Rethinking Management of the Replacement Gilt

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▪ Introduction

The interaction between management, environment and genotype have resulted in only modest improvements in litter size in the last ten years. Nevertheless, improved nutritional management of lactating sows has improved and lactation lengths of less than 21 days may increase pigs weaned/sow/year in many situations. However, herd replacement rates can be high when short lactations are used. This places emphasis on retention rate and reproductive performance of first parity sows in the breeding herd and demands a greater emphasis on improved gilt pool management. Figure 1 emphasizes the importance of maintaining inventory in the breeding herd and, as reviewed by Dial in the next paper in these proceedings, improved gilt pool management is required to ensure that availability of gilts for service does not limit the ability of herds to achieve their breeding targets. Table 1 emphasizes the relative importance of meeting breeding targets to overall herd productivity.

The starting point for the present discussion of the management of replacement gilts is that traditional systems of gilt pool management do not allow producers to ensure a consistent and well defined pool of replacement gilts, consistent with high breeding herd performance. In particular, most traditional systems preclude any opportunity for implementing a gilt “selection” program that includes any prediction of reproductive ability. We believe that this is possible, but requires management of gilts from an earlier age, and implementation of optimal puberty induction programs. Changes in management systems can also:

- facilitate the use of techniques to increase fertility of first parity sows,
- provide time to achieve proper quarantine and acclimation of gilts without incurring extra non-productive days, and
- allows implementation of nutrition programs that allow producers to meet targets for age, weight and fatness at breeding.

Figure 1. Interrelationships between factors influencing weaned pig output.

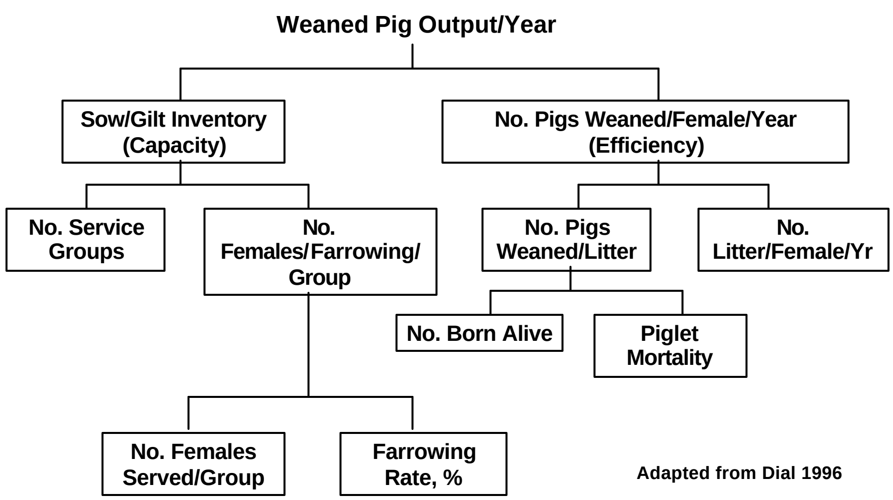


Table 1. Relative Importance of Factors Influencing the Number of Pigs Weaned Per Week

Factor	%
Number of Sows Served	60
Farrowing Rate	30
Number Born Alive per Litter	5
Mortality of Pigs Born Alive	5

As induction of puberty (first estrus) is an essential part of effective gilt development programs, factors that affect puberty induction are very critical. These will be reviewed, with a particular focus of effects of growth performance and use of boar stimulation. Secondly, we will discuss evidence relating age at puberty to subsequent reproductive performance. This information will demonstrate the potential to change existing systems of gilt management to better serve the industry. In the next paper, Dr. Dial will discuss the implementation of such changes into overall management systems.

▪ Growth and Sexual Maturation.

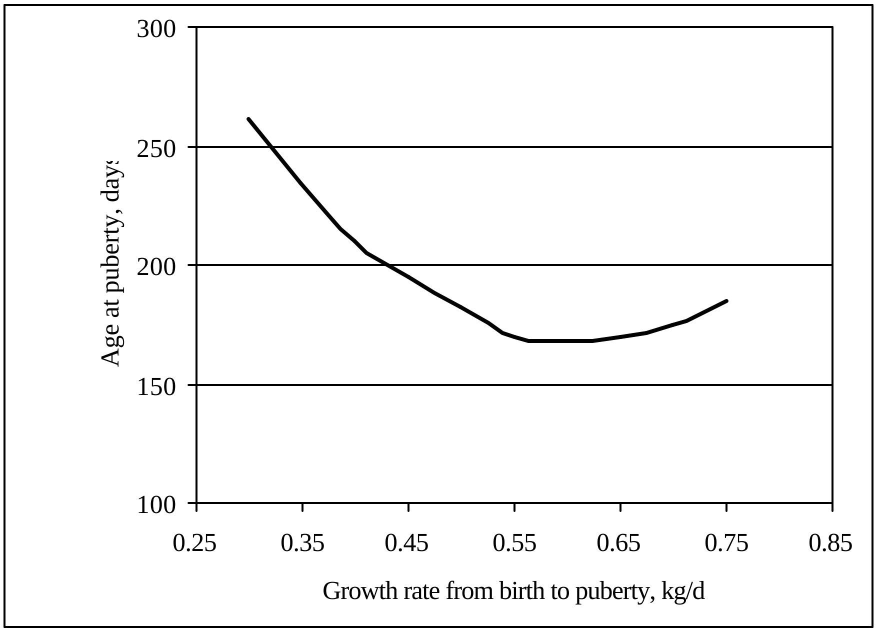
Aggressive selection for lean growth performance and feed conversion efficiency has left us with important problems for the nutrition and management of replacement gilts. As would be predicted from other species, body growth in the gilt is now proceeding more rapidly than the process of sexual maturation, and we have to deal with gilts that are probably getting heavier, but no younger, at sexual maturity. Also, if replacement gilts are fed to achieve their maximal lean growth potential this will increase mature body weight and lifetime maintenance costs in the breeding herd. High growth rates may also have negative effects on the physical fitness of replacement gilts and the welfare and culling rates of higher parity sows. Reliable data on the relationships between growth/nutrition in the gilt and breeding performance is very lacking for existing commercial genotypes, yet this information is essential for the development of proper nutritional programs for the breeding herd.

As the basis for setting growth targets, we must first understand the growth/nutritional requirements of replacement gilts and the impact of growth performance on sexual maturation. In 1982, Hughes presented a detailed review of the relationship between growth and sexual maturity, based on available literature at that time. In particular, he compared the reliability of using weight (a measure of growth performance) or chronological age as a reliable predictor of sexual maturity. **He concluded that there was clearly some threshold below which both weight and growth rate would delay the onset of first estrus.** Delayed onset of first estrus because of low growth performance is probably undesirable. We will therefore review more recent evidence that helps to define the thresholds that exist for growth effects on age at first estrus. This evidence suggests that both low and high growth rates may increase age at first estrus, but that over the intermediate range of growth rates minimum age at first estrus is achieved.

The data of Beltranena et al. (1991) provided information about the relationship between growth performance and age at puberty. In gilts exposed to boar stimulation from 140 days of age, the minimum age at puberty was around 160 days and this could be achieved at body weights of around 90 kg if gilts were fed appropriately (Figure 2). These data clearly confirm the negative effects of low growth rates on age at first estrus, and in this data set, **the threshold below which low growth rate delayed puberty onset appeared to be around 550 g gain per day from birth to puberty.**

- Presented another way, these data suggest that achieving 80 kg of bodyweight at the time of boar stimulation at 140 days was adequate for achieving minimum age and weight at first estrus.

Figure 2. Relationship between growth rate[1] and age at first estrus in gilts first stimulated with boars at 140 days of age.

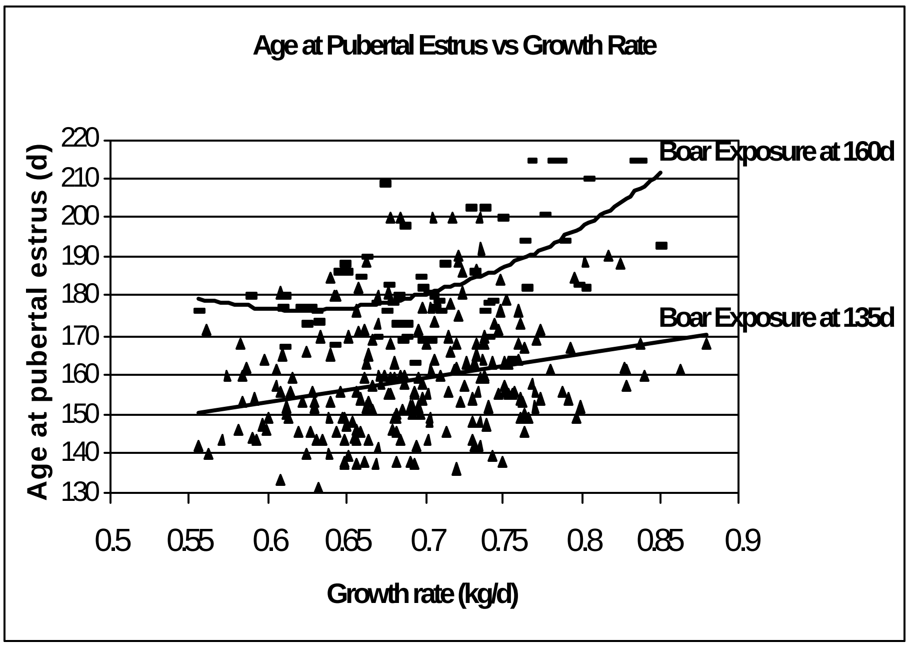


[1] Low growth rates were achieved by feed restriction in a proportion of these gilts; gilts with the higher growth rates were fed to appetite. (after Beltranena et al., 1991)

The data in Figure 2 indicate that there is no advantage, in terms of reducing age at first estrus, in exceeding a growth rate of between 550 and 600 g per day during the rearing period. **Higher growth rates simply produce heavier gilts at first estrus and at breeding.** Therefore, unless producers have good evidence that heavier bodyweights are needed at first estrus, the extra costs of developing heavier gilts can be avoided.

Very few of the gilts in the study represented in Figure 2 achieved the higher growth rates that are possible with contemporary commercial genotypes under good management conditions. However, the best fit to the data was quadratic, suggesting that high growth rates might also increase age at first estrus. This appeared to be something of an enigma, and we have tried to confirm this effect in recent studies. Figure 3 presents the combined data from two different experiments in this series (J. Patterson, University of Alberta, unpublished data). The first experiment involved GP generation gilts that were fed to appetite on a standard diet from arrival at the gilt pool facility and stimulated with boars from 160 days of age. This experiment was primarily designed to study the effects of different methods of boar contact (see Table 4). However, in Figure 3 the data have been analyzed to present the effect of growth rate from birth to puberty on age at first estrus. The curvilinear relationship that best describes these data indicates two essential points: Firstly, most gilts were above the threshold for achieving minimum age at first estrus (even though delaying boar stimulation to 160 days resulted in an increase in minimum age at first estrus). **Secondly, a definite negative effect of high growth rates on age at first estrus existed.**

Figure 3. Analysis of effects of growth rate (birth to puberty) on age at first estrus in two recent experiments[1] (J. Patterson, University of Alberta, unpublished data).



[1]GP generation gilts were fed to appetite throughout the growth period and first stimulated with boars at 160 days of age. The F_1 progeny of the GP females were provided with different gilt conditioning diets in the second experiment and stimulated with boars from 135 days of age; dietary treatment did not affect age at first estrus in these gilts.

The same trend was apparent in the second experiment using the F_1 progeny of the GP gilts, with boar stimulation from 135 days of age, although the magnitude of the effect of growth rate on age at first estrus was not as great in the second experiment.

These data also confirm that the lower threshold of 550 g per day for growth effects on age at puberty suggested by the study of Beltranena et al. (1991) is probably applicable in contemporary genotypes. **Although growth rates**

ranging from 550 to 800 g per day had little effect on age at first estrus, the impact of inherent differences in growth rate on weight at first estrus is dramatic, representing body weights at 150 days of 82 and 120 kg, respectively.

- If we set a target for weight and backfat at breeding of 125 kg and 15 mm, respectively, and we wish to breed at second estrus to take advantage of the management techniques, then the higher growth rates seen in the gilts in Figure 3 are clearly not appropriate. Gilts first cyclic at 120 kg will carry excess bodyweight and backfat by the time of breeding.
- Additionally, if high growth rates increase age at first estrus beyond 180 days, then the entry-to-service interval, and associated non-productive days, will be an added cost to the breeding herd.

Collectively, these data suggest that there is an upper and lower threshold for growth effects on age at first estrus, above and below which earliest age at puberty will not be achieved. With modern dam line gilts under good nutritional management, there should be little problem in exceeding the lower threshold. However, in the same conditions, it may be necessary to develop gilt "conditioning" diets to limit growth performance. **Producers and breeding companies should therefore have reliable information about the growth rate that will achieve the minimal age at first estrus in a particular genotype, as the first step to developing effective gilt management programs.**

Nutritional Management of Beyond First Estrus

Having minimized age and bodyweight at first estrus, it is then possible to use various strategies to enhance the reproductive maturity of gilts before breeding. At the same time, the nutrition of the gilt can be controlled to achieve desired targets for bodyweight and backfat at breeding. It has been suggested that 125 kg of bodyweight and 15 mm of backfat at breeding, are targets that will ensure good lifetime performance, assuming good nutritonal management in gestation and lactation (Aherne, 1996; Aherne et al., 1999). **There is no consistent evidence that less than maximal growth rates (in the 600 to 750 g per day range from birth to onset of first estrus) have any detrimental effects on lifetime reproductive performance (Aherne and Williams, 1992), or on sow longevity in the herd (Rozeboom, 1996). Indeed, available evidence suggests that very high growth rates and higher body weights at breeding can decrease lifetime breeding performance.**

▪ Relative Importance of Growth in Determining Age at First Estrus

The data in Figure 3 clearly demonstrate a very important point that we must be aware of in the management of replacement gilts. **Although, as discussed above, the extremes of growth performance can affect age at first estrus, inherent differences in age at first estrus, independent of growth rate is a much bigger factor.** In Figure 3, the effect of even the extremes of growth performance in gilts stimulated with boars from 135 days of age accounted at most for a 20-day difference in age at first estrus, whereas at least a 50-day difference existed within any given growth rate.

Therefore, as long as growth rate does not limit age at first estrus, gilt pool management systems need to be able to identify inherent differences in pubertal age. In the gilts used in the experiments shown in Figure 3, litter of origin was an important factor in age at first estrus, confirming reports from a number of earlier studies (Deligeorgis et al., 1985; Beltranena et al., 1991) and the more recent data of Almeida et al. (2000a). This may indicate genetic effects, although the data of Deligeorgis et al. (1985) also indicate that birth weight, weaning weight and even sex ratio of pigs in a litter may impact age at first estrus.

▪ Selection for Fertility

Contemporary selection criteria used to identify F_1 replacement gilts are limited to growth and conformation, with little attention to any indicators of potential fertility. However, there are extensive data suggesting that selection for superior fertility is possible if appropriate management strategies are adopted. However, this selection for reproductive merit must start at an early stage. Many gilt production systems do not allow this. In the future development of integrated systems of pig production it is important to provide opportunities to select a better population of females for inclusion in the breeding herd.

Because gilts are often at market weight before they are considered part of the breeding herd, there is a financial penalty to retaining gilts in the gilt pool unless they are eventually bred. It would be an advantage from an economic and management perspective to identify sexually mature, and desirable, replacement females at an early stage. With appropriate management programs this is possible, and need not conflict with requirements for particular for body condition, or age, at first breeding. The goal should be to induce gilts to cycle at the earliest possible weight, which, as discussed earlier, will require gilts to have adequate lean growth performance. Once this has been achieved, known cyclic gilts can be managed to meet the weekly breeding requirements of the herd and their nutrition can be managed to ensure required weight and fatness at breeding. Gilts that respond poorly to puberty induction, together with non-cyclic gilts, can be immediately culled with little financial loss.

Gilts exhibiting poor indications of reproductive performance should not become a part of the breeding herd.

If achieving minimal age at puberty is an important goal, we must use all available management tools achieve this goal. With adequate growth performance, optimal use of boar stimulation may result in a considerable proportion of gilts being induced to cycle even earlier than the herd average, perhaps as early as 120 to 140 days of age. **If replacement gilt management programs allow us to recognize these gilts, then we have the option of selecting gilts as replacements on the basis of early onset of estrus.** Available evidence indicates that these gilts will be more fertile during their breeding lifetime (Tables 2 and 3). With an aggressive system of gilt management, non-select gilts will be identified before they reach market weight and can be culled without the penalty of accumulating excessive non-productive days.

Table 2. Performance of early and late maturing gilts.[1]

	Control	Early	P
Age at puberty, d	158	144	.04
Ovulation rate	14.1	14.3	NS
Number weaned	8.5	8.5	NS
WSI[2], d	20.8	8.1	.02
% farrowing, 5 litters	39	59	.17

[1]Holder et al. 1995
[2]weaning to service interval

Table 3. Performance of early and late maturing gilts.[1]

	Early Puberty	Late Puberty	P
% cycling regularly	83	54	.05
Number of litters/sow	2.2	1.4	.05
Number born alive	9.3	8.3	.10

[1]Nelson et al. 1990

Evidence that innate differences in sexual maturation exist, irrespective of growth performance, is found in several studies. The likely link between early onset of puberty as a litter dependent trait and other aspects of fertility was also evident in recent work at the University of Alberta, in which litter of origin affected the endocrine status of gilts in the peri-estrous period and even the length of the estrous cycle (Almeida et al., 2000b).

Creating a pool of known cyclic gilts at the earliest possible age provides major advantages

- for the development of effective gilt synchronization programs that will ensure that breeding targets are met
- for the use of techniques that will enhance the fertility and litter size of the bred

Achieving both of these goals will still allow us to breed gilts at a suggested target of around 125kg and 15mm or more of back fat at second estrus (Aherne, 1996; Aherne et al., 1999).

Use of boars in gilt selection programs

It has been shown consistently that direct contact of gilts with the salivary pheromones of a mature boar is the only effective way of using boars to stimulate puberty onset (see review of Hughes, 1982; Deligeorgis et al., 1984). In this situation the boar is delivering a “primer pheromone” in his saliva, which is a modified male steroid hormone. In a direct contact situation, gilts will actively “solicit” the boar; additionally, several gilts at one time can gain access to the salivary signal. There is also evidence that other aspects of direct boar contact are part of the trigger for pubertal estrus. There is universal agreement on two things:

- Even 10 to 15 minutes per day of direct contact between a group of 6 to 10 gilts and a mature boar can be effective for inducing puberty
- Fence-line contact with boars is much less effective for inducing pubertal estrus

It is not difficult to appreciate that even if gilts are allowed good fence-line contact with a boar, only one or two gilts at a time can gain access to the head of the boar, and this assumes that the boar is willing to stand at the fence-line for long periods to provide this service. Data from a recent comparison of different protocols for stimulation of gilts with boars, using boar introduction from 160 days of age, are shown in Table 4.

Table 4. Age, weight and back fat (P2) of gilts at the time of initial stimulation with a rotation of mature, vasectomized boars starting at 160 days of age and at pubertal estrus. [1]

Method of boar use [2]	At 160 days			At Pubertal Estrus		
	Age (d)	Wt (kg)	P2 (mm)	Age (d)	Wt (kg)	P2 (mm)
GB	159.1 (0.7)	103.3 (1.8)	12.3 (0.6)	180.8 (2.8)[a]	126.5 (3.4)	15.8 (0.9)
BG	160.0 (0.7)	108.9 (1.8)	13.1 (0.6)	185.4 (3.0)[ab]	128.3 (3.6)	15.5 (1.0)
BS	159.4 (0.8)	108.3 (2.0)	13.4 (0.6)	191.4 (3.1)[b]	137.4 (3.7)	17.3 (0.9)

[1]Unpublished data of J.L. Patterson , 1999, University of Alberta
[2]Three methods of stimulation with boars were evaluated: Direct contact of group pens of gilts with a boar in a purpose built boar stimulation area (GB: n=30); Direct contact with boars in gilt group pens (BG: n=31); Fence-line contact between boars and gilts housed in individual gilt stalls (BS: n=28).
*LS means (standard error of the mean); Different subscripts within column denote treatment differences at P # 0.05

These data indicate that any system of direct boar contact is the most efficient way of inducing pubertal estrus; use of fence-line contact in this study added an average of 10 non-productive days to the entry-to-service interval!

Evidence for gilt responses to different frequency and duration of exposure to mature boars was recently extensively reviewed by Levis (2000) and indicates improvement in responses from more frequent boar use.

The management of the gilt/boar interaction is greatly facilitated by the use of vasectomized boars of an appropriate size. In this situation direct supervision may not be needed for the period of daily stimulation. If breeding occurs this is an advantage.

Several studies have shown that breeding at the pubertal estrus improves conception rate and litter size born when gilts are bred with fertile boars or AI at second estrus.

In our standard gilt management program, groups of 6 to 8 gilts are stimulated with a rotation of three vasectomized boars on a daily basis, and as far as possible all gilts are bred at first standing heat. In addition to improving gilt fertility, this also helps to maintain high libido in the boars and prevents them from becoming aggressive when they are with the gilts. Gilts can then be grouped according to the time of first recorded estrus. This already starts to create potential breeding groups that can be efficiently observed for second estrus and bred when required.

It is virtually impossible to create an effective gilt stimulation and heat check program if gilts are housed in stalls in the breeding barn. Specific gilt pens should be available to maximize the use of boars in gilt management.

▪ Synchronization of Pubertal Estrus using Boar Contact as an aid to Gilt Management

The factors that may contribute to puberty onset, and possible use of different hormonal strategies to induce first estrus, were comprehensively reviewed by Hughes (1982) and Paterson (1982). Little has changed since these reviews were published. Use of natural boar pheromones can be very effective in inducing a fairly synchronous onset of first heat, as long as gilt can be managed to optimize the response to exposure to boars (Hughes, 1982).

Stimulation of gilts with boars can be used in two ways:

1) Early and repeated exposure to boars from below the expected age of first estrus will identify gilts that are the most sexually advanced (precocious).

Although the number of gilts cycling in any one week may be low, the supply of gilts for breeding is fairly constant. As long as the size of the gilt pool could be increased to provide the required number of estrus gilts per week, there would be little need to use synchronization of estrus to meet breeding targets. **Another advantage of this approach is that gilts will have more cycles before being bred, and this will improve first litter size.** An example of the pattern of pubertal estrus when gilts are stimulated at an early age is seen in the recent data of Patterson (University of Alberta, unpublished data, Figure 4).

2) If gilts are older and heavier at the time of transportation to the gilt pool and first exposure to boars, then boar contact can be used to induce a more synchronous expression of first estrus.

The assumption here is that many gilts have already achieved the weight and age threshold to attain puberty, but have not been exposed to the stimulus needed to trigger final sexual maturity. When these stimuli are applied we expect to see increased numbers of gilts reach estrus in the weeks immediately following boar introduction; however, on average, they will be older and heavier

Figure 4. Response of gilts to daily direct contact with mature vasectomized boars from 135 days of age (unpublished data of J. Patterson, University of Alberta, 1999/2000)

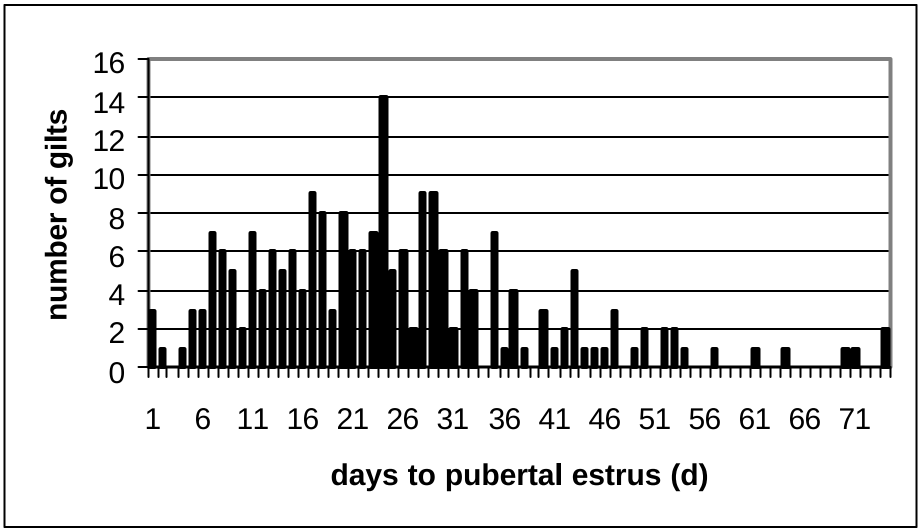
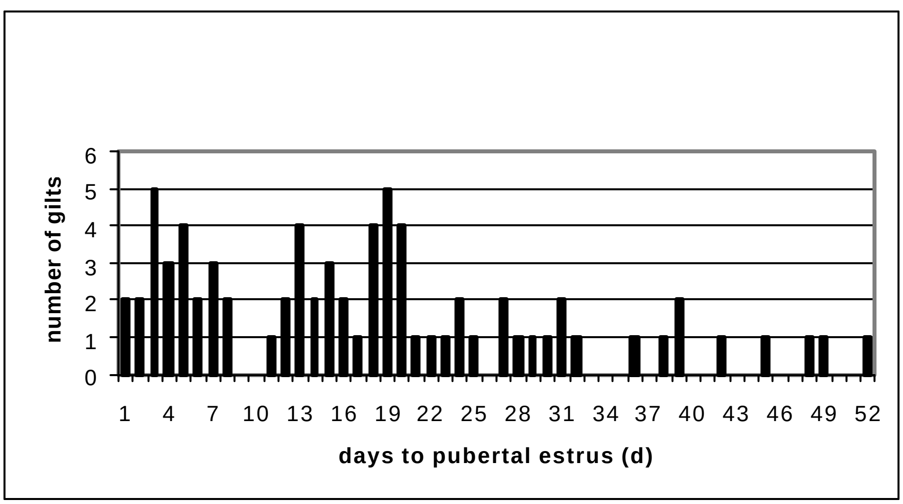


Figure 5. Response of gilts to daily direct contact with mature vasectomized boars from 160 days of age (unpublished data of J. Patterson, University of Alberta, 1999/2000)



at first estrus compared to the situation described above. An example of such a response is seen in a second set of data from Patterson (University of Alberta, unpublished data; Figure 5). Although the number of gilts per week available for breeding is greater, there are two disadvantages. First, we cannot identify gilts that are the most sexually mature. Second, in order to meet regular breeding targets it may be necessary to use heat synchronization, because the large availability of gilts in the first weeks after stimulation will exceed breeding requirements. Some of these gilts must either be kept for a complete 21-day cycle and become part of a later breeding group, or estrus must be synchronized in a proportion of the gilts. If gilts are stimulated close to, or after reaching market weight, this results in extra non-productive days.

To implement any chosen strategy for using boar stimulation, it is necessary to know the average age at which a given gilt genotype is likely to reach puberty under exiting management conditions, and then to time boar introduction accordingly. Delaying boar introduction beyond 160 days will generally result increasing age at first estrus. ***Therefore, producers must have good justification for implementing management strategies that result in delayed onset of estrus because of late boar introduction.***

▪ Conclusion

Improved management of the gilt pool is an essential component of overall breeding herd management. Existing management practices do not take advantage of puberty stimulation techniques as a means of identifying the more fertile gilts, or for improving the pre-breeding management of gilts without accumulating unwanted non-productive days. Attention to improved gilt pool management will also improve lifetime performance of the breeding herd.

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