Meeting the sow's reproductive potential

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The objective of modern pig production is to maximise the quantity and quality of pig meat produced per sow per year, or per lifetime, at minimal cost. It is of prime importance to ensure that the sow produces an adequate number of piglets per year, or per lifetime, and nutrition and management are key elements in achieving this, since these have a major effect on the chief components of litter size – ovulation rate, fertilisation rate and embryo survival.

On many farms the actual level of performance is well below the animal's capability and 22-24 piglets reared per sow per year is the norm, 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 are more commonly found in practice.

Improving productivity

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 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. Interestingly, the difference between the total number of piglets born and those weaned (approximately two piglets per litter) 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.

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 Fig. 1, demonstrating the importance of both nutrition and management.

COMPONENT	CONTRIBUTING FACTORS
Ovulation rate	Hormonal stimulation, gilt selection, boar stimulation, flush-feeding, body condition, nutrition.
Fertilisation rate	Semen quality, mating technique, stockmanship.
Embryo survival	Feeding post mating, minerals and vitamins, minimise stress.
Piglets born (No./weight)	Reduce stillbirths, sow body condition, housing, nutrition.
Piglets weaned (No./weight)	Pre-weaning mortality, milk yield, nutrition, appetite, health status, supplementary nutrition to piglets.
Litters/sow/year	Wean-mating period, empty days, nutrition, boar effect, reduce stress, body condition, parity effect, herd management.

Fig. 1. Components of litter size in pigs and contributing factors.

Gilt body condition

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

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

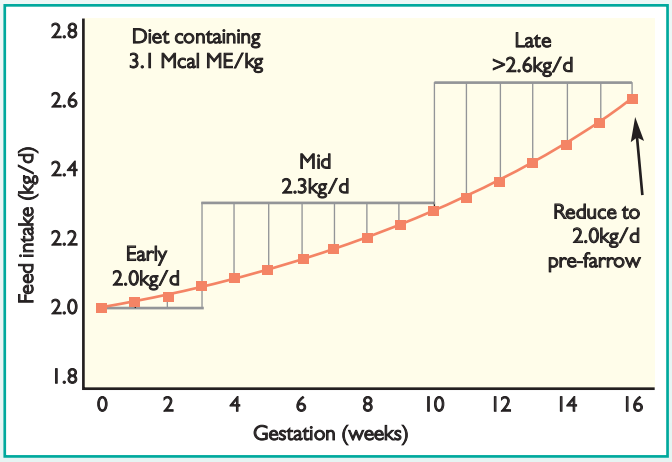
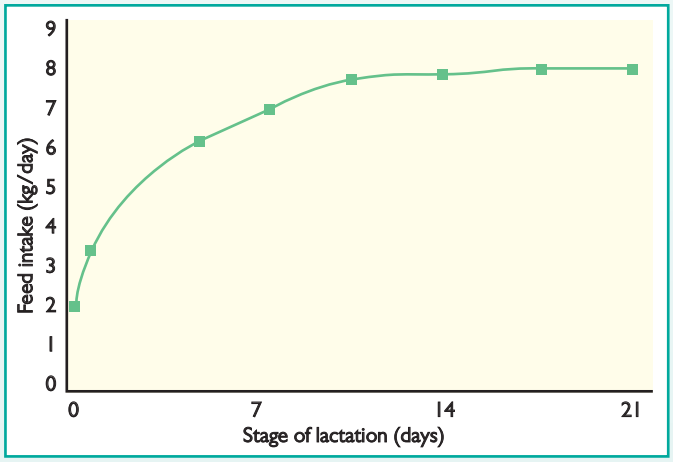


Fig. 3. Feed requirements during lactation. 200kg sow at farrowing: 10kg weight loss during lactation. Litter size: 10 piglets; piglet weight at 21 days: 7kg.



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the animal. The gilt must therefore be sufficiently mature, of appropriate body condition and have adequate reserves of lean and fat in her body.

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

- 210-230 days of age.
- 125-145kg body weight.
- 16-20mm P2 backfat thickness.
- Mating at second or third oestrus.

To achieve these, it is suggested that the young breeding gilt be selected at ~60kg body weight and put on a special gilt rearer diet and feeding regime, as indicated in Table 1. 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.

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 vitamins 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.

Gestation and lactation

Designing a feeding and management strategy requires knowledge of the nutrient needs at all stages of the reproductive cycle. Tables 2 and 3 show the energy and lysine requirements of the sow during gestation and lactation.

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 2. 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.

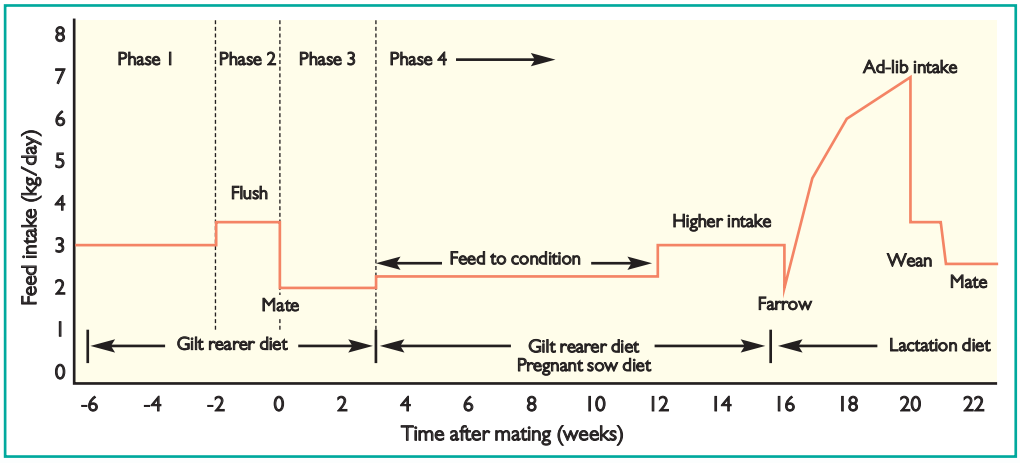

Fig. 4. Suggested feeding strategy for the modern sow (first parity).

This is illustrated for a gilt during its first gestation in Fig, 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.

	Body weight (kg)	Age (days)	Backfat thickness (P2 mm)	MJ DE per kg diet	Lysine (g)	Feeding strategy (kg/d)
Phase 1	25-60	60-100	-7	14.0	12.0	ad-libitum
Phase 2	60-125	100-210	7-16	13.5	8.0	2.5-3.5
Phase 3	125-140	210-230	16-18	13.5	8.0	ad-libitum
Phase 4	Early gestation	230-260		13.5	8.0	2.0

Table 1. Phased feeding regime for gilts. These are suggested values. Body weight and backfat thickness may vary slightly, depending on genotype and environmental circumstances.

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 in lactation is to meet the requirement for milk production of the sow, which increases from about 3-4 litres/day just after farrowing to 10-12 litres/day in peak lactation.

Indeed, the values presented in Table 3 are mean values throughout lactation, which do not reflect the increasing needs of the sow as the litter growth and hence milk yield increase.

To match this increasing nutritional need, feed intake should be increased gradually during the first 4-5 days of lactation (approximately 0.5kg/day) until the sow is consuming 4-5kg/day when she should be fed to appetite (Fig. 3).

It is a good idea to provide a lactation feeding scale for sows of different parities and litter size and to have this to hand for each sow in the farrowing house.

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 4.

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: 13.5 MJ DE and 8.0g lysine/kg.
- Pregnancy: 13.0MJ DE and 5.5-6.0g lysine/kg.
- Lactation (general): 14.0MJ DE and 10g lysine/kg.
- Lactation (gilts: low intake): 14.5 MJ DE and 11g lysine/kg.
- Lactation (sows: high intake): 13.5 MJ DE and 9g lysine/kg.
- Wean-mating: 14.0 MJ DE and 10g 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 Fig. 4.

The feeding levels shown apply to gilts in parity 1; for older sows, feed

Table 2. Energy and lysine requirements of the sow during gestation (Close and Cole, 2000).

Body weight at mating (kg)	Net weight gain* (kg)	Energy (MJ DE/day)	Lysine (g/day)	Feed (kg/day)
120	45	29.6	15.8	2.25
150	35	31.4	13.8	2.4
200	25	33.0	12.0	2.55
250	15	35.0	10.5	2.7
300	10	38.0	10.0	2.9

* Excludes growth of gravid uterus and mammary glands. Feed contains 13.0 MJDE/kg.

Table 3. Nutrient requirements during lactation (Close and Cole, 2000).

Body weight after farrowing (kg)	Energy (MJ DE/day)		Lysine (g/day)		Feed (kg/day)	
	10 piglets	12 piglets	10 piglets	12 piglets	10 piglets	12 piglets
150	79	94	49.0	58.0	5.8	6.6
200	87	99	50.0	59.0	6.2	7.0
250	92	104	51.0	60.0	6.5	7.3
300	96	109	52.0	61.5	6.8	7.7

* Feed containing 14.0 MJ DE/kg

- 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

Table 4. Practical aids to enhance appetite.

intake in each subsequent pregnancy should therefore be increased by 0.2 kg/day, depending upon body condition.

Reducing 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 1.35kg. 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 (Sel-Plex) 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 is also increased. This enhances the immune system of the piglet and hence reduces pre- and post-weaning mortality, as well as increasing the weaning weight of the piglet.

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, giving it better suckling ability .

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 colostrum and milk yield of the sow results in inadequate nourishment of the piglets and poorer immune status; they become more susceptible to stress and disease.

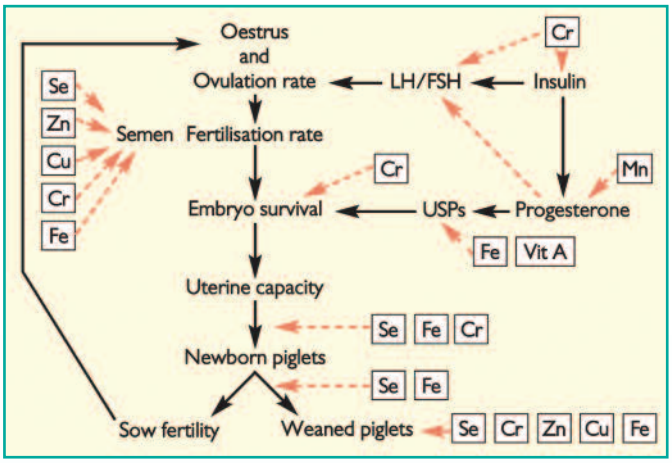

Fig. 5. The potential role of trace elements in sow reproduction (Close, 1999b).

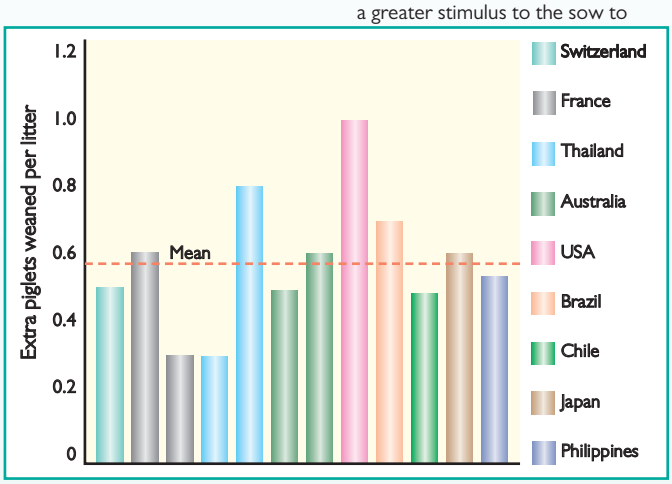

Fig. 6. Sow-Pak and litter size: extra piglets weaned per litter (mean responses).

Table 5. Effect of Bio-Mos on sow and piglet performance (Funderburke, 2002).

	Control	Bio-Mos
No. of sows	517	509
Average parity	3.23	3.29
No. of piglets born alive	9.96	9.78
Average birth weight (kg)	1.66	1.69**
Pre-weaning mortality (%)	11.27	9.09***
No. of piglets weaned	8.84	8.89
Piglet growth rate (g/d)	177	195***
Piglet weaning weight (kg)	5.47	5.80***
Wean-oestrus interval (days)	7.27	5.20***
Sows returning to oestrus after weaning (%)	77.8	88.0

* P<0.10; ** P<0.05; *** P<0.01

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.

Colostrum quality is important, as the newborn piglet is born immunologically immature and is dependent on the immunoglobulin in colostrum to build up its passive immunity.

Thus, the higher the levels of immunoglobulins in colostrum, particularly IgG, the greater the immunity of the piglet and hence its growth rate and weaning weight.

It is known that MOS modulates immunity in animals and Funderburke (2002) has shown that adding MOS (Bio-Mos) to the diet of the sow in late gestation and Lactation significantly increased the IgG concentration in colostrum, with pre-weaning mortality being reduced by 19% and piglet weaning weight being increased by 0.35kg.

In addition, the period between weaning and mating of the sow was reduced by two days (Table 5).

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

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Table 6. Trace mineral intake in relation to body weight and parity.

Mineral	Recommended[1] per kg diet	Parity 1 (160kg)[2] Intake mg/day	Intake mg/kg BW	Parity 3+ (240kg)[3] Intake mg/d	Intake mg/kg BW	Diff. (%)
Fe (mg)	100	272	1.70	312	1.30	23
Zn (mg)	100	272	1.70	312	1.30	23
Cu(mg)	15	41	0.25	47	0.19	23
Mn (mg)	40	108	0.68	125	0.52	23
Se (mg)	0.25	0.68	0.0043	0.78	0.0033	23

[1]MLC: 2004. [2]Feed 2.3kg/day in gestation and 5.0kg/day over a 21 day lactation. [3]Feed 2.6kg/day in gestation and 6.0kg/day over a 21 day lactation.

Vitamin	Suggested allowances (per kg diet)
A (Retinol) (IU)	8,000-10,000
D (Calciferol) (IU)	750-1,200
E (Tocopherol) (IU)	50-75
K (Menadione) (mg)	1-2
B1 (Thiamin) (mg)	1-2
B2 (Riboflavin) (mg)	3-5
Niacin (mg)	10-20
B6 (Pyridoxine) (mg)	1.5-2.0
B12 (Cyanocobalamin) (mg)	0.015-0.020
Pantothenic acid (mg)	12-15
Biotin (mg)	0.3-1.0
Folic acid (mg)	3-4
Choline (g)	1.5-2.0
C (Ascorbic acid)	–
Essential fatty acids: linoleic acid (g)	7
arachidonic acid (g)	5

* Higher values in gilt rearer and lactation diets

Table 7. Suggested vitamin allowances for the breeding sow.*

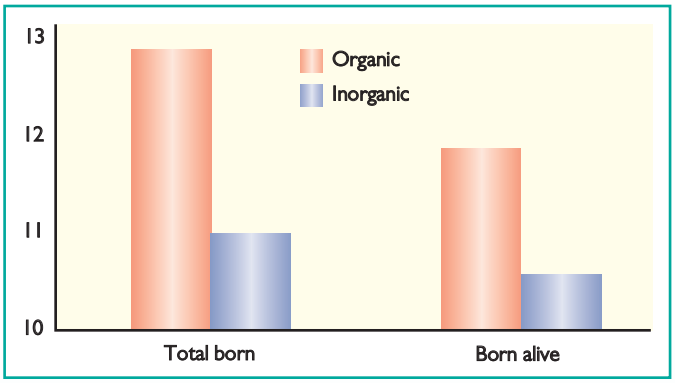

Fig. 7. Mineral source and litter size (Mahan and Peters, 2006).

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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).

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 minerals – and trace minerals in particular – in reproduction, and how they are involved in the different components that determine litter size (Fig. 5), may help answer this question.

Several recent studies have been carried out to establish if the level and sources of dietary minerals could enhance sow productivity.

Fehse and Close (2000) fed highly productive sows a special package of organic minerals, Alltech Inc's Sow-Pak (iron, zinc, manganese, copper, chromium and selenium) in addition to the normal level of inorganic minerals over a two 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.

A summary of several recent worldwide studies where Sow-Pak was added to the diet of the sow throughout gestation and lactation is presented in Fig. 6.

The overall response was an extra 0.6 piglets weaned per litter, equivalent to an extra 1.3 piglets per sow per year.

This shows a very profitable response. Indeed, the sow would only need to produce 0.25 extra piglets per year to cover the extra cost of including the organic minerals.

Thus, the ROI (return over investment) is 7:1 – a very cost effective investment!

Mahan and Peters (2006) reported over one extra piglet weaned per litter when the sows' diets were supplemented over several parities with organic (Bioplex) minerals (Fig. 7) instead of inorganic minerals.

Based on this information, it is recommended that only organic sources of trace minerals (either as partial or total replacement) are provided in the diet of the sow between selection and culling.

It may well be that in the modern, hyper-prolific sow fed diets containing the normal recommended levels of minerals, there is a gradual depletion of her body 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 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.

Table 8. Successful solutions for sows.

- Keep good records. Identify reasons for culling.
- Select gilts as early as possible. Important for acclimatisation.
- Feed special gilt rearing diet. Flush-feed before mating for high ovulation rate.
- 1st mating at 220-230 days of age.
  - 130-140kg body weight.
  - 16-20mm P2 (condition score: 3.0).
  - Second or third oestrus period.
- Reduce feed intake in gilts for three weeks post-mating for high embryo survival.
- Then feed to body condition. Target condition score at farrowing 3.5.
- If temperature <20°C, increase feed allowance by 4% per 1°C below 20°C.
- Increase feed intake over last four weeks of gestation to optimise birthweight and mammary development.
- Reduce feed 1-2 days before farrowing to facilitate farrowing process.
- After farrowing gradually increase daily intake over first week, then feed to appetite.
- Good appetite during lactation is critical for high piglet weaning weight.
- Mean requirements during lactation 100 MJ DE and 60g lysine/day.
- Minimise loss of body weight and condition. Target condition score at weaning 2.5.
- Piglet weaning weight: 7kg at 23 days. Each 1kg litter growth rate requires four litres of milk.
- Feed separate gestation and lactation diets:
  - Gestation: 13.0 MJ DE and 6g lysine/kg.
  - Lactation: 13.5-14.5 MJ DE and 8-11g lysine/kg.
- Lactating sows need 30-50 litres water/day; nipple flow rate >2.0 litres/minute.
- Reduce demand on sow. Provide supplementary feeding to piglets. Good hygiene. Cross-foster or split-wean.
- Reduce empty or non-productive days. Each day costs €2.7.
- Organic minerals boost reproductive performance. Role of: Se, Cr, Fe and Sow-Pak.
- Vitamins and minerals must be supplied in adequate amounts and available form. Increase allowance by 5% with each parity.
- Ensure good sow health and welfare. Role of MOS.
- Do not forget the boar! Semen quality = high fertilisation rate = high litter size.

Vitamin requirements

Although vitamins are needed for the normal functioning of the body, several vitamins play a specific role in reproduction; for example vitamins A and B, biotin, folic acid and choline.

The requirements for these and the other fat and water soluble vitamins are presented in Table 7.

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 and the boar throughout their reproductive life.

A summary checklist of practical tips to ensure good sow productivity is provided in Table 8. ■

References are available from the authors on request