29

NUTRITION AND REPRODUCTION

D.J.A. COLE
Department of Agriculture and Horticulture, University of Nottingham School of Agriculture, Sutton Bonington, Loughborough, Leicestershire, UK

It is well known that the establishment of nutrient requirements of the sow is made difficult by the considerable variation that exists in reproductive characteristics. Much less success has been achieved than with the growing pig where performance is usually measured by some aspect of the efficient production of lean meat.

Thus, it is necessary to establish the production objectives of the breeding sow. For example, it is generally considered that the production of the maximum number of piglets per unit time (such as, per year) is important. At the same time it is important that the piglets are of adequate size and viability at birth and at whatever age they are weaned. Consequently the influence of nutrition during pregnancy and lactation needs to be well established. As the sow does not reach reproductive maturity until about the fourth parity, it is desirable that it is kept well beyond this stage to take advantage of the most prolific period of its life. Thus, the influence of nutrition is of interest in more than just the short term.

While the measurement of the response of the sow to its nutrition is not simple, the following can be identified as areas of importance :

1. *Short-term reproductive performance* e.g. how nutrition in pregnancy affects subsequent litter size or how nutrition in lactation affects piglet and sow weight at weaning.
2. *Medium-term reproductive performance* e.g. the effect of nutrition in lactation on performance in the next pregnancy.
3. *Long-term reproductive performance* e.g. the effect of nutrition in the early stages of reproductive life on the whole breeding lifetime.

While these have been listed as three separate items they are, of course, all connected. In order to reconcile these different objectives an approach is often taken of considering the influence of nutrition on immediate reproductive performance and also on the sow's body condition as a measure of its likely reproductive performance in the medium and long term. Weight change of the sow has often been used as a measure of body condition. However, it is recognized that the role of changes in both body condition and liveweight of the sow need further study.

A strategy of maximum conservation

A number of feeding regimens have been based on the marked depletion of body reserves during lactation with a high degree of restoration through high level feeding in the subsequent pregnancy. Such changes have usually been monitored through weight change and it is unlikely that loss and gain of weight reflect identical loss and gain in body tissues. It is proposed that the strategy needed for the long-term nutrition of the sow is one based on the maximum conservation of body condition in lactation with the minimum loss of weight. Such a strategy would then rely on minimum restoration of weight and condition in the following pregnancy. The benefits of this are continuous as it is well known that the greater the weight gains in pregnancy the greater the weight loss in lactation. An extreme example of this is given in *Figure 29.1*. In addition the sow would be liberally fed during the period of maximum production (i.e. lactation). Thus, the aim is a strategy of carefully controlled and limited weight gains in pregnancy with the maximum conservation of weight and condition in lactation.

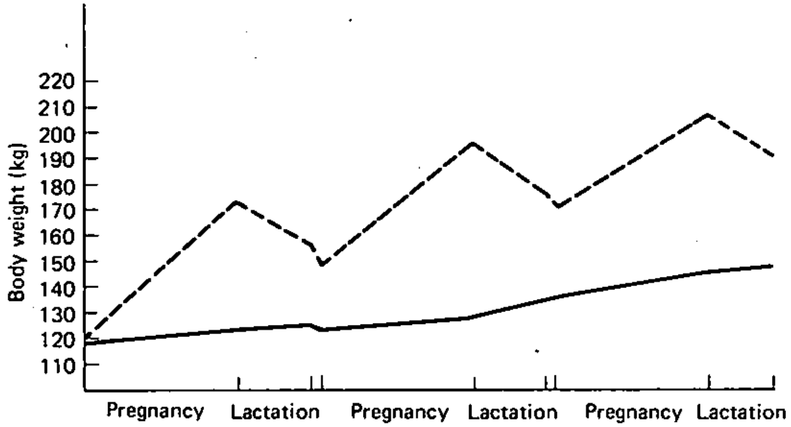

Figure 29.1 Maternal weight change of sows fed 1.8 kg + 0.36 kg/piglet suckled/day during lactation and 2.8 kg/day (---) or 1.4 kg/day (—) during pregnancy. From Lodge, Elsley and MacPherson (1966b)

The gilt

The influence of nutrition during the rearing phase has been dealt with in Chapter 11. However, nutrition before the oestrus of first mating is of consequence because of its well-established effect on ovulation rate at this stage. For example, in an extensive review of the subject Anderson and Melampy (1972) suggested that the most effective time to start high level feeding was about 14 days before oestrus; such an effect may account for the type of response given in *Table 29.1*.

Table 29.1 INFLUENCE OF FEED LEVEL DURING THE REARING PERIOD ON THE LITTER SIZE OF GILTS

Number of piglets born Maximum 2.7 kg/day			*Ad libitum*
1st heat	*2nd heat*	*3rd heat*	*1st heat*
8.4	9.8	10.4	11.0

From MacPherson, Hovell and Jones (1977)

Pregnancy

ENERGY AND FEED INTAKE

The response to energy intake in pregnancy is generally reflected in response to total feed intake. During pregnancy the sow needs food to meet the demands of the developing litter and to achieve some weight gain, either as true growth or pregnancy anabolism. At some stage pregnancy anabolism gives way to the catabolism of lactation and the point at which this occurs appears to be in late pregnancy but has not been well established. However, it has already been suggested that large weight gains in pregnancy are not desirable in maintaining optimum weight change and body condition in the long-term reproduction of the sow.

A well known characteristic of the pregnant sow is its considerably greater efficiency of feed utilization than the non-pregnant female. This was well illustrated by Salmon-Legagneur and Rerat (1962) who showed that the sow was able to produce a litter of pigs on a diet comprising little more than a maintenance ration for a non-pregnant animal (*Table 29.2*). Consequently the establishment of energy requirements during pregnancy does not lend itself to the use of factorial estimates.

Table 29.2 WEIGHT GAINS OF SOWS DURING PREGNANCY ON LOW (0.87 kg/100 kg LIVEWEIGHT/DAY) AND HIGH (1.8 kg/100 kg LIVEWEIGHT/DAY) PLANES OF NUTRITION IN PREGNANCY

	Total gestation food intake (kg)	*Weight at mating* (kg)	*Weight before mating* (kg)	*Weight after parturition* (kg)
Low plane				
Pregnant sows	225	229.7	273.9	249.8
Non-pregnant sows	224	230.7	235.0	235.0
High plane				
Pregnant sows	418	230.2	308.2	284.1
Non-pregnant sows	419	231.0	270.0	270.0

Gain of pregnant sows[a]	*Low plane* (kg)	*High plane* (kg)
Foetuses	15.4	13.8
Loss of parturition (placenta, fluids)	8.7	10.3
True anabolism	15.8	14.9
Growth	4.3	39.0
Total	44.2	78.0

[a]Difference between weight before mating and weight at mating
From Salmon-Legagneur and Rerat (1962)

In terms of energy level in pregnancy it has been suggested by Brooks and Cole (1971) that digestible energy (DE) intake should not fall below 25 MJ/day. This should be regarded as a minimum figure and takes no account of variation in age, weight or environmental conditions. While there is likely to be some increase in birthweight when energy intake exceeds 25 MJ DE/day, it is only of practical importance where a birthweight problem exists. The major response to increased energy intake will be as maternal weight gain. Up to intakes of about 40 MJ DE/day, this is illustrated by the equation established by Van Schoukbroek and Van Spaendonck (1973):

Increase in sow weight (kg) = $-11.7 + 2.631x - 0.018x^2 \pm 12.1$ (r = 0.71)

where x = energy intake (MJ ME/day). It was further illustrated by the work of Salmon-Legagneur and Rerat (1962) which also shows the

Table 29.3 WEIGHT CHANGES IN PREGNANCY AND LACTATION OF SOWS FED LOW (0.87 kg/100 kg LIVEWEIGHT/DAY) AND HIGH (1.8 kg/100 kg LIVEWEIGHT/DAY) PLANES OF NUTRITION IN PREGNANCY

Plane of nutrition	*Weight at mating* (kg)	*Weight after farrowing* (kg)	*Gain during pregnancy* (kg)	*Weight at weaning* (kg)	*Loss during lactation* (kg)	*Total weight change* (kg)
Low	229.7	249.8	20.1	242.4	7.4	+12.7
High	230.2	284.1	53.9	235.8	48.3	+5.6

From Salmon-Legagneur and Rerat (1962)

influence of weight gain in pregnancy on overall weight change in the reproductive cycle (*Table 29.3*). Sows that had been fed to gain 20.1 kg in pregnancy lost 7.4 kg in lactation, whereas sows fed at a higher level to gain 53.9 kg in pregnancy had a weight loss of 48.3 kg in lactation. Thus, those sows fed to make a large weight gain in pregnancy had a lower net weight gain over the whole reproductive cycle (5.6 kg) than those fed to make only modest weight gains (a net gain of 12.7 kg).

In addition to considering the overall feeding of pregnancy, it is necessary to consider if any one part of it needs a different nutritional regimen to another.

Early pregnancy

Controversy has existed over nutrition in early pregnancy. In a number of cases comparisons of feed level have shown no influence on embryo survival but the data are difficult to interpret because of the variation in duration of treatments. However, several workers have reported improved embryo survival with gilts given lower feed levels. For example, Dutt and

Table 29.4 THE INFLUENCE OF FEED INTAKE IN EARLY PREGNANCY

Duration of treatment in pregnancy			
Days 0–10		*Days 10–20*	
Feed intake (kg/day)	*Embryo survival* (%)	*Feed intake* (kg/day)	*Embryo survival* (%)
4.1	66.0	4.1	67.3
2.5	72.1	2.5	72.0
1.25	78.4	1.25	71.9

From Dutt and Chaney (1968)

Table 29.5 THE INFLUENCE OF FEED INTAKE IN EARLY PREGNANCY ON EMBRYO SURVIVAL TO DAY 30–35

Feed intake (kg/day)			
Days 0–10	*Days 10–30*	*Conception rate* (%)	*Embryo survival* (%)
2.5	2.5	87.1	75.8
2.5	1.5	86.2	76.9
1.5	2.5	87.1	85.4
1.5	1.5	64.3	86.7

From Dyck and Strain (1980)

Chaney (1968) showed a small benefit when feed intake was reduced from the time of implantation onwards but a much bigger benefit when the period of feed restriction was from the day of mating onwards (*Table 29.4*). A similar trend was shown by Dyck and Strain (1980) with quite marked improvements for reduced feed intake from mating to day 10 of pregnancy (*Table 29.5*). However, low feed levels (1.5 kg/day) from mating to the end of the experiment resulted in a lower conception rate. It is important that any trends are considered in relation to the range of dietary treatment levels and their relevance to practical feeding situations. For example, the range of feed intakes in *Table 29.4* should be outside that encountered in practice.

Late pregnancy

Generally energy levels in late pregnancy have had little effect other than to increase piglet birthweight when this might have been expected to be low. However, a similar benefit might also have been achieved by spreading the extra feed over the whole of the pregnancy (Lodge, Elsley and MacPherson, 1966a,b). More recently there have been reports of much shorter term nutrition in late pregnancy influencing pig birthweight. For example, an increase of feed intake from 2.8 to 4.0 kg/day between days 100 and 110 of pregnancy increased piglet birthweight from 1.42 kg to 1.64 kg (Kotarbinska, unpublished). However, other workers (e.g. Hillyer and Phillips, 1980) have failed to obtain these gains.

PROTEIN

There has been considerable variation both in the suggested requirements for protein in pregnancy and in the practical application of research findings. Generally, pregnant sows have a greater nitrogen retention than non-pregnant sows. For example, up to 10% increases were suggested by Salmon-Legagneur (1965) and Heap and Lodge (1967). Although this is well recognized now, it was not accounted for in early estimates of protein requirements.

Reproductive characteristics such as breeding regularity, litter size and piglet birthweight and composition show little response above 140 g crude protein/day (see *Figure 29.2*). There has been little work with protein

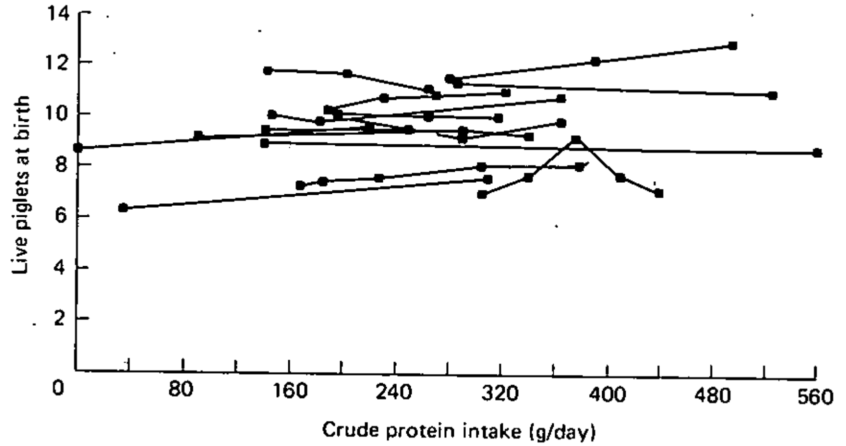

Figure 29.2 Influence of daily crude protein intake in pregnancy on number of piglets at birth. From data of Baker *et al.* (1970a); Boaz (1962); Clawson *et al.* (1963); Elsley and MacPherson (1972); Frobish *et al.* (1966); De Geeter *et al.* (1970a,b); Greenhalgh *et al.* (1977); Hawton and Meade (1971); Hesby *et al.* (1970a); Holden *et al.* (1968); Kemm and Pieterse (1968); Pike and Boaz (1969); Pond *et al.* (1968); Rippel *et al.* (1965a)

intakes lower than this although pigs have been kept on protein-free diets for long periods of pregnancy without adverse effect (Pond *et al.*, 1968). In contrast to reproductive characteristics, maternal weight gain has responded to higher levels, up to about 300 g crude protein/day (*Figure 29.3*).

The study of protein quality as reflected by the requirements for individual amino acids during pregnancy has received little attention. This could reflect both lack of limitation of dietary protein and the difficulty of measuring responses in the breeding animal. As a consequence of this

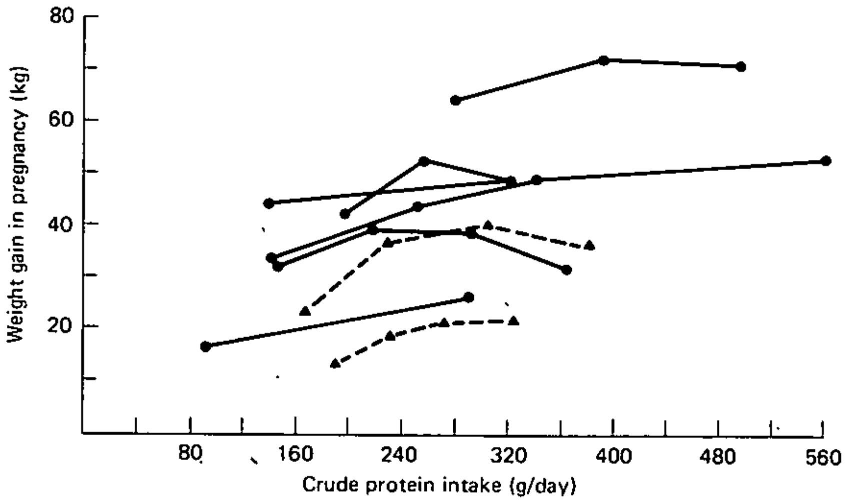

Figure 29.3 Influence of daily crude protein intake in pregnancy on gross (●——●) and net (▲---▲) weight gain of the sow. From data of Baker *et al.* (1970a); Boaz (1962); Clawson *et al.* (1963); Hesby *et al.* (1970a); Holden *et al.* (1968); Rippel *et al.* (1965a)

latter point most of the work has involved the use of indirect techniques to establish requirement values and measurements of nitrogen retention, blood urea and plasma amino acids have been used. The basis for the use of blood urea is that it is the principal excretory product in the pig and represents the difference between protein supply and protein requirements. Blood urea will increase when the dietary supply of protein is raised and fall when it is reduced. However, if the dietary protein level is kept constant, blood urea can be used to monitor the effect of dietary protein quality, and the requirement for an individual amino acid. Thus, the addition of a single amino acid to a deficient diet can be expected to reduce the level of blood urea (due to the improved efficiency of use of the protein) until the 'requirement' level is reached. Further additions of the dietary amino acid would then increase the level of blood urea. The responses of individual amino acids in the blood also have been used to measure dietary adequacy but generally with less success than with blood urea.

Recently there has been a move to describe an ideal protein for particular productive functions (Cole, 1978). For example, with growing pigs it has been suggested that the difference between the requirements of pigs of different sex, breed and liveweight for the deposition of 1 g lean is likely to be in the quantity rather than the quality of protein. Consequently, it should be possible to identify an optimum balance of amino acids which, when supplied with sufficient nitrogen for the synthesis of non-essential nitrogen, would constitute the 'ideal protein'. The balance of essential amino acids in the ideal protein can be described as their ratio to lysine which is usually first limiting in pig diets. A similar approach could be taken for the breeding pig but it is recognized that few response data exist.

The dietary requirement for lysine probably does not exceed 10 g/day (*Table 29.6*). On the basis of the small amount of work reported, the

Table 29.6 SOME ESTIMATES OF LYSINE REQUIREMENTS DURING PREGNANCY

	Feed intake (kg/day)	*Lysine* (% diet)	*Lysine* (g/day)	*Criteria used for estimating requirement*
Woerman and Speer (1976)		0.41	7.5	N retention and piglet performance
Baker *et al.* (1970b)		0.42	8.0	Sow weight change and piglet performance
Rippel *et al.* (1965c)		0.42	7.6	N retention and piglet performance
Duee and Rerat (1974; 1975)		0.43	8.6	Blood urea, sow weight change and piglet performance
Salmon-Legagneur and Duee (1972)	1.90	0.44	8.4	N retention
Hesby *et al.* (1970a,b)	2.22	0.49	10.8	Reproductive performance
Allee and Baker (1970)	2.00	0.49	9.8	N retention
Sohail *et al.* (1978a)	1.82	0.64	10.0	Blood urea and plasma amino acids
Miller *et al.* (1969)		0.66	12.16	N retention

Table 29.7 SOME ESTIMATES OF AMINO ACID REQUIREMENTS DURING PREGNANCY

	Rippel et al. *(1965d)*		*Lucas* et al. *(1969)*		*Miller* et al. *(1969)*	
	(% of diet)	(% of lysine)	(% of diet)	(% of lysine)	(% of diet)	(% of lysine)
Lysine	0.42	100	0.43	100	0.64	100
Methionine + cystine	0.29	69	0.30	70	0.50	78
Tryptophan	0.07	17	0.10	23	0.13	20
Threonine	0.34	81	0.44	102	0.53	83
Leucine	0.56	133	0.72	167	1.42	221
Crude protein	12.5		8.0		15.0	

requirements for other amino acids are given as a percentage of lysine in the diet and also as a balance relative to lysine (*Table 29.7*). It has been suggested that the requirement for non-essential nitrogen is low, of the order of 4.3 g/day (Allee and Baker, 1970).

Lactation

The sow is capable of considerable milk production to meet the needs of the suckling litter and the demands of milk production for energy and nutrients result in very high requirement values relative to those of pregnancy. However, as with other high yielding domestic livestock, allowances established from nutrient requirements need to be within the appetite limits of the animal. As a result of practical problems the level of voluntary feed intake in the lactating sow has received greater attention in recent years.

Feeding during lactation is further complicated by the differences in weaning age that are used. A considerable volume of information exists on requirement values established with lactation lengths of 42–56 days. Less is known about requirements with weaning ages much shorter than this and about the relationships between lactation, reproduction and weight change in the earlier weaned sows.

REQUIREMENTS FOR LACTATION

Energy

Requirements during lactation can be regarded as the sum of the needs of maintenance and production. The equation is completed by the sparing effect on requirements of energy contributed by the weight loss of the sow. However, the desirability and extent of weight loss in relation to the short and long term objectives of reproduction must be considered carefully.

A major factor determining energy requirements during lactation will be variation in milk yield as a result of variation in litter size. Also it is well known that the stage of lactation will influence the energy requirement. The largest changes in milk composition are in early lactation when the change from colostrum to milk results in a fall in milk protein over the first

Table 29.8 CALCULATION OF ENERGY REQUIREMENTS OF SOWS AT DIFFERENT STAGES OF LACTATION

Lactation and requirements	*Weeks of lactation*		
	1 + 2	*3 + 4*	*5 + 6*
Milk yield (kg/day)	5.80	7.15	6.77
Milk energy (MJ/day)[a]	26.22	32.32	30.60
Feed required/day (kg)[b]	6.6	8.15	7.62

[a]Assumed to contain 4.52 MJ/kg
[b]Assumed to contain 12.55 MJ DE/kg
From O'Grady (1980)

10–14 days and a rise in milk fat during the first three days of lactation. Thereafter there is a small but gradual rise in milk protein and a decline in fat. Typically, sow's milk contains about 5.1–5.3 MJ/kg which is produced at an efficiency of about 60%.

Although the stage of lactation can influence energy requirements, it has been suggested that the plane of nutrition is unlikely to influence the level of milk production during the first three weeks (Lodge, 1972). At the other extreme, lactation lengths of greater than six weeks are uncommon. Thus, in calculating the influence of length of lactation on daily energy requirement, it is likely that the greatest emphasis should be placed on weeks 3–6. Examples of suggested energy requirements at different stages of lactation (O'Grady, 1980) are given in *Table 29.8*.

Protein

The quality and quantity of milk produced in lactation are the biggest factors in the determination of protein requirements at this stage. However, there is considerable variation in the suggested requirement values and it is difficult to give recommended values for lactation. The gross efficiency of milk production has been calculated to be of the order of 33% (Lodge, 1959) to 43% (Elsley and MacPherson, 1966). However, responses are normally measured in terms of weight gains of piglets. Generally, low levels of protein have resulted in a slower piglet growth rate, e.g. Greenhalgh *et al.* (1977) who used 9–13% crude protein in the diet and DeGeeter *et al.* (1972) who used 45–309 g crude protein/day, but benefits have not been achieved in raising crude protein intake above about 800 g/day.

Of the essential amino acids, lysine has received most attention in studies of protein quality. The various estimates are mostly based on indirect measures of adequacy and show considerable variation (*Table 29.9*). However, a large number of values fall between 30 and 40 g lysine/day. Protein quality in lactation could lend itself to expression as the requirement for an 'ideal protein'. In the absence of a large amount of experimental evidence the composition of sow's milk might be used as a guideline to the balance of essential amino acids needed in the diet, an approach taken by Speer (1975). However, the validity of such an approach relies on the requirements for milk production being quantitatively much greater than the requirements for maintenance. Wilkinson (1978) calculated that maintenance had little effect on balance when

Table 29.9 SOME ESTIMATES OF LYSINE REQUIREMENTS OF LACTATING SOWS

	Feed intake (kg/day)	*Lysine* (% of diet)	*Lysine intake* (g/day)	*Criteria used for estimating requirement*
Baker *et al.* (1970a,b)	4.0	0.81	32.4	Reproductive performance
Boomgaardt *et al.* (1972)	*ad libitum*	0.60	20.0	Reproductive performance and blood urea
Salmon-Legagneur and Duee (1972)	5.42	0.69	37.4	Piglet performance
Lewis and Speer (1973)	5.45	0.56	30.5	N retention and milk protein
Sohail, Cole and Lewis (1978b)	4.5	0.85	38.4	Plasma amino acids and blood urea
Wilkinson, Cole and Lewis (unpublished)			49.5	Plasma amino acids and blood urea
Wilkinson, Cole and Lewis (unpublished)			40.0	Plasma urea

Table 29.10 THE BALANCE OF DIETARY AMINO ACIDS (LYSINE = 100) BASED ON VALUES FOR MAINTENANCE AND TWO LEVELS OF MILK YIELD

Amino acid	*Maintenance + 250g milk protein*	*Maintenance + 400g milk protein*
Lysine	100	100
Isoleucine	59	57
Leucine	112	113
Methionine	32	30
Threonine	62	60
Tryptophan	17	17
Phenylalanine	55	55
Valine	80	80

From Wilkinson (1978)

estimated from published values for maintenance and the composition of sow's milk. The amino acid most affected was methionine but not to a large extent (*Table 29.10*). However, it should be pointed out that there is little information on which to base the maintenance requirements for amino acids and the values used suggest that they are low (e.g. Baker *et al.*, 1966; Baker and Allee, 1970).

Some estimates of the requirements of other essential amino acids are presented in *Table 29.11*, together with the composition of sow's milk which has been used as a basis for establishing requirement values in some cases (e.g. Speer, 1975). Values also have been expressed as a balance using lysine, the most likely limiting amino acid, as the reference.

Table 29.11 AMINO ACID REQUIREMENTS FOR LACTATION AND AMINOACID COMPOSITION OF SOW'S MILK

	Requirement						*Sow's milk*	
	Baker et al. *(1970a) (gilt)*			*Speer (1975) (sow)*			*Elliot* et al. *(1971)*	
	(% of diet)	(g/day)	(% of lysine)	(% of diet)	(g/day)	(% of lysine)	(% of protein)	(% of lysine)
Arginine	0.34	13.6	42	0.41	22.4	67	4.7	67
Histidine	0.26	10.5	32	0.32	12.5	38	3.6	51
Isoleucine	0.67	27.0	83	0.35	19.1	58	3.7	53
Leucine	0.99	39.6	121	0.68	37.1	112	8.1	116
Lysine	0.81	32.6	100	0.61	33.2	100	7.0	100
Methionine + cystine	0.38	14.2	44	0.27	14.7	44	3.1	44
Phenylalanine + tyrosine	1.00	40.1	123	0.71	38.7	116	8.7	124
Threonine	0.51	20.4	63	0.37	20.2	61	4.4	63
Tryptophan	0.13	5.4	17	0.11	6.0	18	1.3	19
Valine	0.68	27.2	83	0.43	23.5	71	4.4	63

Interrelationships between pregnancy and lactation

Generally in establishing nutrient requirements each part of the reproductive cycle has been treated separately. However, it is important to question the extent to which different parts of the reproductive cycle (e.g. pregnancy and lactation) influence each other, not only in terms of requirements, but also in terms of appetite and body condition. This also reinforces the need to examine the short, medium and long term consequences of current feeding strategy.

Recently one of the major interests in these relationships has been the way in which they might influence feed intake in lactation. It has been known for some time that there is a relationship between feed intake in pregnancy and feed intake in lactation. This is well illustrated by the classical work of Salmon-Legagneur and Rerat (1962). *Table 29.12* shows

Table 29.12 THE RELATIONSHIP BETWEEN FEED INTAKE DURING PREGNANCY AND LACTATION IN THE SOW

Feed intake during pregnancy	*Daily feed intake during pregnancy* (kg)	*Daily feed intake during lactation* (kg)
High	3.68	4.95
Low	1.95	6.23

From Salmon-Legagneur and Rerat (1962)

that doubling of feed intake in pregnancy results in a 20% lower feed intake in lactation. Generally sows fed liberally in gestation have lower feed intakes, greater weight losses and higher milk yields in lactation. However, a more efficient system is not to overfeed in pregnancy but rather to give any extra food necessary in lactation. Such a system is also likely to be beneficial in terms of the long-term condition of the sow.

Feed intake in lactation may also be influenced by protein nutrition in pregnancy. For example, Mahan and Mangan (1975) reported that sows given 12% crude protein in lactation ate more when they had received high levels in pregnancy. However, the feed intakes of sows given 18% crude

Table 29.13 THE RELATIONSHIP BETWEEN FEED INTAKE (KG/DAY) IN LACTATION AND LEVELS OF DIETARY CRUDE PROTEIN IN PREGNANCY AND LACTATION

Protein in pregnancy (%)	*Protein in lactation*	
	12%	*18%*
9	4.2	6.2
13	4.8	6.5
17	5.9	6.2

From Mahan and Mangan (1975)

protein in lactation were unaffected by the protein level during pregnancy (*Table 29.13*). Only one reproductive cycle was involved but work over three and four reproductive cycles has supported their findings (O'Grady, 1971; O'Grady and Hanrahan, 1975). Some experiments have failed to show such relationships (Elsley and MacPherson, 1972; Greenhalgh *et al.*, 1977).

Weaning to remating

Although a lot of attention has been paid to nutrient requirements in pregnancy and lactation the period from weaning to remating is often neglected. It is interesting to consider the results of two experiments conducted at the University of Nottingham. The first of these examined the feed level from weaning to remating of sows which had just weaned their first litter. The results indicated a marked response to feed intake (*Table 29.14*) but this was not supported by the results of an experiment in which third parity sows were used (*Table 29.15*).

Table 29.14 EFFECT OF FEED LEVEL FROM WEANING TO REMATING ON REPRODUCTIVE PERFORMANCE OF GILTS HAVING JUST WEANED THEIR FIRST LITTER

	Feed intake (kg/day)		
	1.8	*2.7*	*3.6*
Interval from weaning to first oestrus (days)	21.6	12.0	9.3
Litter size	9.4	10.1	11.6
Conception rate (%)	58.3	75.0	100

From Brooks and Cole (1972)

Table 29.15 EFFECT OF FEED LEVEL FROM WEANING TO REMATING ON THE REPRODUCTIVE PERFORMANCE OF SOWS HAVING WEANED THEIR THIRD LITTER

	Feed intake (kg/day)			
	1.8	*2.7*	*3.6*	'*semi*-ad libitum'
Interval from weaning to first oestrus	4.92	4.69	5.0	5.0
Litter size	12.6	11.8	12.2	12.3
Conception rate (%)	100	100	100	100

From Brooks *et al.* (1975)

The explanation might be that sows having just weaned their first litter are particularly susceptible to reproductive failure and the extra energy intake would have a beneficial effect, whereas sows having just weaned their third litter would be at the peak of their reproductive performance. In this work there was also a greater weight loss in the first experiment than the second. The period from weaning to remating is short and it is useful insurance to feed high levels from weaning to remating particularly after the first litter. Short term 'flushing' (e.g. for a single day) has generally not been successful (Brooks and Cole, 1974). High protein levels can also be beneficial in improving the return to oestrus (Svajgr *et al.*, 1972).

Conclusions

In conclusion it can be said that while our knowledge on sow nutrition has served us well in the past, it is necessary to ensure that it continues to meet the needs of changes in the future. For example, it is important that we establish the changes that are necessary in nutrition as a result of changes in weaning age. It is also important that experiments are of sufficient duration to enable responses to be measured over longer periods.

References

ALLEE, G.L. and BAKER, D.H. (1970). Limiting nitrogenous factors in corn protein for adult female swine. *J. Anim. Sci.* **30**, 748–752

ANDERSON, L.L. and MELAMPY, R.M. (1972). Factors affecting ovulation rate in the pig. In *Pig Production* (D.J.A. Cole, Ed.), pp. 329–366. London, Butterworths

BAKER, D.H. and ALLEE, G.L. (1970). Effect of dietary carbohydrate on assessment of the leucine need for maintenance of adult swine. *J. Nutr.* **100**, 277–280

BAKER, D.H., BECKER, D.E., NORTON, H.W., JENSEN, A.H. and HARMON, B.G. (1966). Some qualitative amino acid needs of adult swine for maintenance. *J. Nutr.* **88**, 391–396

BAKER, D.H., BECKER, D.E., JENSEN, A.H. and HARMON, B.G. (1970a). Reproductive performance and progeny development as influenced by nutrition during pregnancy and lactation. *Illinois Pork Industry Day Report*, University of Illinois, Urbana, As-655a, p.15

BAKER, D.H., BECKER, D.E., JENSEN, A.H. and HARMON, B.G. (1970b). Protein source and level for pregnant gilts: A comparison of corn, Opaque-2 corn and corn soybean meal diets. *J. Anim. Sci.* **30**, 364–367

BOOMGAARDT, J., BAKER, D.H., JENSEN, A.H. and HARMON, B.G. (1972). Effect of dietary lysine levels on 21 day lactation performance. *J. Anim. Sci.* **34**, 408–410

BROOKS, P.H. and COLE, D.J.A. (1971). Effect of nutrition on reproductive performance in the pig. In *Proceedings of Nutrition Conference for Feed Manufacturers, University of Nottingham* (H. Swan and D. Lewis, Eds.), pp. 21–37. London, Churchill Livingstone

BROOKS, P.H. and COLE, D.J.A. (1972). Studies in sow reproduction. 1. The effect of nutrition between weaning and remating on the reproductive performance of primiparous sows. *Anim. Prod.* **15**, 259–264

BROOKS, P.H. and COLE, D.J.A. (1974). The effect of nutrition during the growing period and the oestrous cycle on the reproductive performance of the pig. *Livest. Prod. Sci.* **1**, 7–20

BROOKS, P.H., COLE, D.J.A., ROWLINSON, P., CROXSON, V.J. and LUSCOMBE, J.R. (1975). Studies in sow reproduction. 3. The effects of nutrition between weaning and remating on the reproductive performance of multiparous sows. *Anim. Prod.* **20**, 407–412

CLAWSON, A.J., RICHARDS, H.L., MATRONE, G. and BARRICK, E.R. (1963). Influence of level of total nutrient and protein intake on reproductive performance in swine. *J. Anim. Sci.* **22**, 662–669

COLE, D.J.A. (1978). Animo acid nutrition of the pig. In *Recent Advances in Animal Nutrition – 1978* (W. Haresign and D. Lewis, Eds.), pp. 59–72. London, Butterworths

DEGEETER, M.J., HAYS, V.W., KRATZER, D.D. and CROMWELL, G.L. (1970a). Reproductive and progeny performance of protein restricted gilts. *J. Anim. Sci.* **31**, 199 (Abstract)

DEGEETER, M.J., HAYS, V.W., CROMWELL, G.L. and KRATZER, D.D. (1970b). Reproductive and progeny performance of protein restricted gilts. *J. Anim. Sci.* **31**, 1020 (Abstract)

DEGEETER, M.J., HAYS, V.W., KRATZER, D.D. and CROMWELL, G.L. (1972). Reproductive performance of gilts fed diets low in protein during gestation and lactation. *J. Anim. Sci.* **35**, 772–777

DUEE, P.H. and RERAT, A. (1974). Etude du besoin en lysine de la truie gestante nullipare. *Journées de la recherche porcine en France*, pp. 49–56. Paris L'Institut Technique du Porc

DUEE, P.H. and RERAT, A. (1975). Etude de besoin en lysine de la truie gestante nullipare. *Annls Zootech.* **24**, 447–464

DUTT, R.H. and CHANEY, C.H. (1968). Feed intake and embryo survival in gilts. *Prog. Rep. Ky agric. Exp. Stn* **No.176**, 33–35

DYCK, G.W. and STRAIN, J.H. (1980). Post-mating feed consumption and reproductive performance in gilts. *Can. J. Anim. Sci.* **60**, 1060 (Abstract)

ELLIOTT, R.F., VAN DER NOOT, G.W., GILBREATH, R.L. and FISHER, H. (1971). Effect of dietary protein level on composition changes in sow colostrum and milk. *J. Anim. Sci.* **32**, 1128–1137

ELSLEY, F.W.H. and MACPHERSON, R.M. (1966). *9th International Congress on Animal Production, Edinburgh*, Science Progress p. 104 (Abstract)

ELSLEY, F.W.H. and MACPHERSON, R.M. (1972). Protein and amino acid requirements in pregnancy and lactation. In *Pig Production* (D.J.A. Cole, Ed.), pp. 417–434. London, Butterworths

FROBISH, L.T., SPEER, V.C. and HAYS, V.W. (1966). Effect of protein and energy intake on reproductive performance in swine. *J. Anim. Sci.* **25**, 729–733

GREENHALGH, J.F.D., ELSLEY, F.W.H., GRUBB, D.A., LIGHTFOOT, A.L., SAUL, D.W., SMITH, P., WALKER, N., WILLIAMS, D. and YEO, M.L. (1977). Comparison of four levels of dietary protein in gestation and two in lactation. *Anim. Prod.* **24**, 307–321

HAWTON, J.D. and MEADE, R.J. (1971). Influence of quantity and quality of protein fed the gravid female on reproductive performance and development of offspring in swine. *J. Anim. Sci.* **32**, 88–95

HEAP, F.C. and LODGE, G.A. (1967). Changes in body composition of the sow during pregnancy. *Anim. Prod.* **9**, 237–245

HESBY, J.H., CONRAD, J.N., PLUMLEE, M.P. and MARTIN, T.G. (1970a). Opaque-2 corn, normal corn and corn-soybean meal gestation diets for swine reproduction. *J. Anim. Sci.* **31**, 474–480

HESBY, J.H., CONRAD, J.N., PLUMLEE, M.P. and HARRINGTON, R.B. (1970b). Nitrogen balance and serum protein response of gestating swine fed Opaque-2 corn, normal corn and corn-soybean diets. *J. Anim. Sci.* **31**, 481–485

HILLYER, G.M. and PHILIPS, P. (1980). The effect of increasing feed level to sows and gilts in late pregnancy on subsequent litter size, litter weight and maternal body-weight change. *Anim. Prod.* **30**, 469 (Abstract)

HOLDEN, P.J., LUCAS, E.W., SPEER, V.C. and HAYS, V.W. (1968). Effect of protein level during pregnancy and lactation on reproductive performance in swine. *J. Anim. Sci.* **27**, 1587–1590

KEMM, E.H. and PIETERSE, P.J.S. (1968). The influence of protein on the productivity of Large White gilts. *Proc. S. Afr. Soc. Anim. Prod.* **7**, 133–135

LEWIS, A.J. and SPEER, V.C. (1973). Lysine requirement of the lactating sow. *J. Anim. Sci.* **37**, 104–110

LODGE, G.A. (1959). Nitrogen metabolism in the lactating sow. *J. agric. Sci., Camb.* **53**, 172–176

LODGE, G.A. (1972). Quantitative aspects of nutrition in pregnancy and lactation. In *Pig Production* (D.J.A. Cole, Ed.), pp. 399–416. London, Butterworths

LODGE, G.A., ELSLEY, F.W.H. and MACPHERSON, R.M. (1966a). The effects of level of feeding of sows during pregnancy. 1. Reproductive performance. *Anim. Prod.* **8**, 29–38

LODGE, G.A., ELSLEY, F.W.H. and MACPHERSON, R.M. (1966b). The effects of level of feeding of sows during pregnancy. 2. Changes in body weight. *Anim. Prod.* **8**, 499–506

LUCAS, E.W., HOLDEN, P.J., SPEER, V.C. and HAYS, V.W. (1969). Effect of protein level during pregnancy and lactation on plasma amino acid profile in swine. *J. Anim. Sci.* **29**, 429–432

MACPHERSON, R.M., HOVELL, F.D.DeB. and JONES, A.S. (1977). Performance of sows first mated at puberty or second or third oestrus and carcass assessment of once-bred gilts. *Anim. Prod.* **24**, 333–342

MAHAN, D.C. and MANGAN, L.T. (1975). Evaluation of various sequences on the nutritional carry-over from gestation to lactation with first-litter sows. *J. Nutr.* **105**, 1291–1298

MILLER, G.M., BECKER, D.E., JENSEN, A.W., HARMON, B.G. and NORTON, H.W. (1969). Effects of protein intake on nitrogen retention by swine during late pregnancy *J. Anim. Sci.* **28**, 204–207

O'GRADY, J.F. (1971). Level and source of protein in the diets of lactating sows. *Ir. J. agric. Res.* **10**, 17–30

O'GRADY, J.F. (1980). Energy and protein nutrition of the sow. In *Recent Advances in Animal Nutrition – 1980* (W. Haresign, Ed.), pp. 121–131. London, Butterworths

O'GRADY, J.F. and HANRAHAN, T.J. (1975). Influence of protein level and amino acid supplementation of diets fed in lactation on the performance of sows and their litters. 1. Sow and litter performance. *Ir. J. agric. Res.* **14**, 127–135

PIKE, I.H. and BOAZ, T.G. (1969). The effect on the reproductive performance of sows of dietary protein concentration and pattern of feeding in pregnancy. *J. agric. Sci., Camb.* **73**, 301–309

POND, W.G., DUNN, J.A., WELLINGTON, G.H., STOUFFER, J.R. and VAN VLECK, L.D. (1968). Weight gain and carcass measurements of pigs from gilts fed adequate vs protein-free diets during gestation. *J. Anim. Sci.* **27**, 1583–1586

RIPPEL, R.H., RASMUSSEN, A.H., JENSEN, A.H., NORTON, H.W. and BECKER, D.E. (1965a). Effect of level and source of protein on reproductive performance of swine. *J. Anim. Sci.* **24**, 203–208

RIPPEL, R.H., HARMON, E.G., JENSEN, A.H., NORTON, H.W. and BECKER, D.E. (1965b). Response of the gravid gilt to levels of protein as determined by nitrogen balance. *J. Anim. Sci.* **24**, 209–215

RIPPEL, R.H., HARMON, B.G., JENSEN, A.H., NORTON, H.W. and BECKER, D.E. (1965c). Essential amino acid supplementation of intact proteins fed to the gravid gilt. *J. Anim. Sci.* **24**, 373–377

RIPPEL, R.H., HARMON, B.G., JENSEN, A.H., NORTON, H.W. and BECKER, D.E. (1965d). Some amino acid requirements of the gravid gilt fed a purified diet. *J. Anim. Sci.* **24**, 378–382

SALMON-LEGAGNEUR, E. (1962). Effect of changes at different times in the plane of nutrition of pregnant sows. *Annls Zootech.* **11**, 173–180

SALMON-LEGAGNEUR, E. (1965). Some aspects of the nutritional relationships between pregnancy and lactation in the sow. *Annls Zootech.* **14**, Special Serial No. 1, 137

SALMON-LEGAGNEUR, E. and DUEE, P.H. (1972). Lysine supplementation of a cereal basal diet in pregnant and lactating sows. *Journées de la recherche porcine en France,* pp. 157–161. Paris, L'Institut Technique du Porc

SALMON-LEGAGNEUR, E. and RERAT, A. (1962). Nutrition of the sow during pregnancy. In *Nutrition of Pigs and Poultry* (J.T. Morgan and D. Lewis, Eds.), pp. 207–223. London, Butterworths

SOHAIL, M.A., COLE, D.J.A. and LEWIS, D. (1978a). Amino acid requirements of the breeding sow: the dietary lysine requirement during pregnancy. *Br. J. Nutr.* **39**, 463–468

SOHAIL, M.A., COLE, D.J.A. and LEWIS, D. (1978b). Amino acid requirements of the breeding sow. 2. The dietary lysine requirement of the lactating sow. *Br. J. Nutr.* **40**, 369–376

SPEER, V.C. (1975). Amino acid requirements for the lactating sow. (Calculated requirements and research on levels of the essential amino acids for lactation: An update). *Feedstuffs* **47**, 21–22

SVAJGR, A.J., HAMMELL, D.L., DEGEETER, M.J., HAYS, V.W., CROMWELL, G.L. and DUTT, R.H. (1972). Reproductive performance of sows on a protein restricted diet. *J. Reprod. Fert.* **30**, 455–458

VAN SCHOUBROEK, F. and VAN SPAENDONCK, R. (1973). Faktorieller Aufban des Energiebedorfs tragender Zuchtsauen. *Z. Tierphysiol. Tierernähr. Futtermittelk.* **31**, 1–21

WILKINSON, R. (1978). Amino acid nutrition of the lactating sow. PhD Thesis. University of Nottingham

WOERMAN, R.L. and SPEER, V.C. (1976). Lysine requirement for reproduction in swine. *J. Anim. Sci.* **42**, 114–120