THE ROLE OF FEEDING AND MANAGEMENT IN ENHANCING SOW REPRODUCTIVE POTENTIAL

W. H. (Bill) Close
Close Consultancy
Wokingham, United Kingdom

ABSTRACT

This paper reports on the role that nutrition and management may play in enhancing reproductive performance of the modern sow. Consideration is given not only to energy and amino acid needs, but also to the mineral nutrition of the sow. Practical guidelines are provided to ensure that the correct target body condition at first mating is achieved and that the nutritional needs are met during gestation and lactation. Ways to enhance appetite during lactation are suggested. The overall objective is to ensure that, as far as is possible, the sows achieve a good level of performance on all farms.

INTRODUCTION

Nutrition and management are key components that ensure the modern sow achieves her genetic potential for reproduction. In practice, the actual level of performance is well below the animal's capability and on many farms the norm is 20-22 piglets reared per sow per year, compared with the often quoted potential of 30 piglets per sow per year. Perhaps a more appropriate measure of reproductive performance is the number of piglets produced per sow lifetime, rather than per year, and target levels of 50-60 have been suggested. However, few sows achieve this and 30-40 piglets per sow lifetime is the norm on many farms.

Production targets for ‘good’ and ‘excellent’ levels of performance are suggested in Table 1. Approximately 10% of producers in many countries achieve excellent levels of performance; so why not more? The questions are: how can productivity be increased; how can losses be reduced and can nutrition and management be improved to increase productivity to acceptable levels? A number of factors that may help to achieve this are discussed in this article.

IMPROVING PRODUCTIVITY (OR REDUCING LOSSES)

To increase productivity it is important to know:

- What are the components of litter size?
- Where do losses occur?
- How can these be manipulated through nutritional and management practices?

Analysis of the results of several herd recording schemes, such as that of the Meat and Livestock Commission (MLC) in the UK (MLC, 1995-2002), would suggest that the major difference between the bottom- and top-producing herds is the number of piglets born and born alive, as well as the number of litters produced per sow per year (Table 2). Interestingly, the difference between the total number of piglets born and those weaned, was similar across all herds, regardless of the level of productivity. This perhaps suggests that, in order to improve performance, there must be an increase in either ovulation and/or fertilisation rate and a decrease in embryo losses, as well as knowledge of those factors that influence them. Similarly, in order to increase the number of litters per sow per year, there must be a reduction in the period between weaning and mating, as well as a reduction in the number of sows that return to oestrus.

Table 1. Production targets for the modern sow.

	Good	Excellent
Sow replacement rate (%)	40	35
Farrowing rate (%)	85	90
Litters / sow / year	2.3	2.4
Empty days * / year	<35	<20
Piglets born alive / litter	11.3	12.5
Piglets weaned / litter	10.2	11.3
Piglets reared / sow / year	23.5	27.0
Piglet weight at weaning ** (kg)	7.0	7.0
Litter weaning weight (kg)	71	77
Sow feed consumed / piglet weaned (kg)	50	50
Litters per sow lifetime	4	5

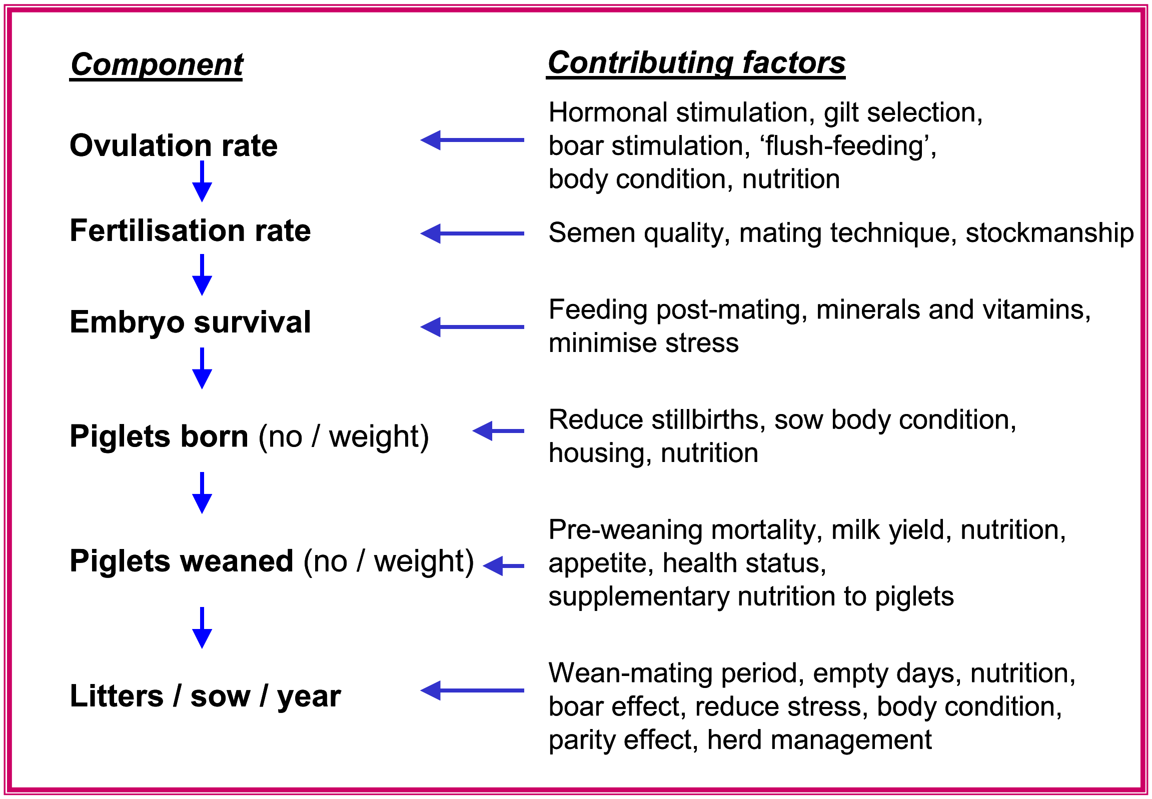
** A 7-day weaning – mating period has been allowed*
*** Piglets weaned at 23 days of age*

Table 2. Litter size in herds of varying productivity (MLC, 1995-2002).

	Bottom 1/3	Average	Top 1/3	Top 10 %
<u>Piglets</u>				
Total born	11.4	11.9	12.3	12.7
Born alive	10.5	11.0	11.4	11.8
Weaned	9.3	9.8	10.2	10.6
<u>Sows</u>				
Litters / sow / year	2.12	2.25	2.34	2.41
Piglets / sow / year	19.7	22.0	23.9	25.6
Non-productive days	53	37	26	13

If improvements are to be made and potential losses reduced, it is important to understand how the different components of litter size impact on reproductive performance and the major factors that influence them. These are outlined in Figure 1, demonstrating the importance of both nutrition and management.

Figure 1. Components of litter size in pigs, and contributing factors.



GILT CONDITION AND MANAGEMENT

The body condition of the gilt at first mating has a significant effect on sow lifetime performance. Animals that do not have sufficient body condition when first selected and introduced on to the farm generally fail to achieve a reasonable number of parities. The better the body condition, the better the lifetime performance of the animal (Gueblez *et al.*,1985; Gaughan *et.al*, 1995; Challinor *et al.*, 1996). The gilt must therefore be sufficiently mature, of appropriate body condition and have adequate reserves of lean and fat in her body. The latter is necessary not only to initiate the reproductive processes *per se*, but also to act as a buffer in times of nutritional inadequacy, when metabolic needs exceed nutrient intake. In addition, body reserves are also needed to protect the animal in poor environmental circumstances.

The young gilt should therefore be of sufficient age, size, maturity and achieve a certain target body condition at first mating. Suggested guidelines are:

- 220 - 230 days of age.
- 130 - 140 kg body weight.
- 16 - 20 mm P_2 backfat thickness.
- Mating at 2^{nd} or 3^{rd} oestrus.

To achieve these, it is suggested that the young breeding gilt be selected at ~60 kg body weight and put on a special gilt rearer diet and feeding regime, as indicated in Table 3. The best practical strategy to ensure maximum ovulation rate and embryo survival in gilts is to provide a high feeding level for the oestrus cycle before mating, that is flush feeding, followed by a low feeding level for the first 21 days post-mating (Ashworth and Pickard, 1998).

The gilt rearer diet should not only contain the correct level of energy and amino acids, but should also be fortified with specific minerals and vitamin that help to stimulate reproduction *per se* and ensure the strong bones and legs that are vital for a long breeding life. Culling because of leg and foot problems is common on many farms.

Table 3. Phased feeding regime for gilts.*

	Body weight (kg)	Age (days)	Backfat thickness (P_2 mm)	Mcal DE per kg diet	Lysine (g) per kg diet	Feeding strategy (kg/d)
Phase 1	25 - 60	60 - 100	- 7	3.25	12.0	*ad-libitum*
Phase 2	60 - 125	100 - 210	7 - 16	3.10	8.0	2.5 - 3.5
Phase 3	125 - 140	210 - 230	16 - 18	3.10	8.0	*ad-libitum*
Phase 4	early gestation	230 - 260		3.10	8.0	2.0

* These are suggested values. Body weight and backfat thickness may vary slightly, depending on genotype and environmental circumstances.

NUTRITION DURING GESTATION AND LACTATION

Designing a feeding and management strategy requires knowledge of the nutrient needs at all stages of the reproductive cycle. Tables 4 and 5 show the energy and lysine requirements of the sow during gestation and lactation. With this knowledge, diets can be formulated and feeding strategies implemented that take account of the individual needs of the animal at each stage of its reproductive cycle and in each type of production system. This is especially important for the modern hyper-prolific sow, where the aim should be to maintain body condition throughout her reproductive life.

During pregnancy, the objective should be to feed the sow a good quality gestation diet for a specified target body weight gain and increase in backfat thickness and to achieve a body condition score of 3.5 at parturition (scale 1-5). These targets change with parity and hence, so will the nutrient requirements, as shown in Table 4. However, the requirements increase as pregnancy progresses, especially in the last trimester of gestation when the nutrient demands of the rapidly-growing foetuses are high. This is illustrated for a gilt during its first gestation (Figure 2). It is therefore important to increase feed intake during this period to ensure a high rate of foetal growth, to maintain the sow in good body condition and to promote the proper development of the mammary glands, which are essential for good colostrum and milk production.

Table 4. Energy and lysine requirements of the sow during gestation (Close and Cole, 2000).

Body weight at mating (kg)	Net weight gain* (kg)	Energy (Mcal ME/day)	Lysine (g/day)	Feed (kg/day)
120	45	6.8	15.8	2.25
150	35	7.2	13.8	2.4
200	25	7.6	12.0	2.55
250	15	8.0	10.5	2.7
300	10	8.7	10.0	2.9

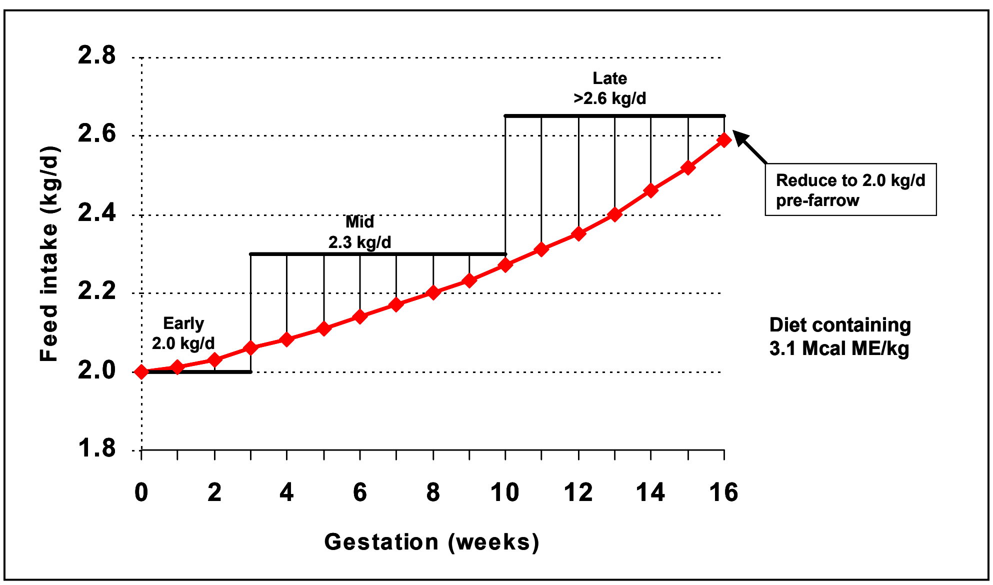
* Excludes growth of gravid uterus and mammary glands. Feed contains 3.0 Mcal ME/kg.

Table 5. Nutrient requirements during lactation (Close and Cole, 2000).

Body weight after farrowing (kg)	Energy (Mcal ME/day)		Lysine (g/day)		Feed (kg/day)	
	10 piglets	12 piglets	10 piglets	12 piglets	10 piglets	12 piglets
150	18.8	21.6	49.0	58.0	5.8	6.6
200	20.0	22.8	50.0	59.0	6.2	7.0
250	21.0	23.8	51.0	60.0	6.5	7.3
300	22.1	25.0	52.0	61.5	6.8	7.7

* Feed containing 3.25 Mcal ME/kg

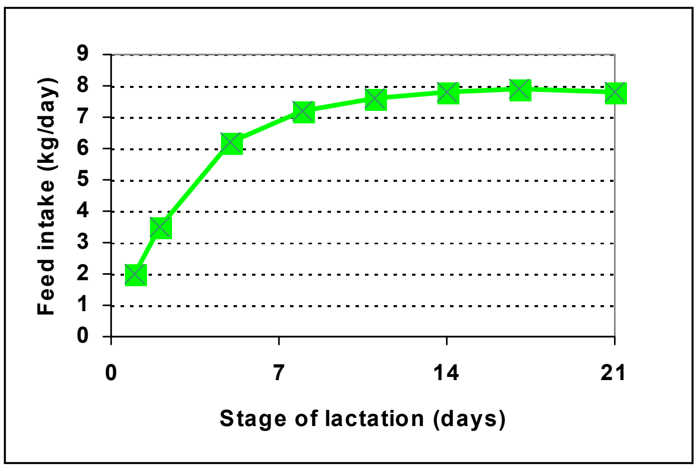
Figure 2. Feed requirements during gestation (parity 1).



During lactation, the objective should be to wean at least 10 piglets of good body weight, with minimal loss of body weight and body condition of the sow. Lactation is perhaps the most critical period in the life of the pig and the nutritional strategies implemented in this period influence both the growth and development of the piglets through to slaughter, as well as the subsequent reproductive potential of the sow and overall productivity.

The major objective of nutrition in lactation is to meet the requirement for milk production of the sow, which increases from about 3-4 L/day just after farrowing to 10-12 L/day in peak lactation. Indeed, the values presented in Table 5 are mean values throughout lactation, which do not reflect the increasing needs of the sow as the litter grows and hence milk yield increases. To match this increasing nutritional need, feed intake should be increased gradually during the first 4-5 days of lactation until the sow is consuming 4-5 kg/day when she should be fed to appetite (Figure 3). It is a good idea to provide a lactation feeding scale for sows of different parities and litter size and to have this on hand for each sow in the farrowing house.

Figure 3. Feed requirements during lactation.



200 kg sow at farrowing: 10 kg weight loss during lactation
Litter size: 10 piglets; piglet weight at 21 days: 7 kg

To achieve adequate intakes in lactation, it is important to use good quality diets and soundly-based feeding strategies. Some practical aids to achieving good feed intakes in lactation are listed in Table 6. It may be necessary to feed several times per day, as a sow fed only twice per day may not be able to consume sufficient nutrients to meet metabolic demands, especially in late lactation. On the other hand, it is important not to over-feed in early lactation, as this may limit the animal's voluntary feed intake in later lactation when the needs are greatest; it may also predispose the sow to MMA.

Table 6. Practical aids to enhance appetite.

- Feed a palatable, nutritious feed
- Feed a well-balanced ration of the appropriate nutrient specification
- Gradually increase daily intake over the first week, thereafter feed *ad libitum*
- Feed must be fresh, not stale or dirty
- Feed several times per day, or to appetite
- Pelleted feed is better than meal
- Ensure that fresh water is freely available at all times (consider wet-feeding)
- If nipple drinkers are provided, water flow rate must be >2 litres/minute
- Avoid exposing sow to high temperatures (<20°C) and reduce environmental stress
- Maintain good climatic control in farrowing house
- Do not overfeed in pregnancy
- Increase gut capacity by feeding high levels of soluble fibre in pregnancy diet
- Separate gestation and lactation diets are essential
- Ensure adequate feeding space
- Improve nutrient availability of diet
- Provide supplementary nutrition to piglets
- Reduce metabolic demand by cross-fostering or forward weaning
- Ensure good welfare and well-being of sow

A major limitation to achieving a good appetite during lactation is lack of water and water must always be provided in adequate quantities. If nipple drinkers are provided, then the flow rate must be at least 2 litres per minute. Large sows suckling large litters may need to consume 40-50 litres/day, especially under hot conditions. A lack of water restricts both the feed intake of the sow and her milk yield.

Post-weaning sows should be maintained on high intakes of the lactation ration to prompt a quick return to oestrus and maximise subsequent litter size. Reducing the number of expensive 'empty' or non-productive days will mean more litters per sow per year.

A 3/5-diet feeding strategy best meets the changing nutritional and metabolic needs of the modern, hyperprolific sow and this helps to ensure optimum productivity of the sow and her offspring.

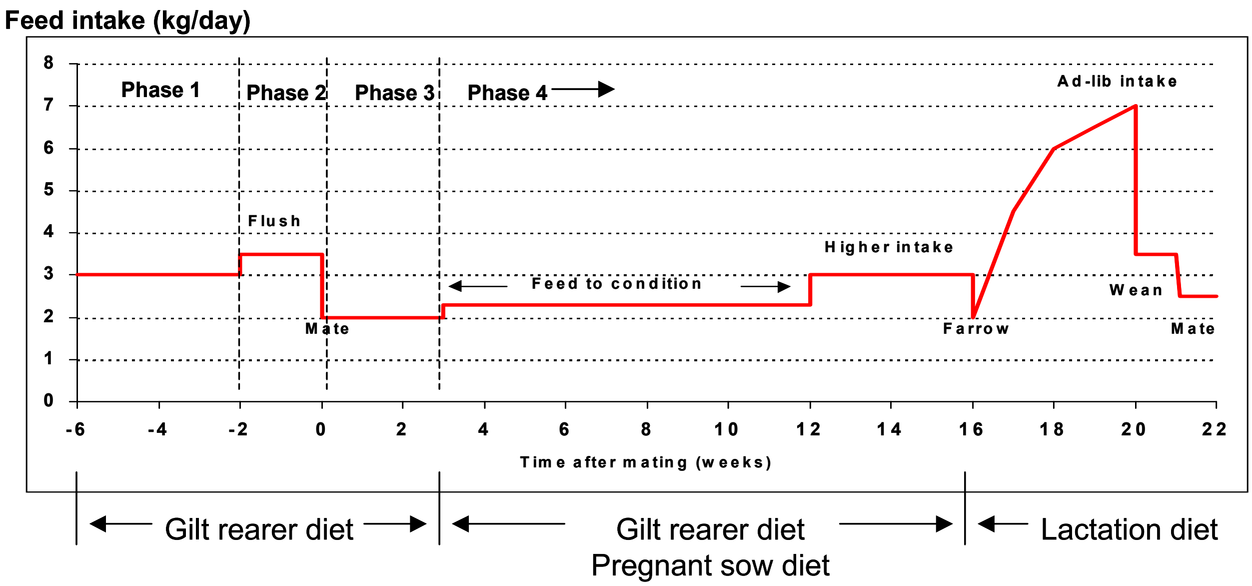
The following dietary specifications are therefore suggested:

Gilt rearer:	3.1 Mcal ME and	8.0 g lysine/kg
Pregnancy:	3.0 Mcal ME and	5.5 - 6.0 g lysine/kg
Lactation (general):	3.25 Mcal ME and	10 g lysine/kg
Lactation (gilts: low intake):	3.35 Mcal ME and	11 g lysine/kg
Lactation (sows: high intake):	3.10 Mcal ME and	9 g lysine/kg

As the lysine content of the diet is known, it is possible to calculate the content of other essential amino acids according to the concept of the 'ideal protein'.

A simple practical feeding strategy that best meets the requirements of the sow at all stages of pregnancy and lactation is illustrated in Figure 4. The feeding levels shown apply to gilts in parity 1; for older sows, feed intake in each subsequent pregnancy should therefore be increased by 0.2 kg/day, depending upon body condition.

Figure 4. Suggested feeding strategy for the modern sow (first parity).



FEEDING TO REDUCE PIGLET LOSSES

From a practical perspective, it is difficult to suggest ways to reduce embryo mortality, other than through good nutrition and management. Some pre-weaning mortality will be associated with overlaying by the sow in early lactation and hence the design of the farrowing crate is important. A good quality gestation sow diet should be fed and feeding levels adjusted to ensure a sow body condition score of 3.5 (scale 1-5). This also helps to ensure that mean piglet birth weight is adequate and above 1.35 kg. Such piglets have sufficient body reserves and vitality to escape overlying by the sow and hence have a high chance of survival. However, on many farms too many piglets are born dead (stillborn) or die during lactation. This increases with the age of the sow and of course affects the number of piglets weaned and hence overall sow productivity.

There is evidence that vitamins and trace minerals, and especially organic trace minerals, may help reduce losses. For example, supplementing the diet with a selenium yeast instead of the inorganic sodium selenite helps to enhance muscle tone of the sow, thus facilitating parturition and reducing stillbirths. The level of Se in milk was also increased (Mahan 2000). This enhances the immune system of the piglet and hence reduces pre-weaning mortality, as well as increasing the weaning weight of the piglet (Janyk *et.al.*, 1998).

Iron is another important trace element, as piglets are born anaemic and must be given supplementary iron after birth, generally in the form of an iron injection. However, adding organic iron to the diet of the sow during gestation and lactation has been shown to increase the iron reserves of the piglet (Ashmead and Graff, 1982; Egeli *et.al.*, 1998), giving it better suckling ability (Close, 1999a). This results in higher colostrum and milk intake, as well as providing a greater stimulus to the sow to produce milk. Pre-weaning mortality is reduced and weaning weight increased. Thus, providing the correct level and source of trace minerals may help to reduce losses.

Low milk yield of the sow results in inadequate nourishment of the piglets and poorer immune status; they become more susceptible to stress and disease. Sauber *et al.* (1999), have shown that the lower the health status, the lower the feed intake and milk yield of the sow and the poorer the performance of the piglets. Thus, measures that improve the appetite and health status of the sow and boost her and her piglets' immune status are very important.

When the appetite of the sow is low, especially under hot conditions, it is important to provide supplementary nutrition to the piglets to ensure that they grow at a good rate during lactation and reach an acceptable body weight at weaning. Azain *et.al.* (1996) have shown that under warm conditions (27.6°C), and when supplementary liquid milk was provided, the piglets consumed sufficient milk to attain a similar growth rate and weaning weight to the piglets weaned under cool conditions (20.7°C).

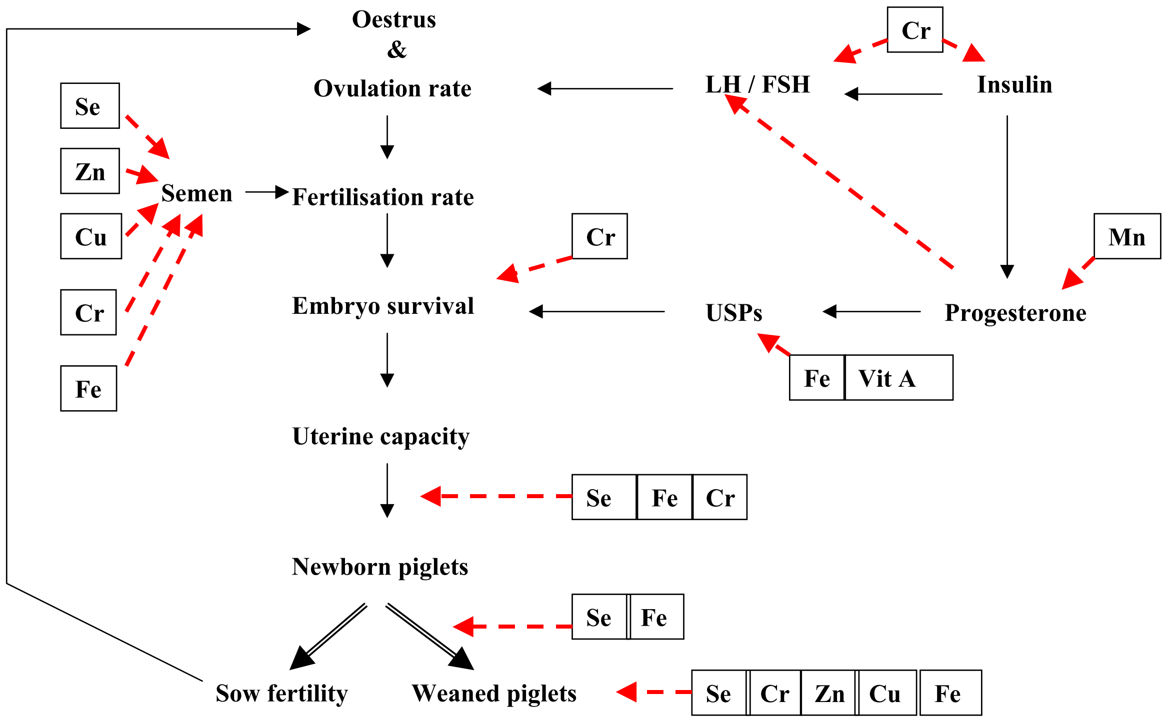
TRACE MINERALS AND REPRODUCTION

One of the possible reasons for the increased losses that occur in older sows may be associated with their reduced mineral status. Mahan and Newton (1995) have shown that the body mineral content of sows after the weaning of their third litter of pigs was significantly lower than that of unbred animals of similar age. In addition, the higher the level of productivity, that is the higher the body weight of the litter at weaning, the lower the maternal body mineral content. For some minerals, their content in the body was reduced by as much as 20%. This suggests that considerable de-mineralisation of the sow's skeletal structure occurred to meet the needs at the higher level of production.

These results raise questions about the actual mineral content in the diet, the availability of the minerals to the animal and the effect of the mineral status of the animal on overall productivity. This is especially pertinent to the sow, and Richards (1999) has shown that already in late gestation, the sow must rely on her liver iron reserves to meet foetal demands for the mineral. Perhaps this trend is halted when organic minerals are provided. The loss of minerals from the body is further exacerbated during lactation and this continuous drain on body reserves results in reduced mineral status as shown by Damgaard Poulsen (1993) and Mahan (2000). The lower mineral status of the sow is of course reflected in the mineral status of the piglet.

The question is: is it possible to protect the sow's mineral reserves from depletion while maintaining or increasing her reproductive performance? A closer look at the role of trace minerals in reproduction and how they are involved in the different components that determine litter size (Figure 5), may help us answer this question.

Figure 5. The potential role of trace elements in sow reproduction (Close, 1999b).



Several recent studies have been carried out to establish if high levels of dietary minerals could enhance sow productivity. For example, Cromwell *et al.* (1993) fed high levels of dietary copper to sows (250 ppm) over six parities and reported that their liver copper concentration increased by more than four-fold. There was no effect on reproductive performance, but birth weight and weaning weight of the piglets was increased. Fehse and Close (2000) fed highly productive sows a special package of organic minerals (iron, zinc, manganese, copper, chromium and selenium) additional to the normal level of inorganic minerals over a 2-year period. Over the peak parities (parities 3-6), 0.5 more piglets were weaned per litter (11.6 compared with 11.1) from those sows fed the additional organic minerals and pre-weaning mortality was also reduced. Interestingly, it was also observed that a greater proportion of the 'supplemented' sows remained in the trial for a longer period of time compared with the 'control' sows. These sows were better able to maintain good productivity and were retained in the herd throughout the most productive parities. Similar improvements in sow productivity have been reported in a trial including 26,000 sows (Smits and Henman, 2000).

It may well be that in the modern, hyper-prolific sow there is a gradual depletion of her mineral reserves and she is therefore unable to maintain long-term a high level of productivity. This may also affect her immune status. The provision of the additional organic minerals may stem the mineral loss from the body and better meet the needs of the animal, enhancing its metabolic, physiological and endocrine status and thus optimising sow productivity.

CONCLUSIONS

To achieve a high level of productivity in the modern sow, it is not sufficient to consider just the nutritional needs of the sow *per se* in terms of changes in body weight and body condition. It is equally crucial to apply nutritional and management strategies that reduce the loss of breeding potential, which is currently about 40% of the genetic potential of the modern hyper-prolific sow. Thus, it is important not only to supply sufficient energy and amino acids in the diet, but also minerals and vitamins in adequate quantities and in the most bio-available form. Similarly, good management practices must be applied to ensure the best health, welfare and well-being of the sow throughout its reproductive life.

LITERATURE CITED

Ashmead, H.D. and Graff, D.J. 1982. Placental transfer of chelated iron. Proceedings of the International Pig Veterinary Congress, Mexico. pp 207.

Ashworth, C.J. and Pickard, A.R. 1998. Embryo Survival and prolificacy. In: Progress in Pig Science, pp 303-325. Edited by J. Wiseman, M.A. Varley and J.P. Chadick. Nottingham University Press, Nottingham.

Azain, M.J., Tomkins, T., Sowinski, J.S., Arentson, R.A. and Jewell, D.E. 1996. Effect of supplemental pig milk replacer on litter performance: seasonal variation in response. Journal of Animal Science, 74: 2195-2002

Challinor, C.M., Dams, G., Edwards, B. and Close, W.H. 1996. The effect of body condition of gilts at first mating on long-term sow productivity. Animal Science, 62, 660 (Abstract).

Close, W.H. 1999. Mineral nutrition in the new millennium: the scientific case for organic minerals. In: Concepts of Pig Science 1999 pp 131-142. Edited by T.P. Lyons and D.J A. Cole. Nottingham University Press, Nottingham.

Close, W.H. 1999b. Organic minerals for pigs. In: Biotechnology in the Feed Industry: Proceedings of Alltech's 15th Annual Symposium. pp 51-60. Edited by T.P. Lyons and K.A. Jacques. Nottingham University Press, Nottingham.

Close, W.H. and Cole, D.J.A. 2000. Nutrition of Sows and Boars. Nottingham University Press, Nottingham. 377 pages.

Cromwell, G.L., Monegue, H.J. and Stahly, T.S. 1993. Long-term effects of feeding a high copper diet to sows during gestation and lactation. J. Anim.Sci. 71: 2996-3002.

Damgaard Poulsen, H. 1993. Minerals for sows. Significance of main effects and interactions on performance and biochemical traits. PhD Thesis: University of København.

Egeli, A.K., Framstad, T. and Grønninger, D. 1998. The effect of peroral administration of amino acid-chelated iron to pregnant sows in preventing sow and piglet anaemia. Acta Veterinaria Scandinavia, 39: 77-87.

Fehse, R. and Close, W.H. 2000. The effect of the addition of organic trace elements on the performance of a hyperprolific sow herd. In: Biotechnology in the Feed Industry.

Proceedings of the 16th Annual Symposium. pp 309-325. Edited by T.P. Lyons and K.A. Jacques. Nottingham University Press, Nottingham.

Gaughan, J.B., Cameron, R.D.A., Dryden, G.M. and Josey, M.J. 1995. Effect of selection on leanness on overall reproductive performance in Large White sows. J. Anim Sci. 61: 561-564.

Gueblez, R., Gestin, J.M. and Le Henaff, G. 1985. Incidence de l'age et de l'epaisseur de lard dorsal a 100 kg sur la carriere reproductive des truies large white. Journees de la Recherche Porcine en France, 17: 113-120.

Janyk, W.S., Opperman, D.J., Rall, C.C., Opperman P.L. and Browne, A.T. 1998. Effect of organic or inorganic selenium and vitamin E supplementation on the reproductive performance of sows. Proceedings of the Asia-Pacific Animal Science Meeting, July 1998.

Mahan, D and Newton, C A 1995. Effect of initial breeding weight on macro- and micro-mineral composition over a three-parity period using a high-producing sow genotype. Journal of Animal Science, 73: 151-158.

Mahan, D.C. 2000. Effect of organic and inorganic selenium sources and levels on sow colostrum and milk selenium content. Journal of Animal Science, 78: 100-105.

Meat and Livestock Commission. 1995-2002. Pig Yearbook. Meat and Livestock Commission, Milton Keynes.

Richards, M.P. 1999. Zinc, copper and iron metabolism during porcine fetal development. Biological Trace Element Research, 69: 27-44.

Sauber, T.E., Stahly, T.S. and Nonnecke, B.J. 1999. Effect of level of chronic immune system activation on the lactational performance of sows. J. Anim. Sci., 77: 1985-1993.

Smits, R.J. and Henman, D.H. 2000. Practical experiences with Bioplexes in intensive pig production. In: Biotechnology in the Feed Industry. Proceedings of the 16th Annual Symposium. pp 293-300. Edited by T.P. Lyons and K.A. Jacques. Nottingham University Press, Nottingham.