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Investigating the proportion of gilt progeny which enter the breeding herd

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Executive Summary

Gilt progeny (progeny born to primiparous sows) have inferior performance compared to sow progeny due to being born lighter, having slower growth rates and higher rates of morbidity and mortality. However, there is a scarcity of data on the effects that these characteristics might have on their reproductive performance and longevity in the breeding herd. The current project aimed to quantify the performance of gilt progeny in the F1 breeding herd at a large pig farm in Corowa in New South Wales (Rivalea Australia Pty Ltd).

The performance of gilt progeny was benchmarked against that of sow progeny in terms of reaching first mating, performance to parity 4, and longevity to parity 3 using all gilts selected for entering the breeding herd from the 1st of January 2014 until the 31st of December 2015 and their performance data over that period. Performance data were taken from the Rivalea record keeping program, PigFM, and consisted of a number of traits including liveweight (birth, 21 days of age, 2 weeks post-weaning and selection), all matings and their outcomes, farrowing performance (number born alive, number of stillbirths, number of mummified foetuses at each parity reached within the 2 year period, number weaned and lactation length), number of non-productive days (NPD) and longevity to parity 3.

Gilt progeny were lighter than sow progeny at each liveweight measurement (Birth: 1.44 kg vs 1.64 kg, respectively, P<0.001; Selection 99.1 kg vs 102.7 kg, respectively, P<0.001), and had a higher P2 backfat level at the same liveweight at selection than sow progeny (15.5 mm vs 15.2 mm, respectively; P=0.023). Gilt progeny selected into the breeding herd made it to first mating before 270 days of age less often than sow progeny (80.7% vs 84.4%, respectively; P<0.001), and took over 1 day longer to be mated (223.6 vs 222.4 days of age, respectively; P=0.003). Despite this sow progeny had a lower farrowing rate from this mating (86.4% vs 82.6%, respectively; P<0.001). Once first mated, there were no significant differences in performance parameters between groups for the first 4 parities, except gilt progeny had less piglets weaned at parity 1 than sow progeny (P=0.016), and a longer WOI between weaning the second litter and the subsequent mating (P=0.050). There were no differences between the groups in terms of any longevity parameters.

The results from this study indicate that gilt progeny may be less developed reproductively at selection and therefore show higher rates of anoestrus than sow progeny before the first mating. However, after farrowing their first litter, gilt progeny perform just as well in the breeding herd as sow progeny and last just as long in the herd at least up until parity 3. At this stage it is recommended to continue to include gilt progeny in the replacement gilt selection process, and further research is needed to determine if gilt progeny need a separate selection criteria to sow progeny to reduce reproductive wastage from higher rates of anoestrus.

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1. Background to Research

Gilts represent a significant proportion of the Australian breeding herd, with recent sow replacement rates in Australia reported at 56.1%, with 22.7% of sows mated being primiparous (Australian Pork Limited 2013). First litter progeny born to these sows ('gilt progeny') are eligible for selection as replacement gilts themselves in nucleus and F1 breeding herds.

Gilt progeny are generally born (Hendrix *et al.* 1978; Miller *et al.* 2012a) and weaned (Wilson and Johnson 1980; Carney-Hinkle *et al.* 2013) lighter than progeny born to multiparous sows, are lighter at the conclusion of the finishing stage (Gatford *et al.* 2009; APL project 2014/461, in progress), and have been shown to exhibit higher rates of disease and mortality in the early stages of development before and immediately after weaning (Holyoake 2006; Miller *et al.* 2012a). The former may be a consequence of breeding gilts at such a young age, when they are still partitioning energy into their own growth rather than the growth of their foetuses (Sinclair *et al.* 1996), and when uterine capacity may be limiting (Gluckman and Hanson 2004; Redmer *et al.* 2004). The latter may be caused by differences in colostrum intake, quality and absorption, as colostrum from gilts may be lower in yield (Devillers *et al.* 2007) and contain lower levels of immunoglobulins (Ig; Inoue *et al.* 1980; Inoue 1981; Klobasa *et al.* 1986) and growth factors (Averette *et al.* 1999; Monaco *et al.* 2005) than colostrum from sows of higher parities. Gastrointestinal tract barrier function of their progeny may be underdeveloped as a consequence.
These characteristics may have negative implications for the selection of gilt progeny as replacements in the breeding herd and their reproductive performance and overall longevity. Gilt progeny are more likely to be selected into nucleus herds that utilise estimated breeding values (EBVs) in their selection process, as a result of increased genetic turnover. In F1 multiplier herds, which may not have EBVs calculated as is the case at Rivalea, having lighter body weights at selection as a result of slower growth rates early in life may result in a smaller proportion of gilt progeny not being selected for breeding. Little is known about the effect of dam parity on reproductive performance of the resulting progeny, however there is evidence to suggest that being born to a gilt can result in lower remating rates and prolonged wean to oestrus intervals (WOI; Tummaruk *et al.* 2001). Additionally, females that are compromised in terms of birth weight (Magnabosco *et al.* 2016), colostrum intake and immune status (Vallet *et al.* 2015; Vallet *et al.* 2016), and growth rate and liveweight around the time of selection and first mating (Kummer *et al.* 2006; Amaral Filha *et al.* 2009; Roongsitthichai *et al.* 2013), have been shown to exhibit a reduced reproductive capacity.

Research in this field is warranted to give an understanding of the effects of selecting gilt progeny as breeding females, to determine whether it is economically viable to involve these smaller, slower growing progeny in the selection process. If these progeny are compromised in terms of reproductive capacity and longevity in the breeding herd due to the shortcomings mentioned, producers could make decisions about their selection processes to improve herd efficiency.

2. Objectives of the Research Project

This project aims to:

1. Benchmark the reproductive performance of F1 gilts born to primiparous sows (i.e. 'gilt progeny') compared to that of gilts born to multiparous sows.
2. Investigate reproductive outcomes, including removal rates and cause, first mating reproductive outcomes, litter performance and longevity (to parity 3) in the breeding herd.

It is hypothesised that gilt progeny will take longer or fail to reach first mating more often, have higher rates of gestation failure, lower litter sizes at birth and weaning, a higher number of non-productive days (NPD), and reduced overall reproductive longevity.

3. Introductory Technical Information

As mentioned above, there has been little research to determine the effects of dam parity (primiparous vs. multiparous) on the reproductive efficiency of breeding sows. Therefore research in this area is helpful to understand the implications of selecting gilt progeny for breeding, and advise producers as to the best practice when managing genetic programs to derive the best outcome from their replacement breeding stock.

4. Research Methodology

4.1 Animals

Production records for a total of 18,136 gilts (Primegro™) selected to enter the breeding herd at Rivalea's site in Corowa, New South Wales from 1st of January 2014 to 31st of December 2015 were included in this study. This included 3,164 gilt progeny and 14,972 sow progeny. Records analysed prior to selection were therefore only included for gilts that were selected to the breeding herd, as including data from animals not selected, but eligible for selection, was beyond the scope of this study.

These animals were managed under commercial conditions at Rivalea's Corowa site. The site consists of five farms, all of which house gestating sows in group pens throughout gestation. Gilts were either mated at first or second observed oestrus, depending on the farm, time of year, and management recommendation indicated by the Allometric Growth Tape for Gilts (SRDP, University of Alberta, Canada). The current study utilises retrospective production data records for the animals selected in the time period above.

4.2 Data collection

Data was extracted from Rivalea's record keeping program (PigFM). All records for all pigs selected during the experimental period were used in the analysis, meaning pigs were at different stages of their reproductive lifecycle at the end of the recording period, and this was accounted for in the analysis.

Records analysed prior to selection included:

- Birth litter size (BLS); n = 18,136
- Birth weight (BWT; kg); n = 12,815
- 21 day weight (21WT; kg); n = 9,263
- Teat number at birth (Teat#); n = 14,156
- Post-wean weight (approximately 2 weeks post-weaning; PWWT; kg); n = 3,224
- Selection weight (at approximately 24 weeks of age; SelWT; kg); n = 13,201
- Selection backfat (P2; mm); n = 3,929.

Live weights at 21d of age (21WT) and PWWT of a subset of these gilts were obtained from a subsequent APL project (2012/2435).

Records analysed post-selection included:

- Age at first observed oestrus (AgeO1; d); n = 2,640
- Age at first mating (AgeM1; d); n = 14,077
- Days between first observed oestrus and first mating (M1-O1; d); n = 2,390
- Approximate weight at first mating (measured using growth tape, SRDP, University of Alberta, Canada; M1WT; kg); n = 10,448
- Days between selection and first mating (M1-Sel; d); n = 14,077
- Age at mating (Age; d), gestation length (GL; d), number born alive (BA), number of stillbirths (SB), number of mummified foetuses (Mumm), total born (TB), lactation length (LL), number of pigs weaned (#W) and subsequent wean to oestrus interval (WOI) at each parity achieved in the recording period (see Table 1)
- Total number of medication events (Med#); n = 18,136
- Age first medicated (AgeMed; d); n = 2,338

- Average WOI (AveWOI; d); n = 8,266
- Non-productive days for sows that reached parity 3 (NPD; d); n = 2,558
- Total matings (TotM); n = 14,077
- Total litters produced (TotL); n = 14,077
- Number of reproductive failures (returns, aborts, negative tests etc.; #RF); n = 14,077
- Age (AgeRem; d) and parity (ParRem) at death or removal from the herd; n = 3,332.

Table 1: Number of records after data clean-up at each parity, of sows that farrowed and were weaned at that parity within the experimental period (1st January 2014 to 31st of December 2015).

Parity 1	**n**	**Parity 2**	**n**	**Parity 3**	**n**	**Parity 4**	**n**
Farrowed	10,366	Farrowed	5,629	Farrowed	2,701	Farrowed	934
Weaned	8,991	Weaned	4,649	Weaned	2,148	Weaned	633

4.3 Statistical analysis

Data were analysed using SPSS software (IBM SPSS; Version 21.0, USA). Continuous variables (e.g. first mating age, number weaned etc.) were analysed using the MIXED procedure, with dam treatment (gilt progeny vs. sow progeny) as a fixed factor, and other blocking and/or nuisance factors and covariates included in the final model as appropriate (see Section 5). Any outliers (>1.5 times the interquartile range) or obvious data input errors were excluded from the analysis. Nuisance factors and covariates found to have significant effects on some of the traits measured included birth month (BMth), birth litter size (BLS), age (Age) and weight (WT) of the pig at measurement, farrowing shed (Sh[Farm]), mating month (MMth), total matings (TotM) and age at the end of the experimental period (Ageatend), and are denoted in the model formula (see Results). There was no effect of farm on any trait measured, and this was therefore omitted from the overall model.

Non-productive days (NPD) were calculated for all pigs that reached parity 3, up until their third farrowing. This variable was calculated to include any day the sow was not gestating or lactating, for example:

NPD = (Days from selection to successful parity 1 mating date) + (Days from weaning date to next successful mating date for each parity).

The following binomial traits were set up to evaluate first mating achievement/success and longevity to parity 3, based on ranges of appropriate ages at which to reach these milestones:

- Mated – first mated at or before 270 d of age, of pigs at least 270 d of age by the end of the experimental period.
- Removed before first mating – removed from herd before having the chance to be mated at least once, of pigs that were not mated at or before 270 d of age.
- Reached parity 3 – farrowed a third litter at or before 700 d of age, of pigs at least 700d of age by the end of the experimental period.
- Removed before parity 3 – removed prior to farrowing a third litter, of pigs that had not farrowed a third litter at or before 700 d of age.

Appropriate ages were based on the range of ages at first mating and birth of the third litter (approximately 97.5% of animals fell within this range). A limit was set on the age of the sows at the end of the experimental period to include only sows that had reached the age at which they would have the opportunity to achieve these milestones. The success of the first mating was analysed on the subset of sows that had achieved a first mating, regardless of what age this was reached. Of the pigs removed prior to first mating or parity 3 within the appropriate age ranges, removals were grouped as reproductive, health, structural or other reasons and analysed as binomial traits.

An additional binomial trait (Medicated) was set up to assess the frequency of sows medicated at least once before reaching parity 3 between treatment groups, and this was based on the subset of sows that had successfully reached parity 3 within the experimental period. Any medications recorded after sows had reached parity 3 were not included in this analysis. Binomial variables were analysed using chi square (χ^2).

5. Results

5.1 Liveweight

Sow progeny were significantly heavier than gilt progeny (P<0.001) at all periods where a liveweight was obtained (Table 2; Figure 1). Birth weight of gilt progeny was even lighter when correcting for the smaller litter size (total born) of their birth litter (12.39 ± 0.07 pigs for gilt litters vs. 13.71 ± 0.05 for sow litters). Age at selection (AgeSel) tended to be higher for gilt progeny (P=0.057), and therefore models for selection parameters were adjusted accordingly, where the effect of AgeSel was significant (Table 2). Sow progeny grew faster (P<0.001) than gilt progeny up until selection. At selection, both groups showed similar levels of backfat (P=0.66; Table 2), however when correcting for their lighter body weight at this time, gilt progeny were significantly fatter (P=0.023) than sow progeny.

Table 2: Estimated marginal means and statistical models used for the analysis of reproductive traits between gilt progeny (GP) and sow progeny (SP) from birth until selection.

Trait	Model	Gilt Progeny	Sow Progeny	P-value
Farrowing house				
BWT (kg)	y = Tmt + BMth + BLS	1.44 ± 0.01[a]	1.64 ± 0.01[b]	<0.001
	y = Tmt + BMth	1.48 ± 0.01[a]	1.64 ± 0.01[b]	<0.001
21WT (kg)	y = Tmt + BMth + BLS + Age21WT	5.47 ± 0.08[a]	6.58 ± 0.08[b]	<0.001
ROG (g/d)	y = Tmt + BMth + BLS	191 ± 2[a]	234 ± 2[b]	<0.001
Teat#	y = Tmt + BMth	14.05 ± 0.04	14.10 ± 0.04	0.14
Post weaning (PW)				
PWWT (kg)	y = Tmt + BMth + BLS + AgePW	11.0 ± 0.3[a]	12.7 ± 0.3[b]	<0.001
21-PW ROG (g/d)	y = Tmt + BMth + BLS + AgePW	213 ± 11[a]	242 ± 11[b]	<0.001
BWT-PW ROG (g/d)	y = Tmt + BMth + BLS + AgePW	206 ± 6[a]	240 ± 6[b]	<0.001
Selection (Sel)				
AgeSel (d)	y = Tmt + BMth	169.3 ± 0.6	169.2 ± 0.6	0.057
SelWT (kg)	y = Tmt + BMth + BLS + AgeSel	99.1 ± 0.9[a]	102.7 ± 0.9[b]	<0.001
21-Sel ROG (g/d)	y = Tmt + BMth + BLS + Age21WT	641 ± 7[a]	655 ± 7[b]	<0.001
BWT-Sel ROG (g/d)	y = Tmt + BMth + BLS	581 ± 6[a]	601 ± 6[b]	<0.001
P2 backfat (mm)	y = Tmt + BMth + AgeSel	14.9 ± 0.4	15.0 ± 0.4	0.66
	y = Tmt + BMth + SelWT	15.5 ± 0.3[a]	15.2 ± 0.2[b]	0.023

[a,b]Means within a row with different superscripts are significantly different (P<0.05).
BWT = birth weight; 21WT = 21 day weight; ROG = rate of gain; Teat# = teat number; PWWT = post-wean weight; 21-PW = 21 days to post-wean; BWT-PW = birth to post-wean; AgeSel = age at selection; SelWT = selection weight; 21-Sel = 21 days to selection; BWT-Sel = birth to selection; Tmt = dam treatment (gilt vs sow); BMth = birth month; BLS = birth litter size; Age21WT = age at 21 day weight; AgePWWT = age at post-wean weight

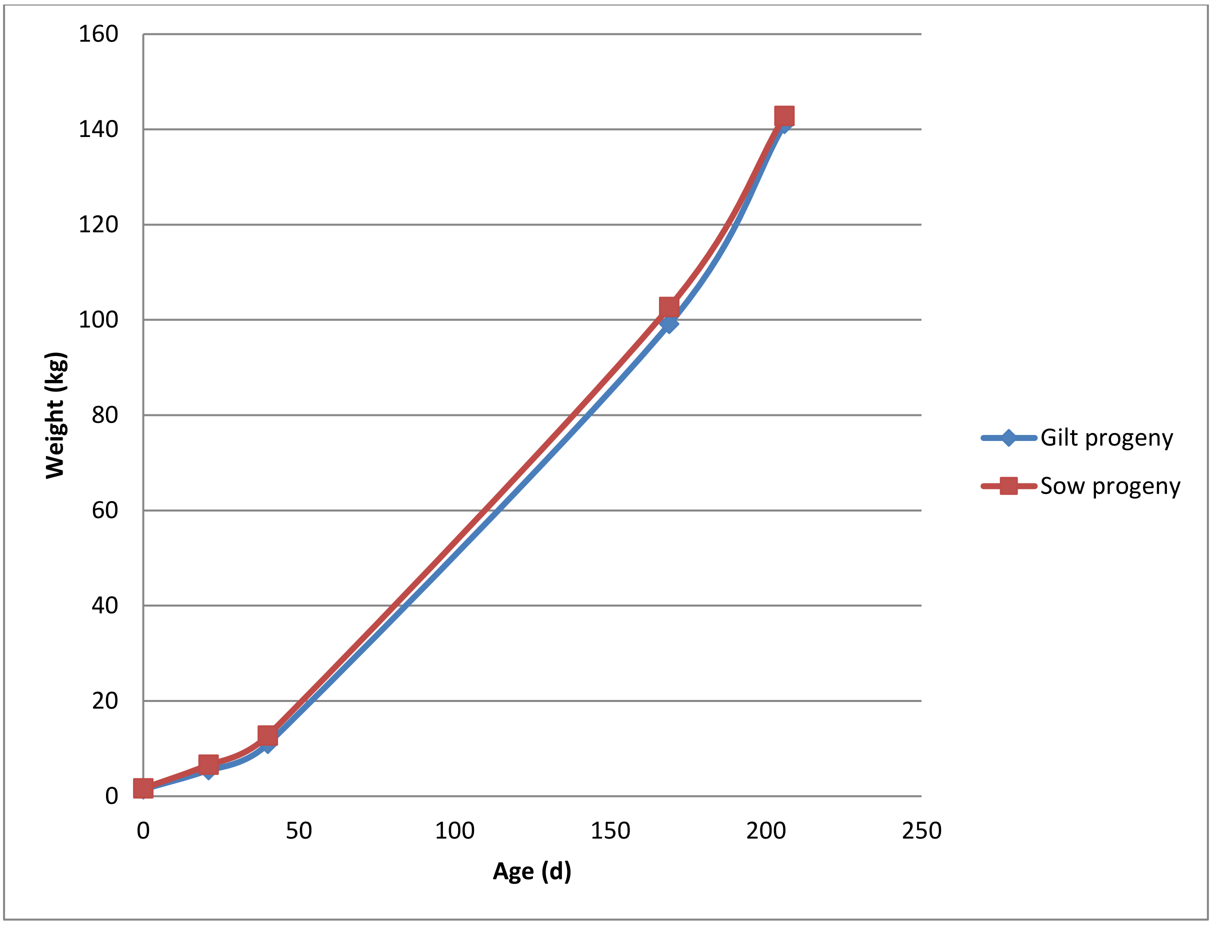

Figure 1: Liveweight differences between gilt progeny and sow progeny selected for breeding from birth to first mating.

5.2 First mating

There was no difference (P=0.79) between the two groups in terms of age at which first oestrus was observed, however age at first mating was higher in gilt progeny (P=0.003; Table 3), and gilt progeny had a higher (P=0.006) number of days between detection of first oestrus and first mating. From selection, gilt progeny took approximately one more (P=0.003) day to reach first mating than sow progeny.

Fewer (P<0.001) selected gilt progeny were mated compared to that of sow progeny (Table 4), which was primarily due to a higher (P=0.038) number of gilt progeny being removed from the herd either for reproductive, health or structural reasons before having the chance to be mated. Of those pigs removed from the herd before first mating, more (P<0.001) gilt progeny were removed for reproductive reasons (i.e. anoestrus) than sow progeny, whereas more (P=0.005) sow progeny were removed for health reasons (e.g. sudden death, unthrifty, etc.), and tended to be removed more often (P=0.092) for structural reasons (e.g. lame, prolapse, udder defects, etc.; Table 4; Figure 2).

Of those sows that had been first mated in the experimental period, more (P<0.001) sow progeny were mated unsuccessfully than gilt progeny, with more pregnancies failing signified by return to oestrus, negative pregnancy test, abortion, etc. (Table 4).

Table 3: Estimated marginal means and statistical models used for the analysis of reproductive traits between gilt progeny (GP) and sow progeny (SP) from selection to first mating.

Trait	**Model**	**GP**	**SP**	**P-value**
First mating				
AgeO1 (d)	y = Tmt + BMth + AgeSel	200.0 ± 0.7	199.9 ± 0.6	0.79
AgeM1 (d)	y = Tmt + BMth + BLS + AgeSel	223.6 ± 1.2[a]	222.4 ± 1.1[b]	0.003
M1-O1 (d)	y = Tmt + BMth + AgeO1	27.2 ± 0.9[a]	25.5 ± 0.7[b]	0.006
M1WT (kg; gilt tape)	y = Tmt + BMth + BLS + AgeM1	141.0 ± 0.5[a]	142.7 ± 0.4[b]	<0.001
Sel-M1 (days)	y = Tmt + BMth + BLS + AgeSel	54.5 ± 1.2[a]	53.2 ± 1.1[b]	0.003

[a,b]Means within a row with different superscripts are significantly different (P<0.05).
AgeO1 = age at first oestrus; AgeM1 = age at first mating; M1-O1 = days from first oestrus to first mating; M1WT = weight at first mating; Sel-M1 = days from selection to first mating; Tmt = dam treatment (gilt vs sow); BMth = birth month; AgeSel = age at selection; BLS = birth litter size.

Table 4: Means (expressed as a percentage) for gilt progeny (GP) versus sow progeny (SP) from the chi-square (χ^2) test analysis for binomial traits.

Trait	GP	SP	χ^2	P-value
Mated	80.7%	84.4%	21.10	<0.001
Not mated	19.3%	15.6%	21.10	<0.001
Remain in herd	11.6%	15.3%	4.29	0.038
Removed	88.4%	84.7%	4.29	0.038
Reproductive reasons	68.2%	57.3%	17.13	<0.001
Health reasons	12.4%	18.1%	7.87	0.005
Structure reasons	15.9%	19.4%	2.84	0.092
Other reasons	3.5%	5.2%	2.26	0.13
First mating farrowing rate	86.4%	82.6%	15.74	<0.001
Reached parity 3	47.5%	49.7%	0.89	0.35
Did not reach parity 3	52.5%	50.3%	0.89	0.35
Remain in herd	6.1%	5.8%	0.03	0.86
Removed	93.9%	94.2%	0.03	0.86
Reproductive reasons	59.1%	56.5%	0.66	0.42
Health reasons	16.5%	19.5%	1.43	0.23
Structure reasons	21.9%	21.3%	0.05	0.82
Other reasons	2.5%	2.7%	0.03	0.87
Medicated	26.3%	27.9%	0.38	0.54

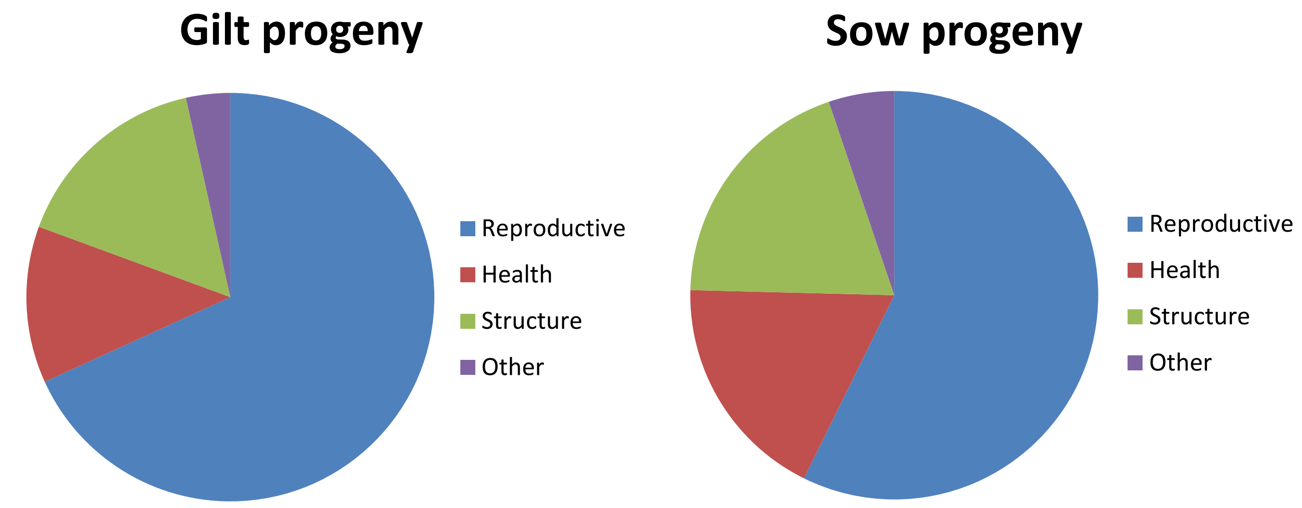

Figure 2: Removal reasons prior to first mating (pigs ≥270 d of age by the end of the experimental period) for gilt and sow progeny.

5.3 Lifetime reproductive performance

There was no difference in total born between the two groups at parity 1 (P=0.51; Table 5). Gilt progeny tended to have less (P=0.091) born alive at their first parity than sow progeny when adjusted for total born, and less (P=0.016) piglets weaned than sow progeny. There were no differences (P>0.10) between the groups in terms of number of stillbirths or number of mummies (Table 5). Gilt progeny tended to have a longer (P=0.088) lactation length at parity 1. There were little differences between the treatment groups for any trait in the subsequent parities (2 to 4; data not shown). Between weaning the second litter and the subsequent mating, gilt progeny had a longer (P=0.050) WOI than sow progeny. At parity 3, gilt progeny tended to have a lower (P=0.087) total born (TB) than sow progeny and a longer (P=0.079) lactation length. These differences were not reflected at other parities (data not shown). There were no differences (P>0.10) between number of pigs medicated (Table 4), and age at which pigs from both groups were first medicated was similar (P>0.10; data not shown). However, sow progeny were medicated (medications per sow) more often (P=0.016) in their reproductive lifetime than gilt progeny (Table 5).

5.4 Longevity

There were no differences (P>0.10) between gilt and sow progeny in terms of longevity in the herd to parity 3 (Table 4). Both groups had similar average WOI, NPD, total matings, litters and reproductive failures, and age and parity at removal (Table 5). Reasons for removals prior to parity 3 were similar for both gilt and sow progeny (Figure 3).

Table 5: Estimated marginal means and statistical models used for the analysis of reproductive traits between gilt progeny (GP) and sow progeny (SP) for parity 1 production traits and longevity traits.

Trait	Model	GP	SP	P-value
Parity 1				
AgeP1	y = Tmt + BMth	225.2 ± 1.8	225.0 ± 1.7	0.72
TB	y = Tmt + AgeP1Far + P1Sh(Farm)	11.57 ± 0.09	11.62 ± 0.07	0.51
BA	y = Tmt + AgeP1Far + P1Sh(Farm) + P1TB	10.83 ± 0.03	10.78 ± 0.02	0.091
SB	y = Tmt + AgeP1Far + P1Sh(Farm) + P1TB	0.62 ± 0.03	0.66 ± 0.02	0.11
Mumm	y = Tmt + P1Sh(Farm) + P1TB	0.12 ± 0.01	0.13 ± 0.01	0.53
LL	y = Tmt + BMth + AgeP1Far + P1MMth + P1Sh(Farm)	27.5 ± 0.3	27.3 ± 0.3	0.088
#W	y = Tmt + BMth + AgeP1Far + P1Sh(Farm)	9.3 ± 0.1[a]	9.2 ± 0.1[b]	0.016
WOI	y = Tmt + AgeP1Far + P1MMth	6.2 ± 0.3	6.2 ± 0.2	0.99
Longevity*				
AgeP3	y = Tmt + BMth	643.5 ± 3.9	641.7 ± 3.7	0.19
AveWOI	y = Tmt + BMth	5.2 ± 0.1	5.1 ± 0.1	0.11
NPD**	y = Tmt + BMth + AgeSel	65.8 ± 2.3	65.2 ± 2.1	0.59
TotM	y = Tmt + BMth + Ageatend	2.30 ± 0.05	2.31 ± 0.04	0.17
TotL	y = Tmt + BMth + Ageatend	1.40 ± 0.04	1.39 ± 0.03	0.84
#RF	y = Tmt + BMth + Ageatend + TotM	0.26 ± 0.01	0.28 ± 0.01	0.20
#Meds	y = Tmt + BMth + BLS + Ageatend	0.24 ± 0.02[a]	0.28 ± 0.01[b]	0.016
AgeRem	y = Tmt + BMth	399.1 ± 20.8	396.1 ± 20.2	0.61
ParRem	y = Tmt + BMth	0.79 ± 0.12	0.79 ± 0.12	0.96

[a,b]Means within a row with different superscripts are significantly different (P<0.05).

*Longevity traits only of pigs that were mated at least once within the experimental period.

**Non-productive days (NPD) until parity 3, of sows that reached at least parity 3 within the experimental period.

AgeP1 = age at parity 1 mating; TB = total born; BA = number born alive; SB = number of stillbirths; Mum = number of mummified foetuses; LL = lactation length; #W = number of piglets weaned; WOI = wean to oestrus interval; AgeP3 = age at parity 3 mating; AveWOI = average wean to oestrus interval; TotM = total matings; TotL = total litters; #RF = number of reproductive failures (anoestrus, abortion etc.); #Meds = number of medications per sow; AgeRem = age at removal from the herd; ParRem = parity at removal from the herd; Tmt = dam treatment (gilt vs sow); BMth = birth month; AgeP1Far = age at parity 1 farrowing; P1Sh(Farm) = shed location of parity 1 farrowing, nested within farm; P1TB = total born at parity 1; P1MMth = month of parity 1 mating; AgeSel = age at selection; Ageatend = age at the end of the experimental period; BLS = birth litter size.

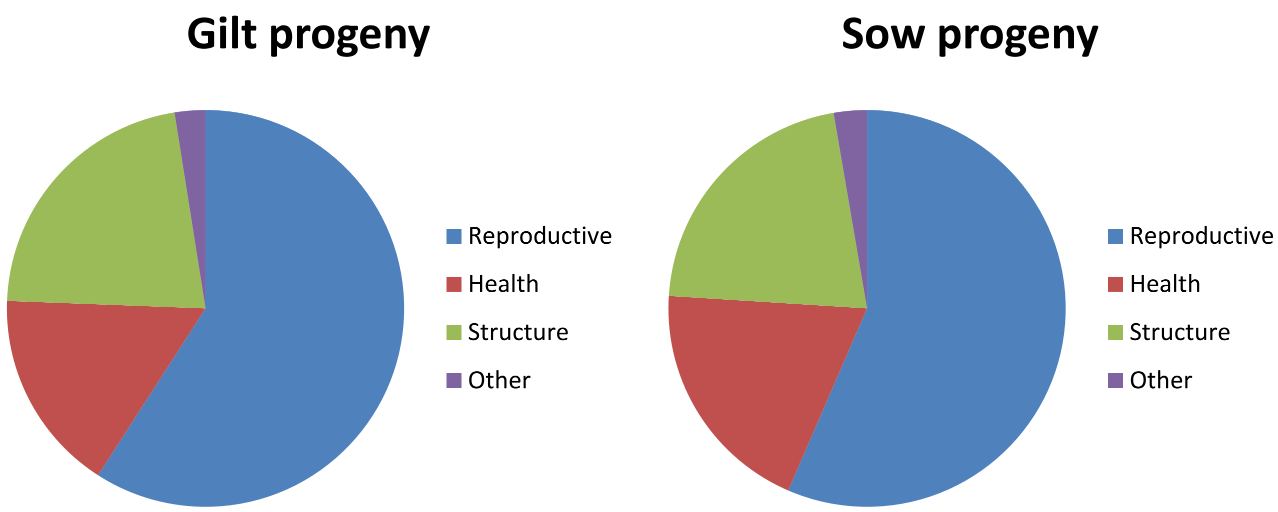

Figure 3: Removal reasons prior to parity 3 (pigs ≥700 d of age by the end of the experimental period) for gilt and sow progeny.

6. Discussion

The overall objective of this study was to evaluate the reproductive performance and longevity in the breeding herd of progeny born to primiparous sows ('gilt progeny') selected as replacement females. It was found that, in accordance with previous studies (Gatford *et al.* 2009; Miller *et al.* 2012b; Carney-Hinkle *et al.* 2013), gilt progeny that were selected were born lighter, grew slower and were therefore lighter at later ages, such as at 21 days of age, 2 weeks after weaning, at selection and at first mating. As this study included only gilts that made it through selection, these figures may be even more disparate if the data for pigs that weren't selected or eligible for selection due to lighter body weights, morbidity or mortality were able to be included in the analysis.

Age at selection was higher in gilt progeny, however this may be an artefact of the batching system, where batches enter the selection process according to the shed they were weaned from. Sheds were loaded according to sow due date (approximately 116 days from first mating date), and as these dates tend to be less accurate for gilts with no prior gestation records, gilt progeny from these sheds may have been older as a consequence. Gilt progeny had 0.3 mm more backfat than sow progeny at selection after adjusting for their lower body weight. This may be due to differences in birth weight, as some studies (Gondret *et al.* 2006; Rehfeldt and Kuhn 2006) report that low birth weight piglets (LBW; less than 1.20 kg) have a higher fat to lean ratio at slaughter (or in this case, selection). This may be due to increased adipocyte numbers in the carcass due to heightened activity of fatty acid synthase and malic enzyme in backfat tissue (Gondret *et al.* 2006). Low birth weight pigs also have less secondary muscle fibres at birth, which may translate into less lean muscle at older ages (Aberle 1984).

Collectively, these results suggest that any differences in growth over the lifetime of a selected gilt born to a gilt are direct results of being born and weaned lighter than sow progeny. Strategies to increase birth weights and (or) growth rates in the pre-weaning period may improve the reproductive performance of these gilts. However, improving birth weights of gilt progeny may be difficult, as pressure to breed gilts earlier in life (Schukken *et al.* 1994) means their parity 1 dams are still partitioning energy into their own growth and energy metabolism (Sinclair *et al.* 1996), and may not have the uterine and (or) mammary capacity to support such large litters. Therefore, improving growth during the pre-weaning period may be an opportunity to improve the subsequent growth of gilt progeny to improve their chances of being selected for the breeding herd, and being more reproductively successful.

The results from this study suggest that gilt progeny reach sexual maturity later than their sow progeny counterparts, and therefore have higher rates of anoestrus and take approximately a day longer to reach first mating. This is in accordance with other studies that found low birth weight (Magnabosco *et al.* 2015; Vallet *et al.* 2016), restricted access to colostrum (Chen *et al.* 2011; Vallet *et al.* 2015), and low growth rates (Amaral Filha *et al.* 2009; Tummaruk *et al.* 2009) in gilts can result in prolonged days from entry to puberty and first mating and (or) slower rates of sexual maturation. Lighter gilts at selection have been shown to have lower levels of oestradiol, IGF-I, medium to heavy follicles and lighter reproductive tracts than heavier gilts (Van Wettere 2008), which may suggest that lighter gilt progeny may be less sexually developed than sow progeny at selection.

Age at first observed oestrus between the two progeny groups in the present study was not found to be significantly different, which suggests that age at first mating was prolonged in gilt progeny due to these gilts not being at a desired weight (as estimated by allometric growth tape) by their first oestrus. In this commercial system, age at first observed oestrus is not always recorded, which may also be a confounding influence. With this in mind, the finding in the present study that sow progeny had higher rates of reproductive loss from the first mating than gilt progeny was unexpected. Tummaruk *et al.* (2001) found that gilts with a younger age at first mating were more likely to have to be mated more than once before farrowing, which is consistent with the current results as sow progeny were approximately one day younger at first mating. It may be possible that gilt progeny that are underdeveloped reproductively are removed during the selection processes as they are under the weight threshold at that period (current threshold in this system 70 kg at 23/24 weeks of age). Larger sow progeny may be selected into the breeding herd, but underlying reproductive issues may not be identified until the time of first mating where these higher rates of reproductive loss occur.

The higher number of sow progeny being removed before their first mating for structural reasons may be due to their higher growth rates, as heavier, faster growing gilts tend to have an increased incidence of lameness as the weight load on the hooves and legs increases (Jørgensen and Sørensen 1998; Prunier *et al.* 2010). The fact that significantly more sow progeny were removed for health reasons and had significantly more medications per sow than gilt progeny is surprising, as other authors have found that gilt progeny have higher morbidity and mortality rates than sow progeny (Holyoake 2006; Miller *et al.* 2012b; Carney-Hinkle *et al.* 2013). This again may reflect smaller, unthrifty gilt progeny not being selected for breeding in this particular herd.

Contrary to the current hypothesis, after gilt progeny were mated at least once, they were generally equivalent to sow progeny in terms of reproductive performance and longevity characteristics. Gilt progeny tended to farrow less live piglets at their first parity than sow progeny, which is in agreement with Vallet *et al.* (2016) who found that pigs born lighter had a shorter uterine length at puberty, which may represent lighter-born gilt progeny. However this difference was not seen at later parities which may indicate that these pigs caught up in terms of reproductive capacity by these later ages.

The WOI after parity 1 was not different between gilt and sow progeny in the current study. This was in contrast to Tummaruk *et al.* (2001) who found that gilt progeny had a significantly higher WOI after parity 1 than progeny born to parity 4 and 5 sows. There were a few differences between the groups in terms of performance indicators at later parities (i.e. WOI after parity 2), however these were not replicated at other parities and therefore seem to be anomalies. It would be interesting to see if these results could be replicated in other herds, as there does not appear to be any apparent reasons as to why these random differences occur.

It was hypothesised that gilt progeny would not persist in the herd to the same degree as sow progeny, as low birth weight (Magnabosco *et al.* 2016), slower growth rates (Tummaruk *et al.* 2001; Roongsitthichai *et al.* 2013), and higher age at first mating (Schukken *et al.* 1994; Koketsu *et al.* 1999) have all been associated with impaired sow longevity. However this was not the case in this dataset, with both groups exhibiting the same amount of sows reaching parity 3. Future studies should focus on investigating the longevity of both gilt and sow progeny beyond parity 3, to see if these differences become more apparent later in life.

Progeny born to gilts (Tummaruk *et al.* 2009) and low-growth-rate gilts (Tummaruk *et al.* 2001) have been known to have longer WOI than their heavier/faster growing counterparts. This, combined with the prolonged selection to first mating interval, meant it was not expected that gilt and sow progeny had the same number of NPDs. The short timeframe of this study (2 years) may have impacted this information and prevented differences from being seen, as sows only reached a maximum of parity 4 within this period. Further analyses should observe longevity over a longer period to clarify if there would be any differences seen over later parities.

It is possible that due to lower growth rates in gilt progeny, these pigs are under the weight limit at selection and are therefore culled before entry into the breeding herd. This would result in better quality gilt progeny being selected for the breeding herd, which may be a reason for the similarities in reproductive performance and longevity between gilt and sow progeny. Unfortunately, investigating the proportion of gilt progeny selected out of the gilt pool available for selection was beyond the scope of this study, as records are not kept for gilts that are culled at selection. Further research into this area is recommended to confirm these assumptions that gilt progeny are selected less frequently due to weight (amongst other) restrictions at selection.

As gilts born to primiparous sows are the result of increased genetic turnover, these progeny often have higher estimated breeding values (EBVs) and may be preferential for selection into nucleus herds as a result (J. Harper, *pers. comm.*). Gilt progeny selected into nucleus herds may therefore have more reproductive problems than sow progeny, which should be a target of research in the future. Longevity per se is not however the priority in these herds as sows are culled/moved out of the nucleus earlier in their reproductive lifetime for genetic turnover gains. It would be of interest however to quantify the effects of dam parity on effectiveness of their progeny as breeding sires to further evaluate the usefulness of gilt progeny as breeding animals, with one study suggesting that the amount of colostrum and milk consumed during the pre-weaning period can affect the reproductive performance of boars (Rahman *et al.* 2014).

In conclusion, a high proportion of gilt progeny are most likely removed from the breeding herd by vigorous selection criteria and those that move through to entry are more likely to exhibit anoestrus before optimal time for first mating, and are hence more likely to be culled. However, once mated, gilt progeny perform just as well in the breeding herd as sow progeny. To the best of this author's knowledge, this is the first study to quantify the differences between gilt progeny and sow progeny selected for breeding in a commercial herd. It is recommended that further research should focus on improving growth and health of gilt progeny, as well as investigating the proportion of gilt progeny that make it to selection, reason for fall out before selection, their lactational performance and longevity beyond parity 3, and if there is overall economic viability of including progeny born to first parity sows in the selection process for commercial herds.

7. Implications & Recommendations

Understanding the shortcomings of gilt progeny in terms of their reproductive performance allows producers to make decisions about whether to use pigs born from gilts as replacement breeding sows. Further research is warranted in this area to determine whether gilt progeny make it through to selection, if they meet the associated selection criteria and therefore how often they are selected for use as breeding sows compared to sow progeny.

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9. Publications Arising

- Introductory chapter – Jessica Craig, Ph.D. thesis (Murdoch University) – due for completion 1st August, 2018.
- To be submitted to the Journal of Swine Health and Production as an original research article – Craig, JR, Collins, CL, Athorn, RZ, Dunshea, FR, Pluske, JR, Investigating the reproductive performance of gilt progeny entering the breeding herd (working title). *Journal of Swine Health and Production*.