MANAGING REPRODUCTION - CRITICAL CONTROL POINTS IN EXCEEDING 30 PIGS PER SOW PER YEAR

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ABSTRACT

Producing 30 pigs weaned per sow per year (PSY) is now within the reach of many progressive pig units in Europe, Canada and the USA, with some enterprises already achieving this output. If the current rate of progress continues, then 30 PSY will become the average output for Denmark by around 2020. In Denmark, genetic selection for number born alive has been the key driver of increased sow productivity, but this has come at a price with pre-weaning mortality rates of 14%, as one of the highest amongst EU countries. Improvements in sow productivity will be achieved in most countries by a combination of measures, which include reductions in non-productive days through better management of the insemination step, adoption of higher standards for AI, timely introduction of gilts and culling of barren sows, combating seasonal infertility, reducing piglet losses before weaning, protecting high health status and having in place trained, skilled, rewarded and motivated stock people.

INTRODUCTION

In Rick Stein's French Odyssey (2005), his opening for cassoulet begins:

A recipe of cassoulet is a bit like a recipe for bouillabaisse: difficult because everyone has their own version and much intolerance abounds. The essence of it seems to me to be the symbiosis of pork, duck fat, beans and garlic, and as with other famous dishes I see my job mainly as removing unwanted ingredients to get back to the essence of what the original dish was about.

This sentiment could equally apply to the plethora of published protocols on sow breeding, insemination, natural or artificial, nutrition and feeding to maximise piglet output on units aspiring to reach the lofty 30 weaned per year seen on a small but increasing number of enterprises in countries like Denmark. Like successful recipes, successful sow-breeding protocols are based on a few key ingredients; an absence of one is a recipe for failure.

To get to the essence of achieving or even exceeding **30 pigs weaned per sow per year** (30 PSY), the critical components are:

1. Fit, fertile and fecund females in oestrus.

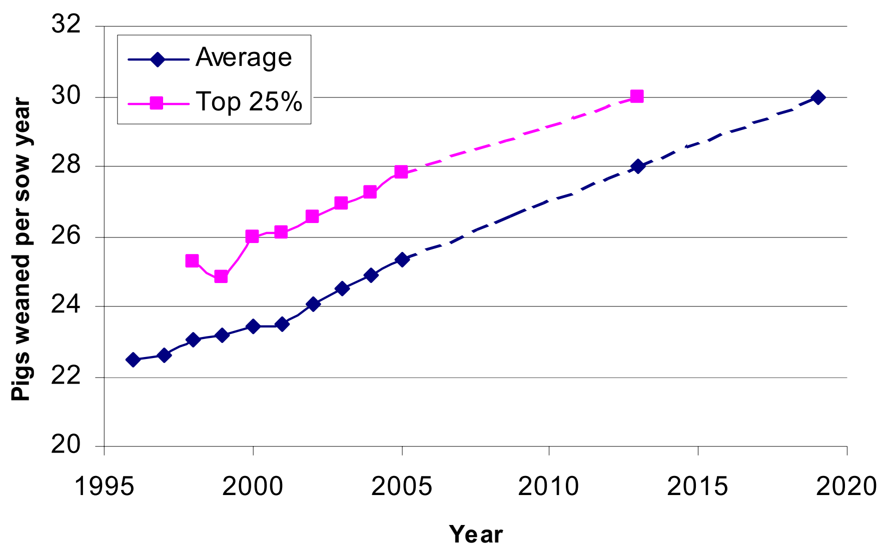
2. Delivery of fertile sperm in the right number, at the right time and in the right place to guarantee conception and maximum number born alive and viable.
3. Minimum number of non-productive or empty days.
4. Maximum number weaned and ultimately finished.

The collective contribution and responsibility of farm staff, vets, geneticists, and nutritionists is to ensure that these components are in place if the objective of 30 PSY is to be met. The importance of disease control, health and welfare management, genetics, nutrition and feeding and staff training will be considered briefly in this context.

30 PSY: The Race Is On

The national average number of pigs weaned per sow per year remains a key statistic in comparing how well a particular country is performing in the pig productivity race. If 30PSY is the winning line then at present there is little doubt that at current progress of around +0.5/year weaned, Denmark will be first to cross it in 2020 (Figure 1). Within Denmark and in other advanced pig producing countries there will be examples where individual producers have already reached 30PSY (Jensen, 2004) and as industry leaders they will take the top 10 or 25% of producers to reach the winning line earlier. These data provide assurance that the 30PSY is a realistic goal for many advanced pig producing countries.

Figure 1. Current and projected sow productivity trends in Denmark.



Resolving 30PSY

The average number of pigs weaned per sow per year (PSY) in a herd is a function of empty days (E), number of piglets born alive per litter (N), % pre-weaning mortality (M), lactation length in days (L), the weaning to conception at first oestrus interval in days (W) and the constant (K_1) gestation length in days where:

$PSY = (((365- E)/(L + W + K_1)) \times N) \times ((100-M)/100)$

On most farms W is a variable but holds considerable potential for reduction and control to a constant ($K_2 \leq 7$) through correct management of sows during lactation to limit weight loss. As K_1 is fixed at 114, and changing L has operational and throughput consequences and can influence N, the major drivers of PSY are E, N and M. If PSY $\geq$ 30 then:

E must be $\leq$ 30, giving a farrowing rate of > 90%.
N must be $\geq$ 14.
M must be $\leq$ 8.

In other words with a lactation length of 21 days, to achieve 30 or more pigs weaned per sow per year, the number of empty or non-productive days per sow per year should be under 30 giving a farrowing rate exceeding 90%, number born alive per litter should exceed 14 and pre-weaning mortality should be less than 8%. At farm staff level, the greatest return on investment and effort will come from minimising E, then minimising M and in partnership with commercial geneticists, vets and nutritionists in maximising N.

READY TO BREED FEMALES FIT FOR PURPOSE

This area has been covered in detail in the companion 2007 London Swine Conference paper: *Nutritional Management of the Gilt for Lifetime Productivity - Feeding for Fitness or Fatness?*

INSEMINATION AND CONCEPTION. ANY TIME, ANY PLACE, ANYWHERE?

Not unless by accident, as evolution has defined a set of conditions or events under which spermatozoa and oocytes may unite to establish pregnancy. Although incremental advances in reproductive technology have been made, our understanding of these events has not changed fundamentally in over 30 years nor have the key management steps to improve sow productivity, for example as published by (English et al., 1982). These have been summarised below, with further detail on current practical know how covered in the joint paper by Doug Wey and discussed during Session 2 of the conference.

An important point is that there is considerable between animal variability around each reproductive event and an understanding of this is a vital element for the successful management of the reproductive process. For example, only a well-trained, skilled and experienced person can detect subtle differences in the stage, duration, expression and intensity of oestrus between individual sows and is therefore able to maximise conception rates and sow litter productivity.

Table 1. **Summary of reproductive events before conception and management inputs.**

Reproductive event	Brief description	Key management inputs to maximise sow output
Oestrus	Is the period during which the sow will allow service by a boar. The average duration of oestrus in sows is 50 hours, with a range of 32 to 69 hours. Signs of oestrus are widely documented.	Oestrus stimulation. Management (nutritional and environmental) to advance the attainment of puberty and rapid return to oestrus following weaning of the litter. Boar exposure. Accurate and timely detection of gilts and sows in oestrus **and** showing the standing reflex.
Ovulation	Shedding of oocytes (eggs) from the ovary into the oviduct and occurs around 70% into the duration of the standing heat. Oocytes remain viable for about 6 to 8 hours after ovulation.	Nutrition to optimise quality and number shed. Timely insemination.
Insemination	Delivery of sperm into the female reproductive tract, naturally or artificially	Timing and minimum stress.
Sperm transportation	Transport of sperm by uterine contraction to the oviduct, taking around 2 hours after insemination.	Timely insemination and minimum stress
Capacitation	Membrane and biochemical changes in sperm cells on exposure to sow reproductive fluids before conception can occur. Takes around 2 to 4 hours after insemination.	Timely insemination.

Timing is Everything

Our understanding of the variation surrounding the timing of reproductive events in sows has helped greatly in targeting the timing of insemination to optimise conception rates and litter productivity. From a review of the literature (e.g. Weitze et al., 1994; Kemp and Soede, 1996; Steverink et al., 1999; Rozeboom, 2001) the key findings are:

- Boar exposure is critical to the timely detection of oestrus for AI but frequency and duration of exposure can influence the sow's oestrus response, for example the occurrence of refractory behaviour from excessive exposure.
- The average duration of oestrus in sows is 50 hours, with a range of 32 to 69 hours. At individual farm level, the range can be from 1 to over 90 hours.
- Duration of oestrus is farm specific, and can be predicted from month to month with a repeatability of 86%.
- Duration of oestrus decreases as the weaning to oestrus interval increases, from 56 hours at 4 days to 46 hours at 6 days.
- The high variation in duration of oestrus results in a high variation in the interval from onset of oestrus to ovulation. Onset of oestrus is therefore not a good predictor of optimal timing of ovulation.
- Sperm are only viable in the female tract for 24 hours.
- Majority of ovulations occur at the beginning of the last third of standing heat.
- Sows inseminated between 0 and 24 hours before ovulation show consistent high fertilization results with 91% normal embryos.
- Where only one insemination has taken place, insemination after ovulation decreases farrowing rate and litter size.
- Farrowing rate is 7% higher for double instead of single artificial inseminations.
- The negative relationship between the weaning to oestrus interval and litter size might be related to suboptimal AI timing relative to ovulation, rather than reduced fertility.

The implications are:

Precise knowledge of the timing of ovulation for each sow would be a powerful tool in the management of farm AI to optimise sow productivity but at this stage such a tool is not widely available.

Timing of AI should be tailored to the individual farm, as duration of oestrus and the weaning to oestrus interval is farm specific.

Farms with short oestrus durations should review factors that may be causing an extended weaning to onset of oestrus interval, such as boar contact and sow body weight loss in lactation. Short oestrus durations narrow the critical window for optimum AI timing relative to ovulation.

Where AI timing is compromising sow productivity, monitoring of the duration of oestrus in a proportion of the sows could retrospectively assist whole herd AI management, as duration of oestrus within farms has high repeatability from month to month.

Insemination Standards

Investment in the gilt and sow is wasted if the quality of the semen is substandard, because the boar is infertile, or in the case of artificial insemination (AI) protocol standards have not been followed at any point between collection of the ejaculate and insemination of the sow.

Doug Wey will cover detailed practical aspects of good insemination standards in his paper, but for completeness they include the following principles:

- Boar nutrition, health, husbandry, housing, age and work load.
- Semen collection and extender protocols, covering biosecurity and hygiene, and temperature control.
- Semen quality assessment.
- Semen storage and transportation.
- Recording and traceability.
- Sanitation and hygiene during insemination.

FILLING EMPTY DAYS

My glass is half full but for each day that a sow remains empty or non-productive costs nearly $4.60 (Peet, 2004). For a herd achieving 30 PSY, limiting empty days is a critical control point, should each sow on average gain one non-productive day (NPD), then annual output for a 500 sow unit will fall by 45 piglets weaned. In herds where sow productivity is limited by empty days, one or more of the following weaknesses may apply:

- Delayed return to heat.
- Failure to detect heat.
- Failure to conceive.
- Failure to detect sows returning to heat.
- Failure to promptly cull non-productive or barren sows.

There may be many underlying causes for the above, but the effort for overcoming them is a point for further discussion and include:

- Maintaining all breeding stock in a healthy and fit condition, including the provision of housing and flooring that avoids physical injury to legs and feet and loss of body condition.
- Nutrition and feeding in lactation to avoid excessive weight loss and reduce the weaning to first service interval.
- Heat detection and timely insemination.
- Accurate identification of sows not in pig, based on careful observations for signs of discharge from day 14 to 15 after service, heat checking at days 18 to 24 using a mature boar, pregnancy diagnosis (PD) at 28 to 35 days and again at 49 to 56 days and daily visual PD beyond 70 days and up to farrowing.
- Aggressive culling policy for sows that fail to return and do not remain pregnant to a re-service.
- Management of the gilt pool to promote the onset of puberty, flow of replacement gilts into the breeding herd and minimise empty days from entry to conception.

The importance of nutritional management during lactation is often overlooked as shortfalls can have a profound effect on the ability of the sow to return to oestrus after weaning. Excessive maternal weight loss during lactation, resulting from inadequate feed intake and nutrient supply, is associated with an extended weaning to first oestrus or service interval, and a reduction in the size of the subsequent litter, particularly in first litter sows (King and Williams, 1984; King and Dunkin, 1986; Kirkwood et al., 1987; Koketsu et al., 1996; Eissen et al., 2003). Steverink et al. (1999) found that farrowing rate decreased by 2% and litter size by 0.4 for each day increase in the weaning to oestrus interval, additionally repeat breeders were found to have lower farrowing rates (73%) compared with sows inseminated during their first heat after weaning (86%). Concerted action here will pay dividends across the herd, as improvements in performance are likely to be seen in all animals.

The benefits of correct nutritional management during lactation are demonstrated (Table 2) by producer application of MLC's Stotfold Sow Feeding Strategy (MLC, 1998), which aims to enhance energy and protein intake using high nutrient diets (14.5 MJ DE/kg and 1% total lysine) and increasing daily feed allowance after farrowing in line with the appetite curve of each sow as a function of lactation day and numbers suckled.

Table 2. Sow productivity benefits from application of the Stotfold feeding strategy.

	Herds using Stotfold Feeding Strategy	All other herds
Number of herds	87	67
Av. Number of sows and gilts	218	216
Born alive per litter	11.05	10.79
Reared per litter	9.79	9.56
Reared per sow per year	22.5	21.6

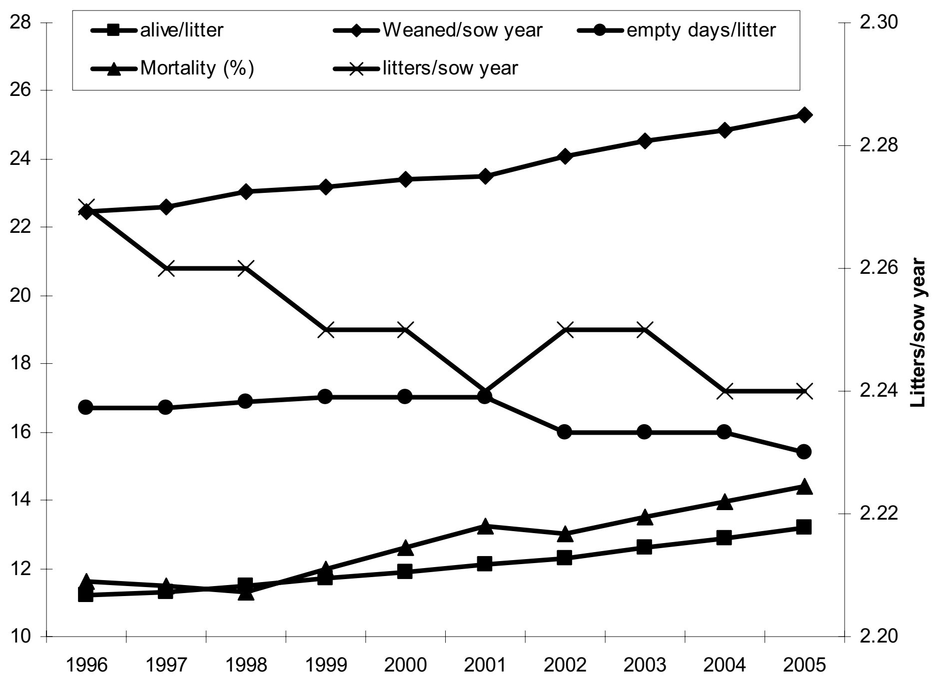
Source: MLC (1997)

Having emphasised the importance of reducing empty days, it is interesting to note that in Denmark, improvements in sow productivity in the national herd have been mainly made through increasing number born alive, as nationally the average number of non-productive days per litter and litters per sow year have remained almost static since 1996 (Figure 2). Nevertheless herds in the top 25% achieving 2.3 litters per sow per year and 27.3 PSY have around 4 fewer NPDs per litter than the national average of 15.4 for 2005.

MAXIMISING NUMBER WEANED

The number of piglets weaned per litter is a function of number born alive, number born viable and pre-weaning mortality. Many factors influence the out turn, some of which have been considered in this paper and others have been the subject of specific scientific papers and comprehensive chapters in generic pig textbooks. By far the greatest contribution to increasing number weaned has been genetic selection for number born alive as seen in sow productivity trends for a number of countries such as Denmark, France, Canada and the USA. At farm level there is considerable scope on many units to reduce pre-weaning mortality.

Figure 2. **Trends in the components of sow productivity in Denmark.**



Genetics

The success of Danbred's selection programme, using AI to create genetic relationships between breeding stock in different herds and enabling the efficient use of multi-trait BLUP, has underpinned Denmark's rapid improvement in sow productivity. The annual genetic gain of around +0.3 piglets born per litter reported in Danish Landrace and Large White purebred herds (Table 3) is a considerable achievement given that the mean heritability for number born alive is only 0.09 (Rothschild and Bidanel, 1998). Similar rates of genetic progress have been reported in France and the USA.

In 1997 the selection strategy in Denmark moved from total born alive to live at five days (LP5) and this has may help to decouple the unfavourable relationship between litter size and piglet weight at birth, and pre-weaning mortality. Genetic progress in LP5 averaged over 2001/02 to 2004/05 in Landrace and Large White purebred herds is reported at 0.17 and 0.23 per year respectively (Danske Slagterier, 2005).

Reducing Pre-Weaning Mortality

Average pre-weaning mortality rates in select European countries plus Canada and the USA are given in Table 4. These show higher rates in countries making greater progress in increasing litter size and a scope for reducing losses as demonstrated by performance within top herds.

Table 3. Litter productivity (2002/03) and annual genetic gain in Danish purebred herds.

	Piglets born per litter
Duroc[b]	9.8 (-)[a]
Hampshire[b]	8.1(-)
Landrace[c]	13.9 (0.33)
Large White[c]	12.9 (0.30)

[a]In parenthesis annual genetic gain.
[b]Sire lines.
[c]Dam lines.

Table 4. Pre-weaning mortality (%) of live born piglets (2004/05).

	Average	Top[a]
Denmark	13.95	11.9
GB	10.34	9.5
France	14.20	-
Netherlands	12.20	-
USA	12.88	12.87
Canada	11.74	9.40

[a] For Denmark top 25%, GB top third, USA and Canada top 10%.
Source: BPEX (2006); Danske Slagterier (2005); www.pigchamp.com

Much has been written on management techniques to reduce the loss of viable new born piglets before weaning. In essence the advice is based on:

- Determining the cause of loss, which in the absence of disease is mainly malnutrition and chilling.
- Corrective action, which mainly focuses on early access of underprivileged piglets to the sow's udder, the provision of thermal comfort and design of the physical environment to reduce the risk of sow crushing.

However, in a recent report on an epidemiological study of risk factors associated with pre-weaning mortality on commercial pig farms (Defra, 2005), crushing of healthy piglets was the major cause of loss (54%), with chilling and crushing of starved piglets accounting for less than 6% of total losses (Table 5). Most deaths (62%) occurred in the first 2 days after birth. The study concluded that the confinement of the sow in farrowing crates during lactation did not significantly decrease liveborn pre-weaning mortality and the most important factors in decreasing losses included the following:

- Stockperson characteristics.
    - Close attendance at farrowing.

        - Monitoring of inter-birth intervals, mucus clearing, placing new born under heat lamps, teat provision, split suckling and cross-fostering within 24 hours after birth.
    - Checking pigs twice daily instead of once.
    - A positive stockperson-pig relationship.
- Good health and biosecurity.
    - Isolation of replacement stock before herd entry.
    - Avoid sows with excessive body condition scores (e.g. > 4.0).
    - Low incidence of lameness in sows.
- Temperature control of the farrowing unit.

Table 5. Percentage of piglets dying from different causes in a survey 122 commercial GB farrowing units.

Cause of Death	Number	Percent of deaths
Crushed healthy	1596	54.45
Low viability	399	13.61
Starved	197	6.72
Unknown	188	6.41
Crushed sick (secondary to starved or low viability)	135	4.61
Diarrhoea	107	3.65
Savaged	50	1.71
Lame	48	1.64
Accident	45	1.54
Suffocated in afterbirth	38	1.3
Congenital abnormality	38	1.3
Splay leg	29	0.99
Chilled	28	0.96
Disease	26	0.89
Navel ill	4	0.14
Tremors	2	0.07
Missing from sheet	1	0.03
Total	2931	100

Source: Defra (2005)

In the UK, the move to batch farrowing, pushed by the emergence of PMWS, has probably helped to reduce pre-weaning mortality by concentrating staffing effort, increasing the scope for cross-fostering and more importantly reducing the disease burden in farrowing units through improved sanitary and hygiene measures.

HEALTH MATTERS

Nothing matters more to the wellbeing and productivity of farmed livestock than biosecurity and their health status. In Britain, the catastrophic impact, either directly of new pig diseases

(PRRS and PMWS) or indirectly from the loss of national biosecurity through notifiable disease outbreaks (CSF and FMD), on productivity and in turn competitiveness, sends a clear message that health and biosecurity status must be rigorously protected at farm and national level.

The importance of farm biosecurity is illustrated by the findings of a retrospective cohort study of PMWS on pig farms in Great Britain (Green, 2005). It concluded that factors associated with an increased risk of herd breakdown included purchase of gilts, large herd size, not requesting three or more days pig freedom from visitors, proximity to a grower unit and, towards the end of the epidemic, proximity to a farm with PMWS.

The emergence of PMWS in East Anglia in 1999 and its subsequent and rapid spread north into Yorkshire and eventually Scotland caused serious losses, with mortality levels in weaned pigs on some units reaching 20 to 25%. Animal movement restrictions applied during the FMD outbreak in 2001 disrupted sow replacement policy and herd parity profiles on many units and on some units the effects of this are still felt today. Reduced producer returns, lack of confidence and business investment, coupled with the devastating impact of PMWS and FMD have effectively placed Great Britain at the bottom of the 2005 European league table of sector productivity and profitability (Table 6).

Table 6. Productivity and cost of production for 2005 in selected EU countries.

	Denmark	Netherlands	France	Ireland	Great Britain
Litters/sow year	2.27	2.33	2.24	2.28	2.22
Weaned/sow year	26.1	24.5	24.2	23.1	21.5
Finished/sow year	24.3	23.4	22.4	21.9	19.4
Carcase weight (kg)	80.2	89.9	90.7	76.6	76.2
Lean meat/sow year (kg)	1161	1157	1206	969	880
Cost of production (p/kg dead weight)	91.66	85.71	90.57	93.96	104.41

Source: BPEX (2006)

SKILLED PEOPLE ARE THE MOST IMPORTANT RESOURCE

The positive impact of trained and skilled stockpeople on the health and welfare, productivity and profitability of livestock, including pigs, often goes unrecognised. Training of new recruits and continuing education of all stockpeople is probably one of the most cost effective approaches to improving pig performance, (English et al., 1992). This is particularly true in the care and management of the sow, which requires a different set of complex skills at each stage of the breeding cycle to capture her reproductive potential and maximise litter productivity.

The value of training is demonstrated in a European study (English et al., 1999), which compared performance on commercial units before and after staff completed a structured training programme. On all three units training increased the number of pigs reared per sow per year by an average of nearly 2, representing a 13% improvement in sow productivity. The significance of positive stock worker input in reducing piglet pre-weaning mortality as reported in a recent epidemiological study (Defra, 2005) has been covered earlier.

In the UK and in other western European countries it is becoming increasingly difficult to meet the pig industry's demand for trained and skilled stockpeople and the recruitment of new entrants to the sector. With a population of 60 million in the UK, it seems inconceivable that we cannot find people to resource a national herd of around 440,000 breeding sows, with an increasing number of jobs being filled by workers from the former Eastern European Block countries following recent enlargement of the EU.

CLIMATE CHANGE

Next to disease outbreaks, climate change is potentially the most serious threat to pig productivity in temperate countries. In Britain around 25 to 30% of the breeding herd is managed on outdoor systems, where the provision of shade and wallows are the few effective means for relieving heat stress. The prediction is that 2007 will break last year's record of the hottest recorded to date. It is possible that long-term fertility levels under outdoor production may deteriorate under the effects of rising and extreme summer temperatures. Seasonal infertility can also affect indoor herds, for example in a herd of 1200, records over 4 years showed that the number of returns per month increased steadily from 60 in April to 120 in October (Mackinnon, 2006).

Future solutions for combating the negative effects of climate change on pig productivity are likely to be based on a number of approaches, such as housing design, genetic selection and nutritional management. One approach, which holds potential, is liquid feeding of lactating sows to maintain intake and reduce weight loss. Currently there are very few units in the UK which liquid feed lactating sows, and those which do report positive effects on sow body condition scores, rebreeding after weaning and piglet weaning weights. A number of UK producers are now experimenting with liquid feeding of outdoor sows, with some success. As well as reducing the impact of heat stress, this also eliminates the serious and widespread problem of feed loss through bird predation.

THE BRITISH PIG INDUSTRY

Sow productivity is the cornerstone of a competitive pig industry. As Britain's gap with Denmark has increased from 1.2 to 4.6 weaned and 1.6 to 4.9 finished per sow per year from 1999 to 2005 respectively, the formation of the British Pig Executive (BPEX) in 1999 resulted in the implementation of a Road to Recovery Strategy. This has as one of its current aims to increase sow output by around 3.5 finished per year in line with a 2009/10 weighted average for Denmark, the Netherlands, France and Ireland. Underpinning this strategic target have been a number of BPEX led initiatives (see www.bpex.org) which include:

British Pig Health Scheme
New Certificates of Competence for On Farm Training Initiatives
New BPEX AI Standard
Knowledge Transfer for Improving On Farm AI Techniques and Management
New field based KT Team of 6 staff, including a pig reproductive specialist

CONCLUSIONS

Thirty pigs per sow year is within the reach of many well managed and operated units as demonstrated by the few but increasing number of producers in advanced pig producing countries who are already achieving this level of output. The key to success includes a herd populated with fit, fertile and fecund females, timing and quality of each insemination, minimising empty days from gilt entry to first conception and thereafter for each weaning to conception interval and maximising number weaned. The tools required to achieve these objectives include expertise in genetics, nutrition, reproduction and health but these cannot substitute the skills and knowledge of experienced stockpeople who are at the coalface of delivering high performance targets.

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