What are the benefits of sow body size at farrowing?

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Introduction

Many gilt development programs recommend that gilts are first bred at 130 to 150 kg body weight and a minimum of 210 days of age. However, recent protocols from Europe, in particular Denmark, now recommend that gilts are bred at an older age and heavier weight. Henrik Jensen, a Danish producer with very high herd productivity, recommends as part of his management protocol that gilts are bred at 160+ kg and nine months of age (270+days) to achieve and/or surpass 30 weaned pigs per sow per year (Stoneman, 2005). Similar protocols are starting to be introduced into North America. There are benefits to breeding gilts at an older age, or at least ensuring sows are heavier at first farrowing. However, what does this management strategy mean to commercial herds in North America?

Many factors, including genetics, facilities, management, nutrition, lactation length, induction of puberty, and estrus first bred contribute to a production system attaining high production targets. Without all or most of these factors in place such lofty targets will be very difficult to achieve. The purpose of this short review is to assess the appropriate age and weight of a gilt at first conception and farrowing. As no single protocol works for every management system and dam line, each production system should assess the protocol that will work best for their situation.

Benefits and costs of an older gilt at first conception

Because so many factors influence the reproductive performance of sows, it is difficult to make generalizations about the long-term influence of age at first conception in any single production system. However, there is little uncertainty about the effect of delaying breeding gilts on sow longevity in most systems. *Gilts that are older at first conception*:

- produce and wean fewer pigs in their lifetime (Schukken et al., 1994; Culbertson and Mabry, 1995; Le Cozler et al., 1998; Koketsu et al., 1999; Babot et al., 2003)
- were removed from the herd sooner (Schukken et al., 1994; Culbertson and Mabry, 1995; Le Cozler et al., 1998; Koketsu et al., 1999)
- their progeny were associated with more non-productive days (Schukken et al., 1994).
- their progeny had higher birth weights (Rozeboom et al., 1996)

In our retrospective analysis of over 28,000 sows in commercial herds between 2000 and 2004, sows that first conceived at 190 to 229 days of age produced about 3 more pigs born, born alive and weaned in their lifetime than sows that first conceived at 260+ days of age (Table 1). The better lifetime productivity of sows bred at a younger age can be explained in this study by such sows remaining in the herd as productive animals for 0.35 more parities, or ~ 40 more days.

The effect of delaying breeding gilts until an older age on subsequent litter size is more uncertain. In several retrospective commercial herd studies, gilts that first conceived at an older age were associated with a larger litter size in the first, and possibly the second, litter (Schukken et al., 1994; Le Cozler et al., 1998; Tummaruk et al., 2000; Holm et al., 2005). Tummaruk et al. (2000) even calculated that a 10-day increase in age at first conception resulted in a 0.1 pig increase in litter size in first-litter sows. However, other studies found little, or no, effect of age at first conception on the size of the first litter (Rozeboom et al., 1996; Babot et al., 2003).

Table 1. Effect of age first conceived on sow lifetime productivity*

	Age first conceived (days)						
	190 - 209	210 - 229	230 - 259	260 - 279	> 280	SEM	Sig
n	4,476	9,906	8,627	2,374	2,303		
Lifetime litter size:							
Total pigs born	38.3 [b]	38.5 [b]	35.9 [a]	34.7 [a]	35.4 [a]	0.6	0.001
Pigs born alive	33.6 [b]	33.8 [b]	31.6 [a]	30.5 [a]	30.9 [a]	0.5	0.001
Weaned	31.3 [c]	31.4 [c]	29.4 [b]	28.2 [a]	28.3 [a]	0.4	0.001
Parity removed	3.57 [c]	3.58 [c]	3.34 [b]	3.21 [a]	3.22 [a]	0.05	0.001
No. NPD per pig							
Pigs born alive	3.4 [a]	3.9 [b]	4.2 [c]	4.2 [c]	4.4 [c]	0.10	0.001
Weaned	3.1 [a]	3.6 [b]	3.8 [c]	3.9 [c]	4.1 [d]	0.09	0.001

* 1 farm in Canada and 3 farms in the US (2000 – 2004)

Source: Clowes (unpublished data)

We found increases in first, second, and older parity sow litter size as age at first conception increased in our recent study. Gilts that were 280+ days at first conception produced 0.50 more pigs born alive and weaned 0.25 more pigs in their first litter than gilts that first conceived at 190 to 209 days of age (Table 2). This effect was less evident (a difference of 0.37 pigs born alive) in the second litter, and had declined further by the third to fifth litters (a difference of 0.19 pigs born alive), with no difference in pigs weaned.

Table 2. Effect of age first conceived on sow productivity*

	Age first conceived (days)						
	190 - 209	210 - 229	230 - 259	260 - 279	> 280	SEM	Sig
Parity 1							
n	4,476	9,906	8,627	2,374	2,302		
Pigs born alive	9.44 [a]	9.63 [b]	9.67 [bc]	9.79 [cd]	9.94 [d]	0.05	0.001
Weaned	8.78 [a]	8.82 [ab]	8.92 [c]	8.89 [cb]	9.03 [d]	0.03	0.001
Parity 2							
n	3,552	7,799	6,513	1,763	1,877		
Pigs born alive	9.65 [a]	9.76 [ab]	9.82 [b]	9.91 [bc]	10.02 [c]	0.07	0.001
Weaned	8.98	9.01	8.97	8.94	9.02	0.03	NS
Parity 3-5							
n	7,325	16,933	13,892	3,802	4,102		
Pigs born alive	9.85 [a]	9.88 [a]	9.92 [ab]	10.00 [bc]	10.04 [c]	0.06	0.01
Weaned	8.90 [b]	8.91 [b]	8.90 [b]	8.93 [b]	8.82 [a]	0.03	0.01

***** 1 farm in Canada and 3 farms in the US (2000 – 2004)

Source: Clowes (unpublished data)

But, what is the optimal economic age at first conception for a gilt? Schukken et al. (1994) considered that the optimal economic age at first conception for a gilt was approximately 200 to 220 days of age when the cost of housing and feeding the gilt from entry into the herd to first conception were taken into account. However, by only combining the effect of litter size and herd life they concluded that the profit per sow was not significantly affected by age at first conception. Others suggest that the optimum age to first conception is 220 to 250 days (Le Cozler et al., 1998) or 221 to 240 days (Babot et al., 2003), and the effect of age at first conception on subsequent gilt performance is also dependent on general sow herd management. In our retrospective study, pigs weaned from sows that first conceived at a younger age (190-209 vs 260+ days) were associated with 0.9 fewer non-productive days (Table 1). Assuming a cost of $2.00 per non-productive day, then in this analysis each pig weaned from a gilt bred at 260+ days or older:

- cost ~$1.80 more to rear than a pig weaned from a gilt first bred at 190 to 209 days of age, based on the additional non-productive days associated with these weaned pigs
- cost ~$0.80 more to rear than a pig weaned from a gilt first bred at 210 to 229 days of age, based on the additional non-productive days associated with these weaned pigs

The range in optimum age at first conception, to ensure high herd productivity, thus appears to be 210 to 240 days. However, this may vary with production system due to variances in genetics, management, housing, costs, and other differences. It must be noted though, that for herds with high retention rates (average parity for sow removal of 5+) the age at first conception appears to have little effect on sow lifetime productivity and/or longevity. The target of such herds might then be to reduce the number of non-productive days per sow and per pig weaned.

In our study, as age at first conception increased fewer sows (Figure 1) were removed from the herd due to:
- poor farrowing performance (8.9 vs 12.2%)
- becoming too large or reaching too high a parity (9.4 vs 14.5%).

However, as age at first conception increased more sows were removed from the herd due to:
- Reproductive problems (40.4 vs 32.0%)
- Health and disease (6.5 vs 4.4%)

Additionally, as age at first conception increased fewer sows were removed from the herd because of being a repeat breeder, and a larger proportion of sows were removed due to no heat and not conceiving (Figure 2).

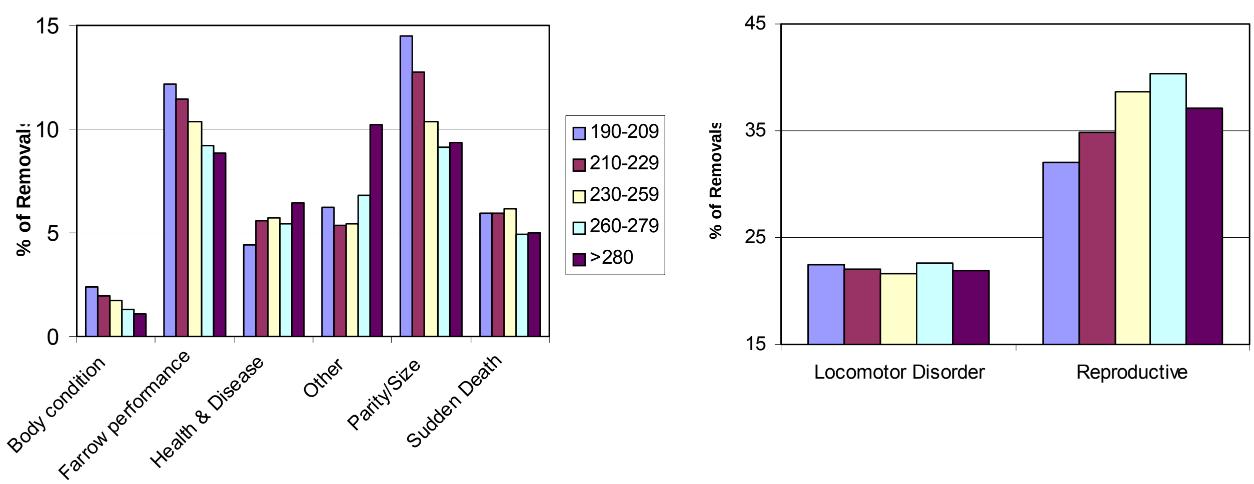

Figure 1. Sow removals by category and age first conceived

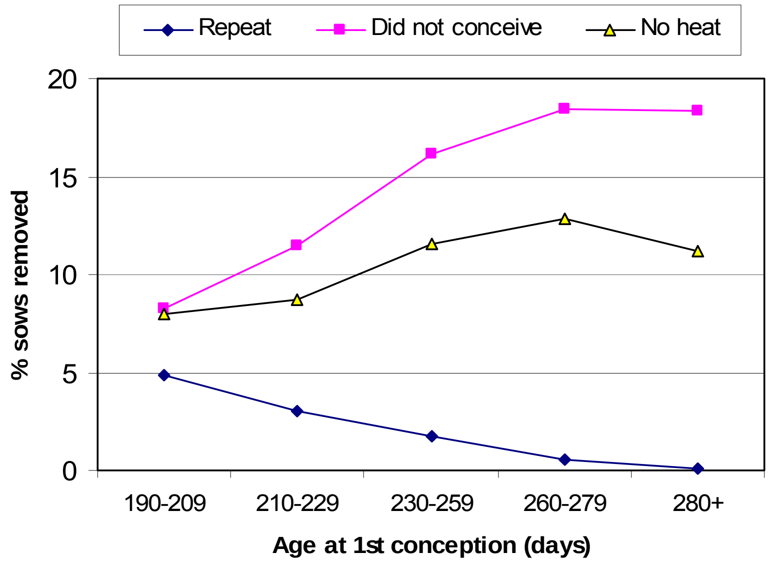

Figure 2. Sow removals for reproductive reasons

Benefits and costs of a heavier gilt at first conception

We now have an understanding of the effect of age at first conception on subsequent sow performance, but what do we know about the effect of gilt body weight at first conception on subsequent sow performance? Several methods may be used to determine this, based on:

1. the size of a sow’s body reserves at first farrowing
2. the gilt’s actual weight at first conception and longevity in the herd
3. gilt age at first conception and growth rate

Size of a sow’s body reserves at first farrowing

Much of the work to assess the optimum weight of a gilt at first conception is based upon work conducted on the size of body reserves available to the sow at first farrowing. First-litter sows are especially vulnerable to a reduction in lactational and reproductive performance (Tantasuparuk et al., 2001), because these animals have a relatively similar level of milk production to older sows but a smaller appetite (Aherne and Williams, 1992), and a smaller body mass to draw upon. As a decline in sow performance starts to occur when sows lose 10 to 12% of their body protein at farrowing (Clowes et al., 2003a; Clowes et al., 2003b) the lighter the animal the smaller the protein reserve to draw upon. Thus, the earlier a decline in sow performance will occur if lactation nutrition is inadequate.

We know that the amino acid mixture released from the sow’s main protein reserve (skeletal muscle) in times of nutrient deprivation does not match that required by the mammary gland for milk biosynthesis and mammary function. It is deficient in some essential amino acids, especially branch chain amino acids such as valine and isoleucine, and provides an excess of non-essential amino acids such as glutamine. We also know that when a sow’s dietary nutrient intake is highly deficient, the sow becomes very dependent on her own (endogenous) amino acid supply. But, by the time the sow has mobilized more than 10 to 12% of her body protein the concentration of some essential amino acids in the body's main free amino acid pool (muscle) is lower than pre-farrowing levels, and some non-essential amino acids are much higher than pre-farrowing levels (Clowes et al., 2004). In such a case, if the sow continues to receive a poor amino acid supply from her diet then the mammary gland's essential amino acid supply will be deficient and milk production declines.

Changes in the body's main free amino acid pool will eventually reflect changes in amino acid levels in the blood, if nutrient intake is poor. This can have disastrous effects on the reproductive axis and the sow's subsequent reproductive performance:

- possibly increasing the competition for central amino acid transporter uptake of key neurotransmitter and their precursors, altering central neurotransmitter concentrations.
- possibly impacting oocyte development and maturation.

Thus, a heavier first-litter sow at farrowing is better protected against:

a) lower milk production and slower litter growth
b) poor subsequent reproductive performance e.g. extended wean-to-service interval, reduced embryo survival rates, reduced farrowing rates etc.,

if the animal's nutrition in lactation is lacking and she loses a large amount of weight, especially protein, in lactation (Mullan and Williams, 1989; Clowes et al., 2003b; Quesnel et al., 2005b).

In a twenty year old Australian study, highly restrict-fed first-litter sows that were 170 kg after farrowing were better able to maintain milk production and thus litter growth in the fourth week of lactation than 140 or 125 kg sows (Figure 4; Mullan and Williams, 1989). Although in this study, 140 kg first-litter sows showed similar three-week litter growth rates to 170 kg sows, the litter growth of these sows was only 1.7 to 2.0 kg/day (6.8 to 8.0 kg milk /day). Today's sows are capable of producing 25+% more milk (over 10 kg of milk/day), so a smaller body reserve of 140 kg after farrowing would likely not suffice to help maintain milk production if a sow's feed intake was very low.

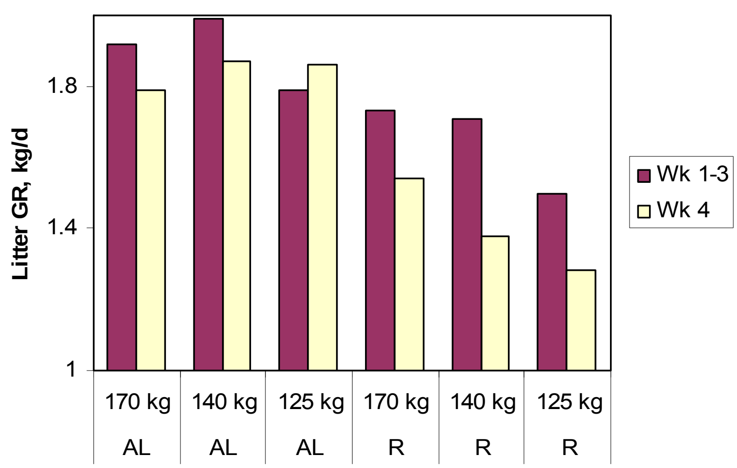

Figure 3. Litter growth rate in first-litter sow with divergent farrowing weights (170, 140, & 125 kg) and feed intakes in lactation (R = Restrict, AL = Ad Libitum)

Source: (Mullan and Williams, 1989)

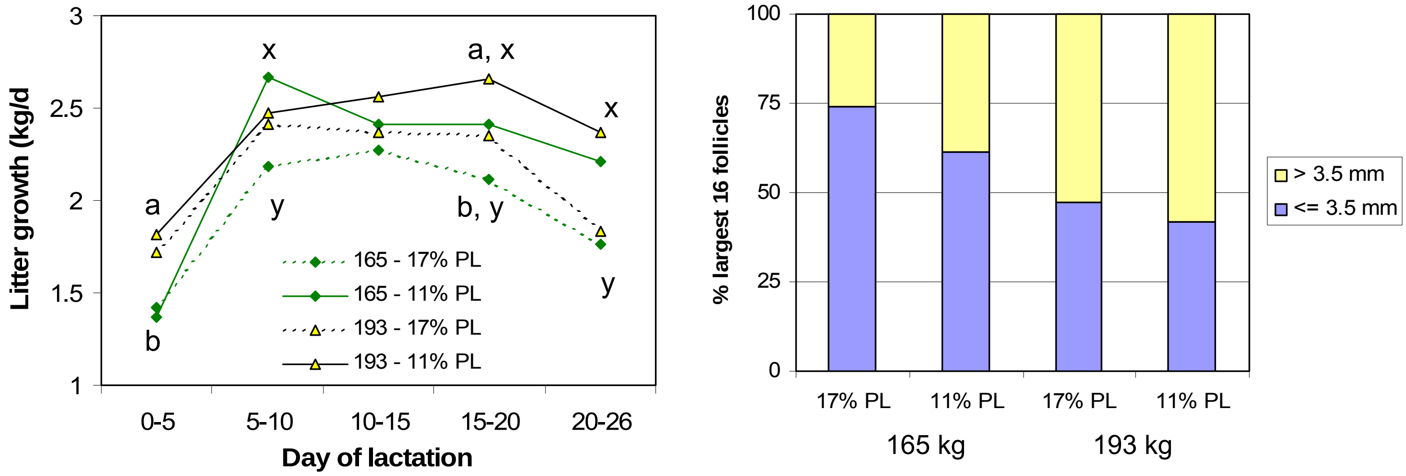

Figure 4. Heavier (193 kg) first-litter sows with large lactational protein losses (17%) have better lactational performance and more larger (> 3.5 mm vs ≤ 3.5 mm) ovarian follicles at weaning than lighter (165 kg) sows

17% PL = 17% lactational protein loss: 23 – 30 kg live weight loss, 24% fat loss)
11% PL = 11% lactational protein loss: 18 – 21 kg live weight loss, 24% fat loss)
ab: within a time period, litter growth rate differs between sow body size (193 vs 165 kg; $P < 0.05$)
xy: within a time period, litter growth rate differs between sow protein loss (17 vs 11%g, $P < 0.05$)

Source: (Clowes et al., 2003b)

Table 3. Sow performance declines once sows lose a large amount of body protein

Farrowing Weight (kg)	**165**		**193**			**Significance** [a]	
Lactation Protein Loss	**11%**	**17%**	**11%**	**17%**	**SEM**	**PBM**	**PL**
Sow live-weight							
at weaning, kg	141	149	163	173	3.5	0.003	0.01
Change in lactation, kg	-23.1	-17.6	-29.7	-21.3	2.4	0.03	0.006
Sow backfat depth							
at farrowing, mm	20.0		22.8		0.9	0.05	
at weaning, mm	18.0	16.5	21.6	17.2	1.3	NS	0.03
Change in lactation, mm	-4.2	-5.1	-5.0	-6.2	1.0	NS	NS
Average litter gain, kg/d	1.93	2.16	2.11	2.29	0.09	0.08	0.02
Follicular fluid estradiol*, ng/ml	0.22	0.29	0.28	0.65	0.10	0.05	0.04

[a] Significance of effect of divergent parturition body masses (PBM) or lactational protein losses (PL).
* Largest 16 follicles

Source:(Clowes et al., 2003b)

Similarly we observed that heavier (193 kg) first-litter sows after farrowing fed low protein intakes in lactation, ultimately losing ~17% of their body protein in lactation, maintained a higher litter growth rate in early and mid lactation than smaller (165 kg) sows. These sows had a more mature ovary at weaning, as indicated by more larger (> 3.5mm) follicles (Figure 4) and higher follicular fluid estradiol levels (Table 3). In a similar study, very heavy (240 kg) first-litter sows after farrowing that lost over 10% of their body protein in lactation were more fertile after weaning than sows that weighed 180 kg after farrowing (Table 4). A larger proportion (86 vs 58%) of the heavier sows that lost over 10% of their body protein returned to estrus within 8 days after weaning.

Table 4. Heavier first-litter sows at farrowing perform better if fed low protein levels

	Control diet	Low protein diet			
Weight at Farrowing	**180 kg**	**180 kg**	**240 kg**	**SEM**	**P**
Weight loss in lactation, kg	19.4 [a]	22.1 [a]	37.6 [b]	3.5	0.001
Backfat loss in lactation, mm	3.2 [b]	1.9 [a]	5.3 [c]	0.5	0.001
Lipid loss in lactation, % day 1 mass	29.2	25.8	28.5	1.8	NS
Protein loss in lactation, % day 1 mass	8.2 [a]	11.1 [ab]	13.5 [b]	1.4	0.02
% sows in estrus within 8 d after weaning	92 [b]	58 [a]	86 [b]		0.03

a,b Within a row, means without a common superscript letter differ by the significance level in that row.

Source: (Quesnel et al., 2005a; Quesnel et al., 2005b)

Thus, a maternal weight after farrowing of 175 to 185 kg appears adequate to provide first-litter sows with some degree of protection against excessive weight loss in lactation. The option of a larger first-litter sow before farrowing might not be economically practical in many production systems, as sows would soon out-grow the facility. These sows will also cost more to feed because of higher maintenance feed requirements. By deducting the recommended maternal weight gain in the first gestation of 35 to 40 kg from a maternal weight after farrowing of 175 to 185 kg, a preferred sow weight range at first conception of 135 to 150 kg is achieved. This weight range is just a guideline and also depends on gestation nutrition. If, due to management and nutrition etc., a production system has no problem with poor lactation feed intakes, especially with the first- and second-litter sows, and with poor retention in the herd then less attention can be paid to breeding gilts at a heavier weight. On the other hand, if there is a problem of poor retention in the herd, care must be taken that gilts not grow too big at first conception, as they will be more likely to out-grow the facility in North America, and be culled early. Systems therefore need to assess these costs against the potential benefits if they change their protocol.

Optimum weight at first conception, based on longevity, ~ 135 kg (Newton and Mahan, 1993)
Newton and Mahan (1993) and Williams et al. (2005) concluded that a gilt weight of 135 kg, rather than 120 or 150 kg, at first conception provided better long-term animal performance. In support of this, a recent study with ~1,700 gilts indicated that gilts weighing less than 135 kg at first conception have over 1.5 fewer pigs total born over 3 parities (Figure 5, Williams et al. (2005).

Calculation of the optimum weight at first conception based on age and growth rate
The weight of a gilt at first conception can also be estimated based on the optimum age at first conception and average growth rate from birth to first conception. From our earlier discussion the optimum age range of a gilt at first conception is 210 to 240 days. We can also assume that

the average growth rate of a gilt from birth to first conception is 0.55 to 0.65 kg/day. This is a simplistic approach, but using these numbers the range in weight at first conception can be calculated as 115 to 155 kg. This range is very wide, and obviously requires a little more caution than the other ranges suggested, but still somewhat fits within the other estimates.

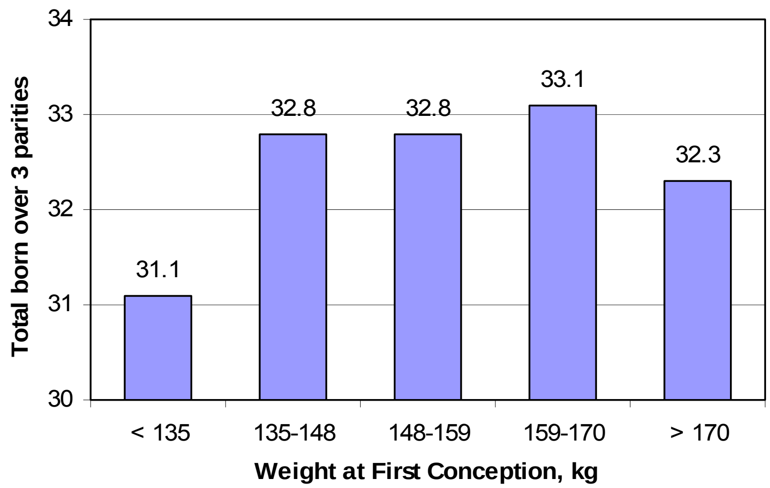

Figure 5. Gilts weighing < 135 kg at first conception produce fewer total born over three parities
Source: (Williams et al., 2005)

Conclusion

In conclusion, it appears the optimum range in age and weight at first conception is 210 to 240 days and 130 to 150 kg, respectively, to ensure good herd productivity, high longevity and a minimum number of non-productive days per pig weaned. This number may vary with production system due to management differences, genetics (hyperprolific sows etc), facilities, and nutrition etc. It must be noted that if herd retention rates are good (average parity sows are removed from a herd of 5+) then age and weight at first conception appears to have little effect on sow lifetime productivity and longevity. In this case the system may want to look at reducing the number of non-productive days per sow and pig weaned by breeding gilts at the younger end of the scale. Production system must therefore assess their options before making any changes to their protocols.

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