PHYSIOLOGICAL LIMITS TO MAXIMIZING SOW PRODUCTIVITY

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ABSTRACT

Major improvements in breeding herd efficiency, as measured by success in meeting critical key performance indicators (KPI) for the breeding herd (body condition and sexual maturity of gilts selected to enter the breeding herd, meeting weekly breeding targets, consistent weaned pig output, and annual replacement rates below 50%), can be achieved by improving sow "fitness", improving efficiency in use of labour and space, and by implementing effective gilt development unit (GDU) programs. It is possible to set ambitious benchmarks for the GDU with available commercial dam-line females (80% gilts selected on the basis of a recorded standing heat within defined time-frames; 100% gilts bred at 2nd or 3rd estrus; 100% gilts bred at target weight of 135 to 150kg; and 85% of gilts bred during a 5-day period). In turn, these will drive excellent levels of performance in the breeding herd. However, these targets can only be achieved by recognizing the key physiological characteristics of contemporary gilt populations, and particularly their exceptional lean growth potential. By controlling body condition (weight rather than "fatness") and relative sexual maturity, producers can maximize first litter performance of gilts and improve their lifetime performance in the breeding herd. Appropriate key performance indicators (KPI) should drive breeding herd management. We suggest that meeting weekly service targets within a short breeding week, and segregated parity management of both the sow and her offspring, will help to achieve the critical KPI of successful breeding herds in the future.

INTRODUCTION: DEFINING "MAXIMAL" SOW PRODUCTIVITY

"Maximal sow productivity" is still usually defined as the number of pigs weaned/sow/year. Alternatively, if the high capitalization costs of the farrowing rooms are to be emphasized, pigs weaned/crate/year may be a more meaningful measure of maximal throughput. However, an industry that is likely to increasingly focus on 1) product quality, and 2) the constraints that welfare and environmental issues will increasingly exert on pork producers, the quality as well as the total number of weaned pigs needs to be considered when determining the best economic returns from the sow breeding farm.

The real or perceived impacts of pork production on the environment are an increasing challenge to the industry. However, these concerns can perhaps be used to advantage if the

Canadian pork industry is willing to rapidly embrace the concept of “environmental nutrition”, as something that can be used as a trading advantage in global pork marketing. This approach to measuring the environmental impact of production systems, in addition to more traditional measures of production efficiency and growth performance, challenges us to adopt a totally integrated approach to measuring the relative efficiency of food-animal production. The ultimate measure of efficiency would reflect total production costs + environmental costs/kg of product sold. Environmental costs would include a measure of the land footprint needed for production, recognizing both efficiency of nutrient utilization (land area for feed production, plus land area, or alternative handling costs, of incorporation manure based nutrients and food-animal processing wastes into arable land with zero impact of the environment), and factors like greenhouse gas(GHG) emissions. The implementation of processes for recycling water and using manure digesters for production of “green” energy, represent future economic opportunities for offsetting the costs of pork production. An emphasis on more comprehensive measures of pork production efficiency will probably find more rapid adoption by Canadian production systems, in view of their smaller scale and greater receptivity to technological advances. If such advances in production efficiency can be implemented, and then audited in pork production chains that allow full traceability at retail level, this would allow Canadian pork products to be differentiated from the larger scale, more commodity-based and “less environmentally friendly” production systems, with which we compete in the export market.

There also seems to be a total lack of cost/benefit analysis associated with much of the recent debate about management programs that are claimed to hold the key to increased sow productivity. As discussed later in this conference, if gilts are properly selected and managed, they can; 1) be bred at second or third estrus, 2) achieve 85 to 90% farrowing rates and over 12 pigs born live in their first litter, 3) be bred at a target weight of 135 to 150 kg at <220 days of age, and 4) be retained in the sow herd for an average of 4 parities per gilt entered. All this can be achieved by simply applying good gilt management programs and there appears to be no limitation in terms of the “prolificacy” of most dam-lines in commercial use in the North American swine industry to reaching a target of 30 pigs weaned/sow/year. The prolificacy and lifetime performance of “Danish” sows has recently been given great publicity. However, 1) the cost of adding on 20 to 30 non-productive days (NPD) per gilt bred when breeding is delayed to over 140 days, with little evidence of any great improvement in lifetime performance, and 2) losing the benefit of being able to select gilts on the basis of their early sexual maturity and then manage them for improved first litter size, seems to bring into question the economic reality of adopting these management strategies.

It is also very unclear whether standard measures of sow productivity are being offered for comparison. In some cases the count of gilt NPD can be extremely low and it appears that age at first service is taken as the day the gilt is placed on the breeding farm inventory. In other words, the entry-to-service interval (ESI) is entered as zero days, and the gilt NPD only includes the cost of returns to estrus after first service and gilts that fail to farrow. In other cases, it is often unclear what NPD contribution is included for gilts never bred, but moved to the sow farms and on inventory. Statements that more than 95% of all gilts arriving at the farms are eventually routinely bred, seems to be inconsistent with some of the counts of gilt NPD provided and real-life experience of the high cost of not properly selecting gilts before entry to the breeding herd. In comparison, our estimates of gilt NPD include an ESI that is counted from the day that gilts in a finishing system would, on average, exceed optimum market weight (around 170 days in Canada, and perhaps 185 days in the USA finished pig market), and the count of NPD includes days accumulated by gilts entered but never bred. We would advise producers not to be heavily influenced by the rather unqualified information being provided, until 1) an objective and standardized comparison is possible, and 2) a cost/benefit analysis of adopting these management strategies in the Canadian pork industry is available.

These introductory comments may seem rather "off-topic" given the title of the presentation, but we would argue that the single greatest failure of Canadian pork production industry, and an even greater failure of the larger production systems in the USA, is an inability to deal with avoidable inefficiencies in pork production systems using excellent dam-lines already available. From a Canadian perspective, this results in a failure to capture much of the marginal benefit that is available because of the exceptional genetic potential and high health status of our breeding stock. Most of the improvements discussed below are already attainable and are based on sound information from the R&D community. Indeed most have already found implementation in the top 10% of production systems. Perhaps the most disappointing aspect of these inbuilt inefficiencies is that they largely represent cost/benefit advantages that are captured at the primary production level. Perhaps we should pay more attention to a well-known "truism" of one our great mentors, Frank Aherne, that "you cannot test drive a Lamborghini in a traffic jam"!

Defining Key Performance Indicators (KPIs) of Breeding Herd Performance?

Given the above comments, the key indicators of breeding herd performance need to be carefully defined, and should reflect the most meaningful measures in terms of overall economic performance. Our producers are trying to make money, and should not be encouraged to see a simplistic measure of productivity like maximal numbers of pigs produced, at any cost, as a worthwhile goal. If a production system is not fully integrated, the terms of contracts at each level of the production chain should reflect the value of the pigs produced. Yet, a correct balance between the quality and the number of weaned pigs produced is not always apparent in the contracts agreed. Consequently, this is often not reflected in the priorities given to improving breeding herd performance. In terms of producing a reliable supply of weaned pigs at the critical nursery stage of production, the most important breeding herd KPIs are probably; 1) uniform numbers of pigs weaned per week, 2) the weight and age of the pigs weaned, and 3) the least variation possible in age and weight at weaning. In turn, if properly rewarded, these KPIs determine the key factors that will be the focus of the breeding herd. As has been repeatedly emphasized in the assessment of key determinants of the number of pigs born and weaned per week, the single biggest factor needing attention is meeting breeding targets. The second largest risk factor is farrowing rate. As shown in Table 1, these factors far outweigh the impact of achieving overall increases in the number of pigs born/litter, or variations in pre-weaning mortality. Thus, the primary focus of the breeding herd should be identifying the sows and gilts available on a weekly basis to meet projected breeding targets.

In the “push” concept of breeding herd management discussed later, a focus on establishing a well managed Gilt Development Unit (GDU) is considered to be the best way of ensuring a constant supply of gilts per week, whilst at the same time improving breeding management within the GDU to achieve consistently high farrowing rates. A constant input of high quality gilts into the breeding herd, with increased longevity, in turn stabilizes the parity structure of the breeding herd. This helps in preventing the somewhat erratic contribution that weaned sows are often seen to make to weekly breeding targets. A constant input of select gilts to the breeding herd also prevents the tendency for a reduction in the voluntary culling of sows to achieve weekly breeding targets. All these factors will prevent breeding farms from entering the “death spiral” that is frequently seen in many of our larger production systems (Williams et al., 2005).

Table 1. The relative importance (%) of different components of breeding herd efficiency for achieving a uniform weaned pig flow to the nursery (Foxcroft and Aherne, 2001; see also Dial et al., 2001).

	%
Number of sows served	60
Farrowing rate	30
Number born alive per litter	5
Mortality of pigs born alive	5

As discussed later, implementation of high quality GDU management can also make a considerable contribution to improving farrowing rate and reducing the variability in the age and weight of pigs weaned. However, such “down-stream” benefits can be used as important KPI, but are often not considered when discussing the benefit of changing GDU management practices.

Are such KPI Consistent with the Concept of Hyper-prolific Sows?

There will always be value in producing the maximal number of offspring from our breeding sows, but in an increasingly differentiated pork market, producers must consider the quality, as well of the quantity, of pigs produced. A consistent flow of good quality weaned pigs should be the principle goal, and is not necessarily best served by developing breeding herd strategies that simply focus on the concept that the “hyper-prolific” sow will necessarily meet this need. Indeed, as discussed elsewhere (Foxcroft and Town, 2004), increased prolificacy may well be associated with increased variability in weaned pig quality. Equally parity effects on postnatal growth potential may warrant segregated parity flows into specific nursery/grow finish systems Town et al., 2004; Moore, 2005). Again, the economic advantages of accepting these challenging and achieving much greater efficiencies in nutrient management would be all the more attractive to Canadian producers if such efficiencies provided a market advantage over our competitors.

This review will therefore focus on optimizing the performance of breeding sow units to remove inherent overall inefficiencies and the sources of variability that prevent us from capturing "maximal" economic value at the grow/finish stage of production. A clear understanding of the physiological limits of existing breeding stock helps us to understand both the challenges and opportunities that exist in achieving these goals.

UNDERSTANDING THE PHENOTYPE OF COMMERCIAL DAM-LINE SOWS

What Happened to Half a Pig Per Litter Per Year of Genetic Improvement?

Based on sound estimates of the heritability of all components of litter size in the sow, and continued improvements in the genetic merit of our nucleus sow populations, we should question why the repeated predictions that an increase in litter size of 0.5 pigs per year was achievable has never been realized at production level. There are probably two main explanations for our inability to capture the greater genetic merit of our breeding sows at production level.

1) Lack of appropriate management of contemporary dam-line females. The production systems created in the North America swine industry have tended to focus on a "least cost of production mentality", in which throughput volume is used to offset relatively lower efficiency of production at a biological level. This approach is not surprising, given that much of this philosophy has been directly transferred from the same corporate investors who are dominant in the poultry industry. For many of these integrated systems, the largest risk of becoming less profitable is an inability to maintain maximal flows through their processing plants. As a result, this corporate, processor-oriented approach to pork production seems to favor the availability of pigs for processing over the quality of these pigs; this approach also appears to place less emphasis on increasing efficiency at the primary production level as long as an adequate supply of finished pigs can be contracted for processing. This seems to result in a general attitude of "malaise" at production level that leads breeding herd managers to believe that improvements in efficiency are not a high priority. Even more alarming, this seems to lead to an attitude that it is the pig (dam-line) and not the inefficient management that is responsible for the lower production efficiency! As shown in Table 2, a simple reference to the performance of the average, compared to the top percentage of production in Canada and the USA, immediately denies such a comfortable assumption!

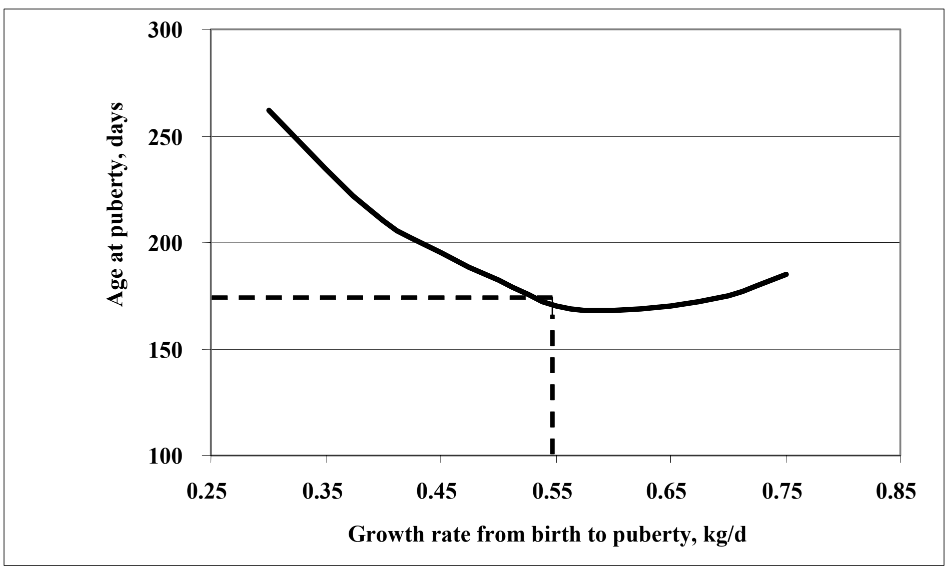
Table 2. Production data taken from the 2002 Breeding Herd Summary for Canada (PigCHAMP, 2002).

Measurement	Mean	Upper 10%	Lower 10%
Average female inventory	1046	2741	240
Annual Replacement Rate (%)	59	33	71
Average parity	2.8	3.8	2.0

2) Changes in lean tissue growth rates in dam-line females. The major changes in the lean growth potential, and associated changes in the overall tissue metabolism of contemporary dam-line sows is not adequately recognized. Compared to selection for reproductive merit, the much greater heritability of growth traits has resulted in improvements in lean growth performance in terminal line pigs that is the very basis of a competitive pork production industry in world meat markets. Inevitably, however, existing dam-lines carry these same traits to a greater or lesser degree. In the major dam-lines used in contemporary pork production in North America, inadequate attention is paid to the changes in basic sow metabolism resulting from this increased potential for lean tissue deposition and an associated lack of fatness in our current dam-lines. Traditional management practices that were established even 20 years ago need to be re-evaluated, if we are to capture the full economic potential of the modern breeding sow and her offspring, in terms of greatly improved nutrient utilization.

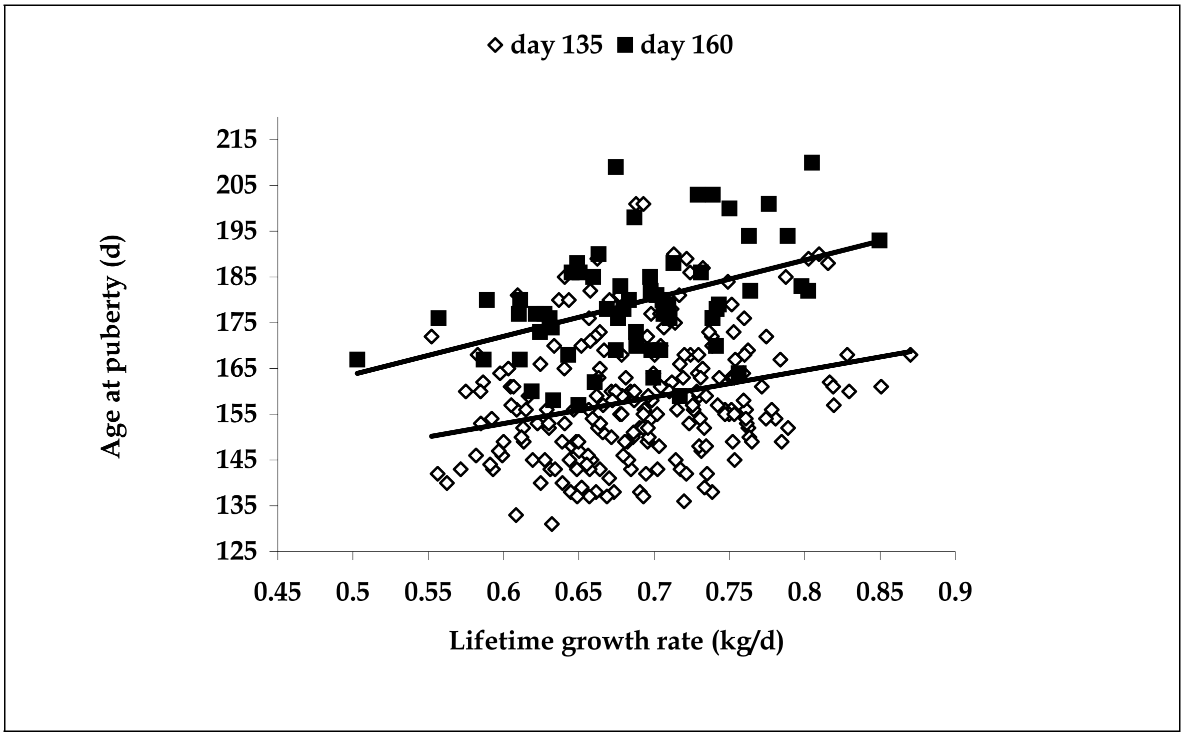
If we look at the relationships between growth and sexual maturation, the earlier data of Beltranena et al. (1991) suggested that only when growth rate was below 0.55 kg/day from birth to onset of boar stimulation at 160 days of age, was there any delay in onset of pubertal estrus (Figure 1).

Figure 1. Relationship between growth rate and age at pubertal estrus in gilts first stimulated with boars at 140 days of age. (After Beltranana et al., 1991). Feed restriction in gilts achieving a lower growth rate was associated with a delay in the onset of puberty.



The more recent data in Figure 2, from a study of Genex grandparent females, and their F1, terminal-line, progeny at the University of Alberta support these conclusions, and the generalization that with unrestricted feeding during the grow/finish phase, it is unlikely that growth rate in commercial dam-line gilts will limit age at the onset of first estrus. Furthermore, the data in Figure 2 emphasize that age at first estrus is very largely dependent on the age at which effective stimulation with boar pheromones and direct boar contact is applied (See Patterson et al., 2002b). Recent comments that pubertal estrus is occurring at older ages in today's commercial dam-lines seems to us to have little substance, unless of course boar stimulation is delayed.

Figure 2. **Effect of puberty stimulation in the gilt commencing either at 160 d (Closed squares; ■) or 135 d (Open diamonds; ◊) of age. Both sets of data indicate that the highest growth rates achieved by feeding gilts ad libitum with diets aimed to maximize lean growth potential may result in a delay in the onset of first estrus. (Data from Patterson, 2001).**



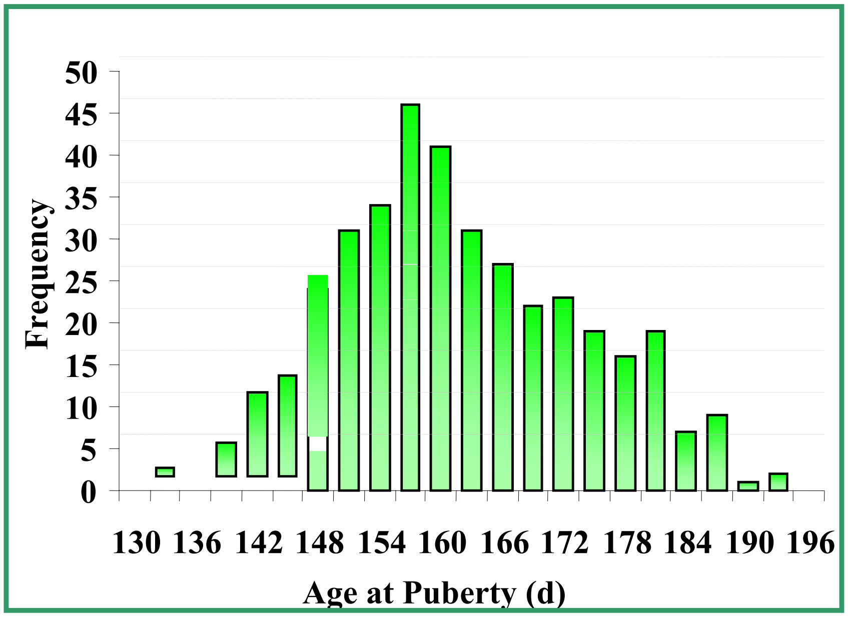
The true distribution of age at first estrus is clearly evident when one re-plots the data in Figure 2 for the F1 gilts that were first exposed to boar contact at 135 days of age, as in Figure 3. Age at pubertal estrus is now seen to be almost normally distributed, with some gilts reaching puberty within days of first boar contact, whilst other gilts may only show pubertal estrus after 50 days of continuous boar contact. However, the data in Figure 3 seem to support the curvilinear "best fit" to the data shown in Figure 1, suggesting a tendency for the highest growth rates to be associated with a marginal delay in pubertal estrus. This may be problematic, in that late maturing and fast growing gilts may become overweight by the time they are bred, and as discussed later, this is one of the major risk factors for poor retention in the breeding herd (Williams et al., 2005).

Finally, to reinforce the view that the growth performance of most commercial dam-line gilts is unlikely to place any constraint on the onset of pubertal estrus, and that pubertal estrus can still be induced at a relatively early age with good boar stimulation, the data in Figure 3 show comparable data from a gilt re-population study conducted in collaboration with the Prairie

Swine Centre Inc., involving PIC Camborough 22 gilts, provided good boar contact from a pen average of 140 days.

These data also serve to demonstrate the total lack of any relationship between growth rate and the population of gilts that did, or did not, have a recorded pubertal estrus within 40 days of commencing boar stimulation.

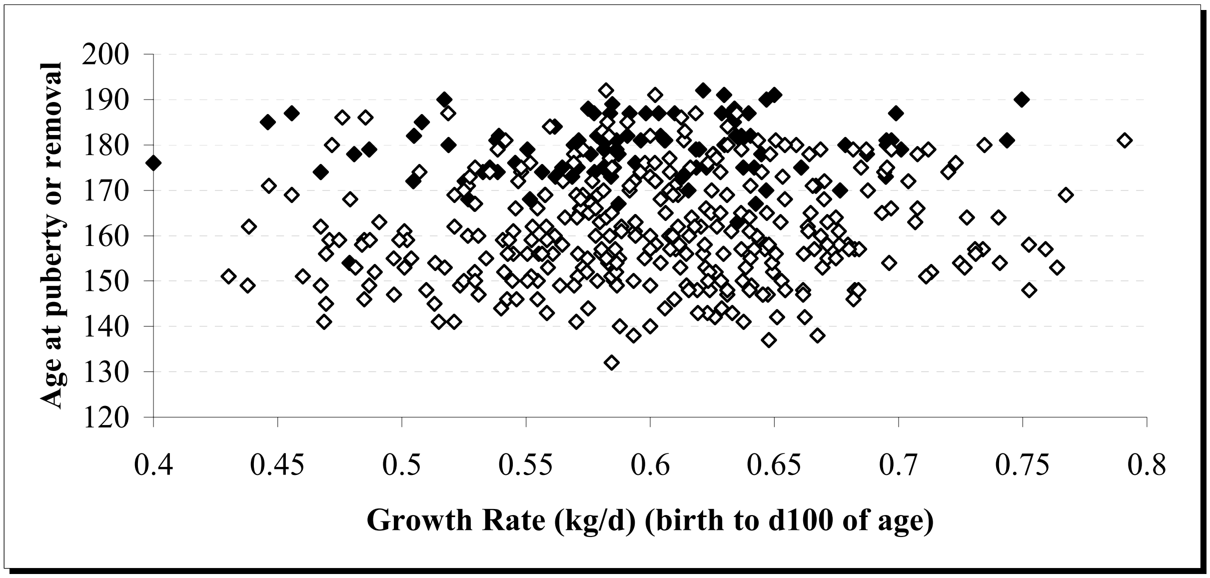
Figure 3. Normal distribution of age at first recorded heat (pubertal estrus) in Genex F1 gilts provided good boar contact from 135 days of age. (Data from Patterson, 2001)



The data presented above and in Figure 4 will hopefully confirm that onset of pubertal estrus has very little association with gilt body weight in gilts grown with unrestricted feed intake. Therefore, in terms of physical maturity, assuming that some arbitrary age will succeed in defining the physical development of gilts at stimulation or breeding is a dangerous assumption. Gilt pool managers seem to ignore the enormous variation in growth rate among groups of gilts, and also the rather uncertain relationship between weight and back-fat. The extremes that were encountered at the time of first recorded estrus in the gilts shown in Figure 3, are shown in Figure 5.

The extremes of sexual maturity and growth rate (boar induced first estrus at around 130 days of age and a growth rate of 0.64 kg/d versus puberty at 189 days of age and a growth rate of 0.80 kg/d) result in first estrus gilts differing in body weight by as much as 73 kg. In terms of gilt conditioning for physical fitness and longevity in the breeding herd, early maturing/slower growing gilts would need to be provided with high energy "fattening" diets to achieve 135 kg body weight and at least 18 mm of back-fat at breeding. In contrast, late maturing/fast growing gilts probably need to be subjected to restricted feeding during development to prevent excessive growth being a cause of lameness and eventual culling. The unavoidable conclusion from these data is that age is not a good measure of weight or fatness, **and the only way to be certain that gilts are at target weight for breeding is to weigh them!**

Figure 4. Relationship between growth rate and age at puberty in response to daily boar stimulation from 140 days of age (open diamonds). Gilts not recorded in estrus by 180 days were designated Non-Responders (closed diamonds). (Prairie Swine Centre and University of Alberta, Swine Technology and Research Centre, unpublished data, 2003).



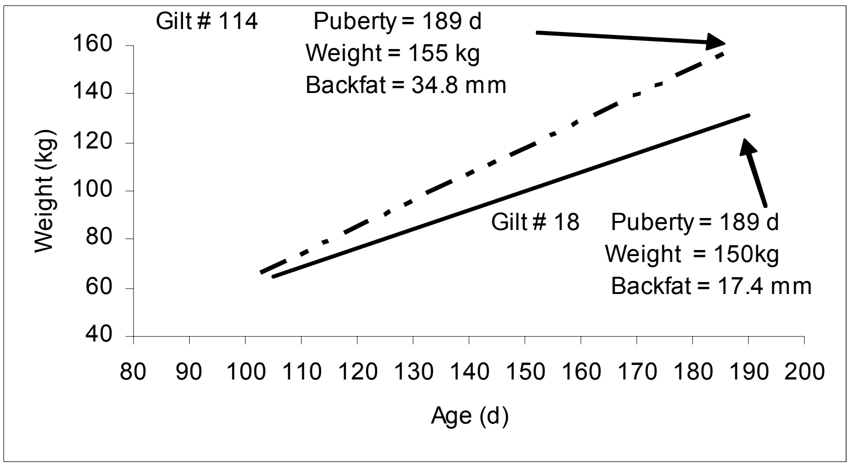
As age at sexual maturity can also vary from 130 to over 200 days, it is impossible to set some arbitrary age and assume that this defines some general level of sexual maturity. Clearly, by starting to assess whether gilts will show a standing heat in response to boar contact at over 200 days, there is little opportunity to determine the relative sexual maturity of individual females. The only benefit from introducing boar contact at such a late stage is the very short period over which pubertal estrus will be observed. However, very efficient boar stimulation programs can involve relatively little labor input per gilt bred, and yet increase the lifetime performance of truly "select" gilts substantially.

The lack of any reliable association between age, and onset of sexual maturity or body weight, implies that these essential benchmarks must be assessed independently in a well-managed GDU and used to allocate gilts to appropriate breeding groups. The aim should be to have gilts as sexually mature as possible before target breeding weight is reached, with the minimal requirement that breeding occurs at least at second estrus. Excluding slower growing gilts may also be cost effective, because, as shown in Figure 6, the number of NPD required to bring these gilts to a target breeding weight can be substantial.

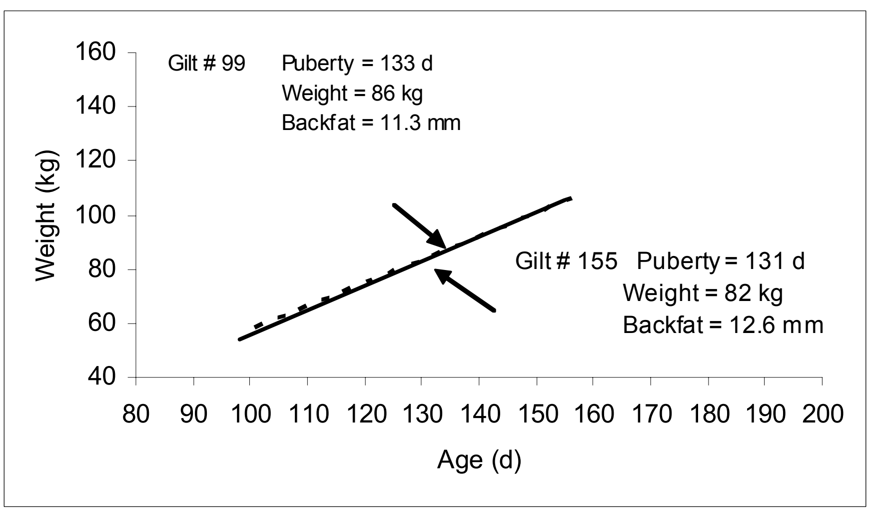
Based on these results, we suggest that a minimum growth rate (> 0.6 kg/day) be achieved at the time of entry to the puberty stimulation phase of GDU management, because 1) excessive NPD to reach target breeding weight results in a lower availability of eligible gilts to breed/pen space/day, and 2) we frequently observe that when gilt breeding targets cannot be met, gilts that are well below the target breeding weight are "pulled forward" and bred anyway. Eventually, these lightweight gilts end up as weaned parity 1 culls and are a major contributor to triggering the "death spiral" that results in excessive annual replacement rates in many breeding herds (see Williams et al., 2005).

Figure 5. An illustration of the extremes of performance within a contemporary group of commercial dam-line gilts provided with direct boar contact from 135 days of age to stimulate onset of first estrus. (Data from Patterson, 2001)

(a)



(b)



Interestingly, the earlier studies of Beltranena et al. (1993) already indicated that the fatness of the gilt was unrelated to the rate of sexual maturity, and this conclusion has also been supported in subsequent experiments. Moreover, in most gilt pools, there is usually a very weak association between weight and measured back-fat, as shown in Figures 7 to 9. Thus, from a management perspective, simply relying on an increase in overall body weight to produce a predictable change in back-fat in all gilts, or to assume that some arbitrary age will be associated with target levels of back-fat in all gilts, is unrealistic.

Consideration of Differences among Dam-Lines (Genotypes)

A question that is frequently asked, and for which the industry has failed to provide adequate data, is the extent the phenotypic relationships described above differ among major commercial dam-lines. Based on recent collaborative studies with two major dam-lines, we conclude that the phenotype of the gilts and first parity sows clearly reflects the extent to which selection for increased lean tissue gain is reflected in these terminal dam-lines. As can be seen in Figure 6, the level of fatness (back-fat measured at the P2 position in both cases) during gilt development tends to be different. Furthermore a maternal weight gain of 50 kg from breeding to farrowing results in a very different response in back-fat gain.

Figure 6. Actual weight and growth rate at 140 days of age shown in relation to the observed and independent age at which pubertal estrus was observed. The number of estrous cycles needed to bring each category of gilt to a target breeding weight of 135 – 150 kg is then indicated. (Prairie Swine Centre, and University of Alberta, Swine Research & Technology Centre, unpublished data 2003).

Growth Rate (kg/d) at 140 d of Age	Weight (kg) at 140 Days of Age	Age at Puberty: 160	165	170	175	180	185	190
0.50	70	143	135	138	140	143	145	148
0.55	77	146	137	140	142	145	136	139
0.60	84	146	137	140	143	146	136	139
0.65	91	145	135	138	141	144	148	137
0.70	98	141	145	148	137	141	144	148
0.75	105	136	140	143	147	135	139	143
0.80	112	145	149	136	140	144	148	152
0.85	119	136	140	145	149	153	157	162
0.90	126	144	149	153	158	162	167	171

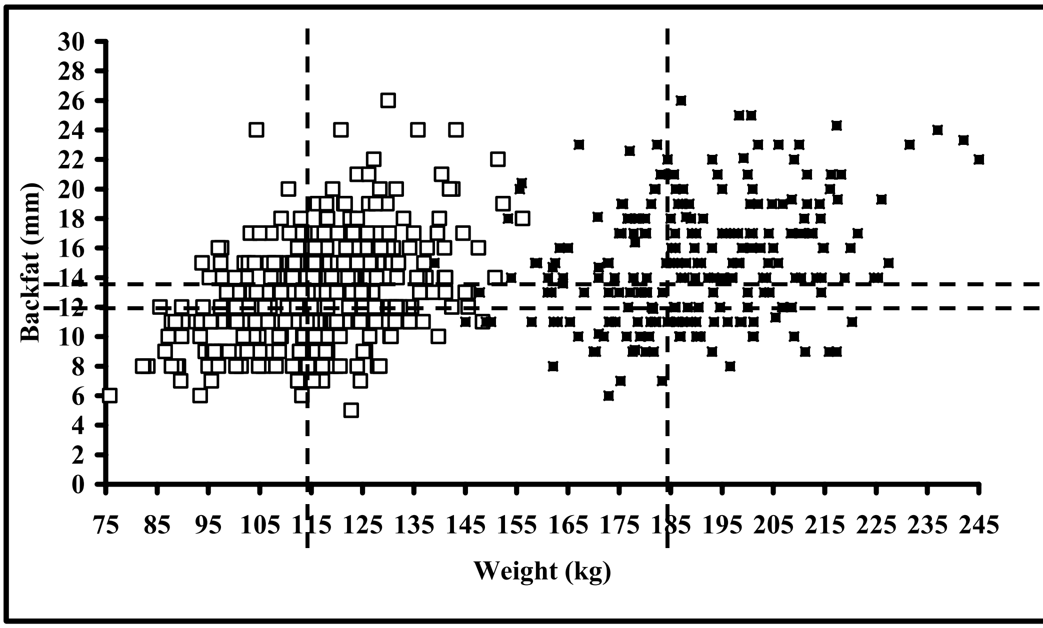
PREDICTED ESTRUS

1st estrus ■ 2nd estrus ▤ 3rd estrus □ 4th estrus ▥ 5th estrus ▦ 6th estrus ▧ 7th estrus ▨

The critical question then becomes, to what extent is this relative leanness of the terminal dam-line likely to affect lifetime productivity of the sow? From existing data, it is hard to suggest that there are any inherent differences in lifetime reproductive performance that can be ascribed to the relative leanness of the sows *per se* (Williams et al., 2005; Figure 8).

Figure 7. Associated changes in sow body weight and back-fat in (a) Camborough 22 and (b) Genex gilts between breeding and farrowing. Dashed lines indicate average weight and back-fat at each time. (Unpublished data, University of Alberta, 2005)

(a)



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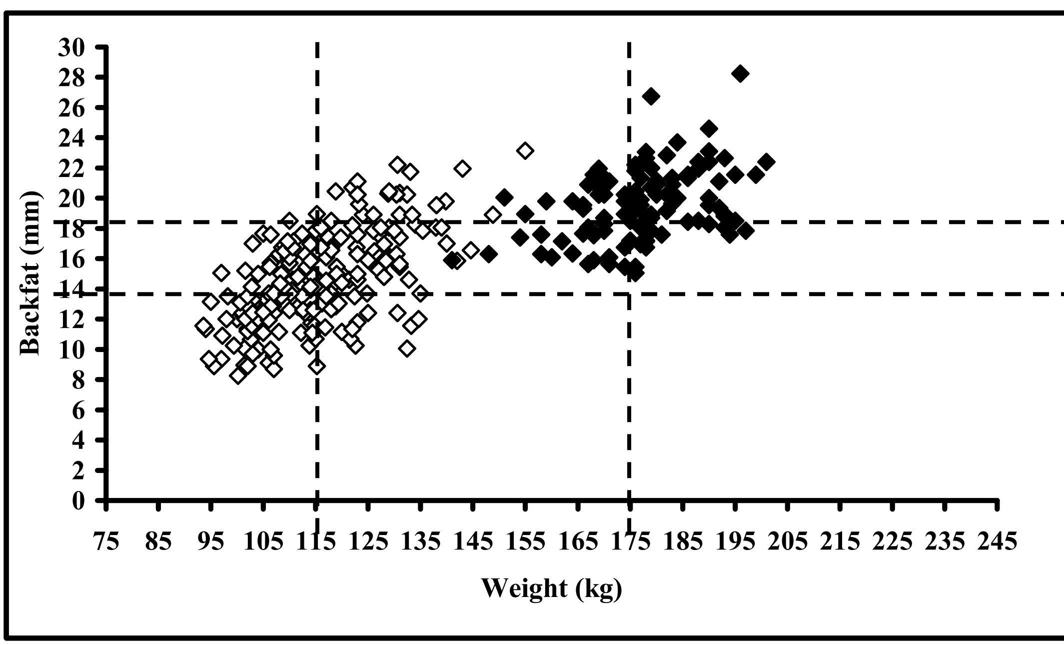
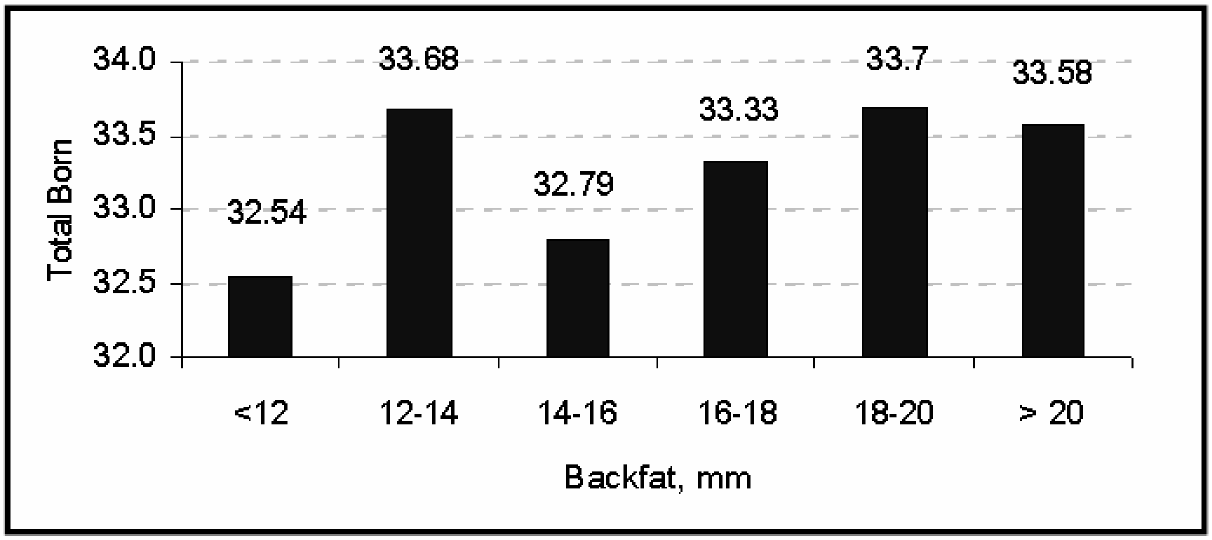


Figure 8. Impact of back-fat at first service on total born through three parities in a large-scale study of Camborough gilts. (Williams et al., 2005)

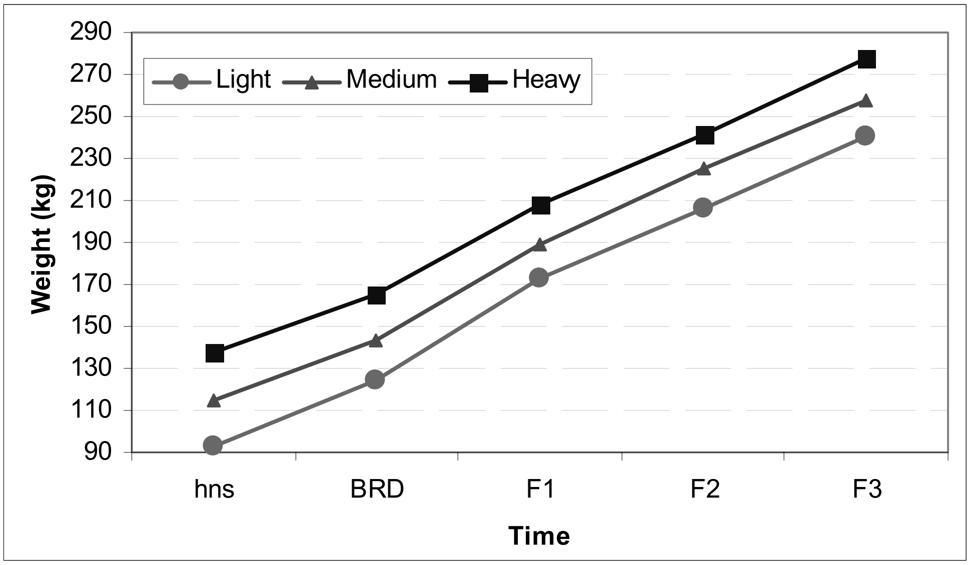


Similar data were reported for the relationship between initial breeding weight and productivity over three parities (Williams et al., 2005). The lack of a consistent relationship between overall sow body weight and back-fat thickness is also seen in data collected over three parities from the gilts shown in Figure 6a. The changes in sow body weight and back-fat over three successive parities, for those sows that were available to record data on each occasion are shown in Figure 8a and 8b, respectively. As can be seen, because gilts were bred by design at third estrus, and the lack of any relationship between body weight and rate of sexual maturity once the critical threshold has been passed, this resulted in a wide range of body weights at breeding and immediately after farrowing their first litter. In general, the pattern of increase in lean body mass over successive parities would meet most conventional targets (Figure 9a), and the changes in measured back-fat were variable and lower than would be suggested as ideal even for the Camborough sow. However, as discussed earlier, the lower than targeted levels of back-fat do not seem to be critical for sow longevity in the breeding herd, or for sow lifetime productivity.

A notable feature of the data shown in Figure 9a is the persistent difference in sow body weight over three parities, despite the fact that management practices in this herd would allow feed intake in gestation to vary with respect to perceived weight and body condition of the sows after breeding. This emphasizes the need to focus on entering gilts into the breeding herd at known and recorded weights, as probably the only reliable way of insuring that lifetime changes in sow weight will be consistent with longevity and good lifetime productivity.

Figure 9. **Mean body weights of gilts bred at third estrus, regardless of body weight, with the data representing the body weight (a) and back-fat (b), respectively, for the lowest, the middle and the highest 10% of gilt weights when first recorded as heat-no-serve after introducing direct contact with boars at 140 days of age when first bred.**

(a)



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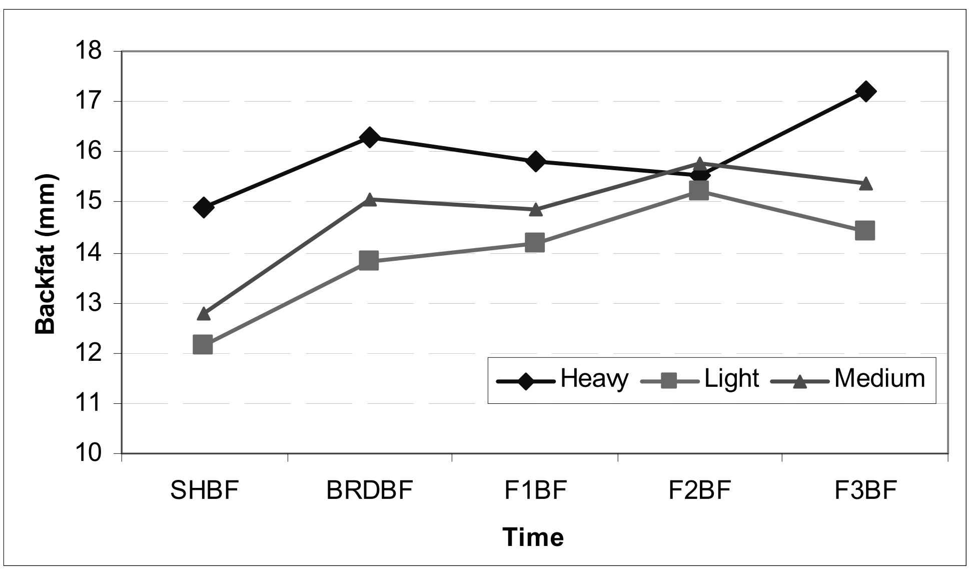

PHYSIOLOGICAL LIMITATIONS TO MAXIMIZING LIFETIME PRODUCTIVITY

As shown in Tables 3 and 4, the performance of contemporary dam-line sows is truly astounding! Their ability to tolerate massive loss of body tissues as a result of experimentally imposed feed restriction at peak lactation, with relatively little effect on many measures of post-weaning fertility, needs to be recognized. Equally, the reality that sows can deposit and mobilize lean tissue, with little impact on fat tissue depots, requires us to accept a new biological paradigm and to manage these sows accordingly.

Table 3. Sow and litter production data for a recent experiment to study the mechanisms mediating effects of tissue catabolism in first parity sows subjected to restricted feed intake from day 14 – 21 of lactation (Restrict) or fed close to appetite until weaning (Controls) on subsequent fertility. (Data are Means ± SEM). (Unpublished data of Vinsky et al., Swine Reproduction-Development Program, University of Alberta, 2004)

Item	Control (n=17)	Restrict (n=17)	P value
Sow data			
Farrow weight (kg)	189.8 ± 12.4	189.1 ± 14.3	0.89
Farrow Backfat (mm)	19.8 ± 3.0	20.5 ± 3.0	0.49
Weight loss (kg)	9.17 ± 6.66	22.35 ± 7.73	<0.0001
Lactation Backfat loss (mm)	1.29 ± 2.51	2.74 ± 2.09	<0.08
Litter data			
Litter Size (piglets)	9.41 ± 0.80	9.47 ± 0.72	0.82
Initial weight per pig (kg)	1.46 ± 0.29	1.36 ± 0.20	0.20
Total weight gain per pig (kg)	5.05 ± 0.53	4.63 ± 0.51	<0.03

Table 4. Embryonic survival and other reproductive characteristics in sows at day 30 of gestation. Data are from the same experiment for which production data are presented in Table 3 and all sows were bred using standard artificial insemination procedures are the same pooled semen after weaning. (Data are Least Square Means ± SEM).

Item	Control (n=16)	Restrict (n=17)	P value
Wean-to-estrus interval (days)	5.29 ± 1.26	5.41 ± 1.33	0.79
Ovulation rate	18.25 ± 0.65	18.24 ± 0.63	0.99
Live Embryos	14.43 ± 0.78	12.29 ± 0.76	<0.06
Embryonic Survival to d30 (%)	97.59 ± 6.76 *	77.34 ± 6.56*	<0.04
Number of Males	7.75 ± 0.59	7.53 ± 0.57	0.79
Number of Females	6.50 ± 0.57	4.71 ± 0.56	<0.04
Proportion of male embryos (%)	58.34 ± 4.52*	67.47 ± 4.38*	0.16

* Arcsin transformed data are presented

These results are typical of similar experiments conducted in lactating and weaned sows in our laboratory over the last 10 years and show the extent to which lean tissue is mobilized to meet the demands of milk production during the first lactation, and in comparison, the small and usually non- significant changes in backfat. Compared to earlier reported impacts of the "thin sow syndrome" on subsequent fertility, contemporary first parity weaned sows show very different responses. The relatively minor impact of sow tissue catabolism on the weaning-to-estrus interval, with variable effects on ovulation rate, shows the resilience of these sows from a reproductive perspective. Second parity litter size is usually decreased in sows that are catabolic at weaning due to increased embryonic loss, but within a single estrous cycle, sows subjected to "skip-a-heat" breeding show excellent productivity (Clowes et al., 1994).

Parallel selection for improved lean growth performance and sow fertility seems to have resulted in a fairly characteristic response to lactational catabolism in contemporary dam-lines. The tendency for only a marginal delay in the return to estrus results in inadequate follicular development by the time that ovulation is triggered (Zak et al., 1997a). The associated lack of oocyte maturity and endocrine changes over the peri-estrous period are key contributors to reduced litter size (Zak et al., 1997b). Management strategies for the breeding sow herd must increasingly recognize the changes in lean growth performance in contemporary dam-line sows (see Willis et al., 2003), and the changes to even traditional hormone therapies that would historically be expected to improve weaned sow fertility (for example see Kirkwood et al., 1998; Foxcroft, 2004). Accepting the risk of being considered somewhat heretical, most of our recent experiments with the lactating and weaned sow lead to the conclusion "**that from a fertility and prolificacy perspective, fatness is simply not the key risk factor"!** In contrast, lean tissue mass is a key consideration for correct management of the gilt, and the lactating and weaned sow, and the experimental evidence to support this contention has been clearly established (Clowes, 2003 a,b; Quesnel and Prunier, 2003).

CONCLUSIONS

Implementing an effective gilt pool management strategy will allow producers to meet targets for body condition (weight, back fat) and physiological maturity (age, estrus at breeding) at 1^{st} service, and ultimately reduce annual replacement rates (target for top 30% of breeding herds should be <50%), improve sow "fitness", decrease sow death losses, and increase labor efficiency and space utilization. Furthermore, all these advantages can ultimately be achieved whilst maintaining economic efficiencies of smaller, well managed, breeding herds.

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