/s/y).

	Heat check at d21			
	Boar	Visual	None	P value
Empty days	49 ± 5	43 ± 10	74 ± 7	0.01
l/s/y	2.2 ± 0.1	23. ± 0.1	2.0 ± 0.1	0.1
w/s/y	22.2 ± 0.5	24 ± 1.2	20.5 ± 0.8	0.1

Age is the biggest contributor to culling (23% of culls given as a reason, range between 0 and 42%; Table 1). For some farms this reflected rigid culling of sows after a certain parity. Reproductive performance was given as a reason in 15% of the culls, and this varied between 0 and 38%. This meant some farms reportedly did not select on reproductive performance, whereas some culled very hard on reproductive performance. As with culling for NIP or return, culling for reproductive performance should take into account the parity of the sows. Culling for NIP or return was provided as a reason for 14% of the cases. Considering the problems with mating management this should be higher. On a considerable number of farms sows got too many return inseminations (two inseminations post weaning should be the limit, for parities >5 one insemination post weaning). For 17% of culls no reason was provided, and this percentage goes up to 40% on single farms. Two farms did not enter any reasons at all in their management programme.

Even though most farms had a reasonable retention rate, replacement rate was higher than recommended on most farms. Culling has an economic impact because of the cost of replacement sows. Especially when culling is related to a low farrowing rate (NIP or returns), there is a large additional impact on empty days because of the poor (late) pick up of NIPS and return, and general lack of scrutiny towards returns. Culling for reproduction or NIPS/returns should not affect P0-P2 sows but should be a culling reason mainly for older parity sows (P3+). Interestingly, seasonal variation only affected four out of 20 farms analysed.

Farm management and Sow Retention and Replacement

Despite multiple analyses there were few management factors identified from the questionnaire stage that impacted on retention rate. This was largely due to the fact that few farms conducted similar management and so there were quite a few categories for every aspect of farm management (for example, following weaning sows could be housed: individually (in pens or stalls) or in groups (mixed, or parity or sized segregated). Given there were 22 farms included in the analysis, this meant that each category only contained a handful of farms and in some cases, only a single farm. Farm factors such as herd size, or type (breeder or farrow to finish) or system (batch or continuous) bore little impact on retention of sows to parity 3. None of the management factors of gilts (age at boar contact and mating, group size, space allowances and type of housing) showed any relationship with retention to third parity. There was some impact of sow housing at weaning, namely group size, on sow retention and replacement (Figures 10 and 11), but these could be explained by a single outlier since, when removed, any relationship disappeared. These interesting findings would suggest that the system in which animals are kept does not limit retention, but it is rather the management within the system that is of significance.

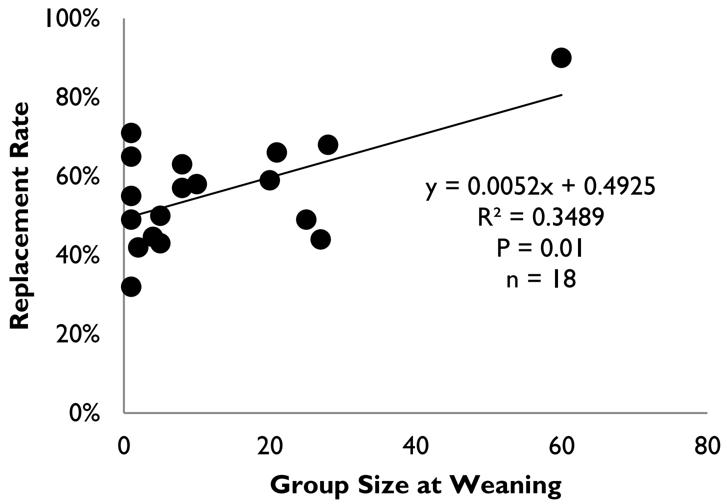

Figure 10. Relationship between the group size of sows at weaning and replacement rate.

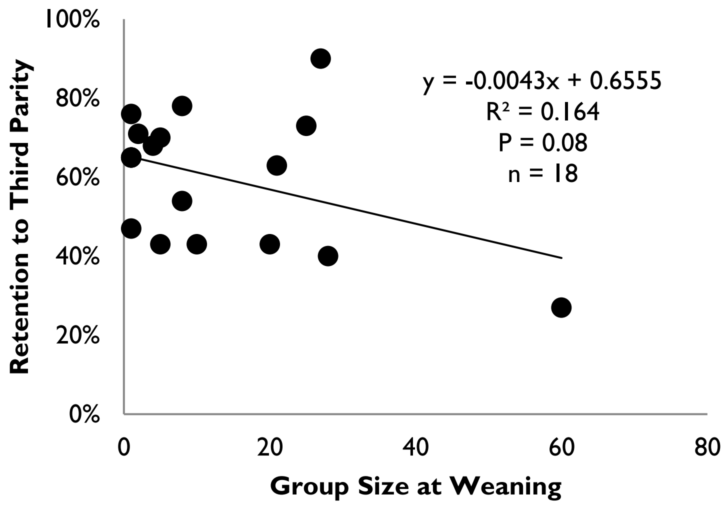

Figure 11. Relationship between the group size of sows at weaning and replacement rate.

Implications & Recommendations

The dataset analysed in this project was a representative sample of Australian farms, in both size and performance. Given that the average retention rate (% of gilts farrowing 3 litters) on farms managed by project participants was 60%, it can be concluded that sow retention was not a major issue across the farms analysed and, by extension, the Australian herd. However, replacement rate was high and this would have strong economic implications. The main reasons for culling young sows were related to reproduction and so the following conclusions were reached:

Gilt Management to Increase Retention

High percentages of return services for gilts and culling of young sows for reproductive issues were two issues observed in this project. This was most likely explained by the fact gilts were mated outside the optimal age range leading to sub-fertile gilts entering the breeding herd. The investigators therefore recommend the following:

- Puberty stimulation and heat detection should be optimised
- Culling strategies should focus on removing gilts that show delayed puberty or heats
- Culling strategies should avoid culling young sows for the wrong reasons

Heat Detection and Mating Strategies

The sub-optimal farrowing rates, low percent bred by seven days post weaning, huge number of empty days resulting from long return to service intervals all suggest that heat detection and mating strategies should be revised. The investigators conclude:

- Removing sub-fertile gilts from the population should improve some of these reproductive traits
- Farms should adopt flexible strategies that change when issues are observed
- Empty days can be reduced by implementing better return detection, though the use of oestrus checks with boars between d18 and 25 and ultrasound testing for pregnancy
- Optimise heat detection and mating

Farrowing House Design and Management

The high stillbirth and pre-wean mortality rates relative to average total born implicates poor farrowing house management within the farms analysed. The focus of this project did not include an analysis of piglet mortality at the level of detail reproduction and sow retention and removal received, and so the investigators conclude that in order to address this poor farrowing house performance, a better understanding of potential causes is required before recommendations can be made.

Specific methods that could be easily implicated to address these reproductive issues were identified by the investigators in current published literature (see Introductory Technical Information) and these techniques were disseminated to the farm participants and others during farm visits, the two workshops as well as a presentation delivered at the South Australian Pig Day, 2016 (see Appendices).

Intellectual Property

There was no licensable technical information generated by this project.

Technical Summary

Sow longevity may not be as big an issue as originally hypothesised. The high removal and replacement rate observed on the participant farms was largely due to issues with reproduction, mainly in gilts and younger parity sows. The investigators therefore recommended the following:

- Gilt management should receive focus in order to increase sow retention
- Heat detection, mating strategies and checks for oestrus returns and pregnancy should be optimised
- The average reproductive performance observed was being exacerbated by poor farrowing house performance

Literature cited

Bracken CJ, Seaman JS, Safranski TJ, Lucy MC. 2002. Effect of PG-600 given at d7 post-weaning on follicular development, estrus and ovulation in a commercial swine herd. *J Anim Sci. 2002 (Suppl. 2)*; 80: 82.

Casser G, Kirkwood RN, Bennett-Steward K, Friendship RM. Towards timed single insemination in sows. *Proc AASV*, 2005.

Casser G, Kirkwood RN, Poljak Z, Friendship R. Effect of estrogen formulation and site of deposition on fertility of artificially inseminated sows treated with human chorionic gonadotrophin to induce ovulation. *J Swine Health Prod*. 2004; 12.

Challinor CM, Dams G, Edwards B, Close WH. The effect of body composition of gilts at first mating on long-term sow productivity. *Anim Sci.* 1996; 62:660 (abstr).

Culbertson MS, Mabry JW. Effect of age at first service on first parity and subsequent lifetime sow performance. *Anim Dairy Sci (annual report)* Univ Georgia 1995.

D'Allaire S, Drolet R. Culling and mortality in breeding animals. In: Straw et al (eds), Diseases of Swine 8th edn. 1003-1016.

De Rensis F, Benedetti S, Silva P, Kirkwood RN. Fertility of sows following artificial insemination at a gonadotrophin-induced estrus coincident with weaning. *Anim Reprod Sci.* 2003; 76:245-250.

Dial GD, Duangkaew C, King V, Rademacher C. The influence of the gilt pool on weaned pig output. *Proc AD Leman Conf.* 1996; 23:39-41.

Holder RB, Lamberson WR, Bates RO, Safranski TJ. Lifetime productivity in gilts previously selected for decreased age at puberty. *Anim Sci.* 1995; 61:115-121.

Hurtgen JP, Leman AD. Use of PMSG in the prevention of seasonal post weaning anestrus in sows. *Theriogenology* 1979; 12:207-214.

Kirkwood RN. Pharmacological intervention in swine reproduction. *Swine Health Prod* 1999; 7:29-35.

Kirkwood RN. Understanding and managing seasonal infertility. *AD Leman Swine Conf.* 2003; 30:164-168.

Kirkwood RN, Aherne FX, Foxcroft GR. Effect of gonadotropin at weaning on reproductive performance of primiparous sows. *Swine Health Prod.* 1998; 6:51-55.

Kirkwood RN, Aherne FX, Monaghan PG, Misutka SC. Breeding gilts at natural or a hormone-induced estrus: Effects on performance over four parities. *Swine Health Prod.* 2000; 8:177-179.

Kirkwood RN, Giebelhaus RJ. Day of injection does not affect the response of weaned sows to PG600. *Swine Health Prod.* 1998; 6:171-173.

Kirkwood RN, Smith WC, Lapwood KR. Influence of oral administration of allyl trenbolone on subsequent litter size of primiparous sows. NZ J Exp Agric. 1986; 14:477-480.

Kirkwood RN, Soede NM, Dyck GW, Thacker PA. The effect of immunoneutralization of PMSG at a gonadotropin-induced oestrus on the duration of ovulation and reproductive performance of sows. *Anim Sci* 1995; 61:321-324.

Kirkwood RN, Thacker PA. The influence of original breeding weight and estrus of breeding on the productivity of sows over four parities. *Can Vet J* 1989; 30:251-252.

Kirkwood RN, Thacker PA. Management of replacement breeding animals. *Vet Clinics Nth America: Food Anim Prac.* 1992; 8:575-587.

Koutsotheodoros K, Hughes PE, Parr RA, et al. The effects of post weaning progestagen treatment (Regumate) of early weaned primiparous sows on subsequent reproductive performance. *Anim Reprod Sci.* 1998; 52:71-79.

Le Cozler Y, Dagorn J, Lindberg JE, et al. Effect of age at first farrowing and herd management on long-term productivity of sows. *Livest Prod Sci.* 1998; 53:135-142.

Lundeheim N, Eliasson-Selling L. Is culling due to a small first litter good business? *Proc 14th IPVS* 1996; p 568.

Morrow WEM, Leman AD, Williamson NB, et al. Improving parity-two litter size in swine. *J Anim Sci.* 1989; 67:1707-1713.

Nelson AH, Mabry JW, Benyshek LL, Marks MA. Correlated responses in reproduction, growth and composition to selection in gilts for extremes of age at puberty and backfat. *Livest Prod Sci*. 1990; 24:237-247.

Rozeboom DW, Pettigrew JE, Moser RL, et al. Influence of gilt age and body composition at first breeding on sow reproductive performance and longevity. *J Anim Sci* 1996; 74:138-150.

Schukken YH, Burman J, Huirne RBM, et al. Evaluation of optimal age at first conception in gilts from data collected in commercial swine herds. *J Anim Sci.* 1994; 72:1387-1392.

Soltwedel KT, Pettigrew JE. Nutritional management of seasonal infertility. *AD Leman Swine Conf.* 2003; 30:156-163.

Stalder KJ, Knauer M, Baas TJ, et al. Sow longevity. *Pig News and Info*. 2004; 25:53N-74N.

Tubbs RC, Cox NM, Dyer K. Effect of PG600 on farrowing rate, litter size, and wean-to-service interval in sows with delayed (>7 days) wean-to-estrus interval. *Proc 14th IPVS, Bologna* 1996; 579.

Tantasuparuk W, Lundeheim N, Dalin AM, Kunavongkrit A, Einarsson S. Weaning-to-service interval in primiparous sows and its relationship with longevity and piglet production. *Livest Prod Sci*. 2001; 69:152-162.

Young LG, King GJ, Walton JS, et al. Reproductive performance over four parities of gilts stimulated to early estrus and mated at first, second or third observed estrus. *Can J Anim Sci*. 1990; 70:483-492.

Publications Arising

List publications and where possible append copies of published articles. Note that all publications arising from the project, either during or after completion, must be approved by APL on the standard APL Request for Disclosure form before release.