6. NUTRITION OF THE BREEDING HERD

Introduction

Adequate nutrition of the breeding herd is essential in order to maximize herd productivity and profit. If one compares the reproductive efficiency of herds obtaining average productivity with those obtaining higher levels of performance, considerable room for improvement is evident (Table 6-1). Improvements in genetic quality and housing can account for some of the variation in reproductive efficiency observed. However, maximum reproductive efficiency can never be obtained unless the best feeding and management practices are also followed.

Table 6-1. Reproductive Efficiency of Average and Superior Swine Herds.

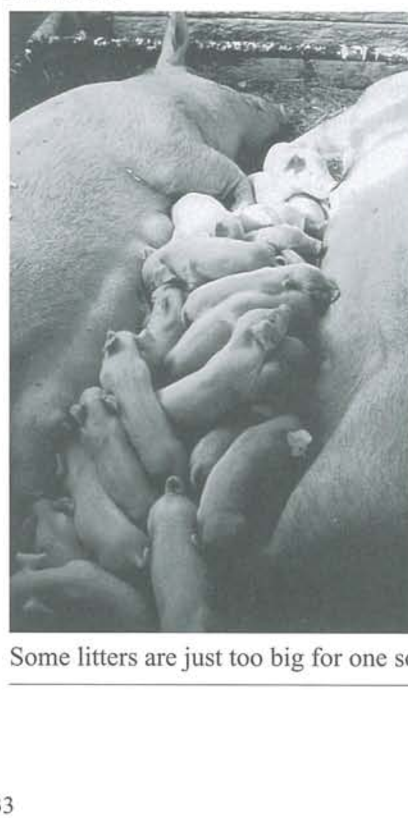
	Typical	Superior
Baby Pig Mortality (%)	12 - 18	8
Weaning to Effective Mating (Days)	8 - 10	5
Farrowing Rate (%)	78 - 85	90
Pigs Weaned/Litter	8.5-9.5	10.5
Litters/Year	2.0-2.3	2.4
Pigs Weaned/Sow/Year	17 - 22	25.2

Before defining their desired feeding program, pork producers need to establish goals for their breeding herd. Typical questions that are relevant include the genotype, the emphasis on sow longevity, the type of housing employed (indoor versus outdoor, group versus individual) and the nature of the current sow herd including factors such as appetite and body condition. Once such questions are answered, the nature of the feeding program can be more accurately defined.

Unfortunately, too many producers try to reduce costs by cutting back on the quality of the diet fed. This is a grave error as it is well documented that feeding poor quality diets will adversely affect reproductive performance. Failure to meet the nutritional needs of the sow may result in smaller litters, a reduction in piglet birth weight and vigor, lower milk production, an increase in the weaning to service interval, a reduction in conception rates and a shortened reproductive lifespan. Therefore, it is vital that the diet provided contains sufficient quantities of energy, protein, essential fatty acids, vitamins and minerals to allow the sow to perform to its genetic potential.

Since nutrition is a primary factor influencing reproductive efficiency, it follows that the establishment of a successful feeding strategy to ensure optimum productivity must be based on a sound knowledge of the response of the sow to specified nutritional inputs. Traditional feeding strategies often utilized the body reserves of the gilt and sow to buffer short-term deficits in nutrient intake with minimum effect on the fetus or suckling piglets. However, modern sows, with a lean genotype and superior reproductive performance, must be managed differently from their counterparts of twenty years ago since they begin their reproductive life with fewer body reserves. Therefore, nutritional responses must be considered more precisely and a strategy designed to conserve body tissue must be employed.

Photo 6-1.



Some litters are just too big for one sow to handle.

Feeding and Management of Replacement Gilts

Survey data indicate that sow culling rates on most commercial swine operations are somewhere between 30 and 50%. As a consequence, replacement gilts will constitute a significant proportion of the breeding females in most swine herds and any improvement in their productivity will have a significant impact on the reproductive performance of the entire herd. Factors influencing gilt productivity include age at successful mating, ovulation rate at the estrus of mating, first litter size and the ability to be successfully rebred. In far too many herds, the gilt is a neglected member of the breeding herd. However, by the adoption of an appropriate replacement policy and proper gilt management, the overall productivity of any swine enterprise can be markedly improved.

Feeding Replacement Gilts During the Rearing Period

Gilts selected to enter the breeding herd will typically have superior growth rates and lower backfat levels than unselected pigs. As a consequence, it is reasonable to expect their nutritional requirements to be greater than those of pigs destined for slaughter. In addition, diets formulated to achieve cost-efficient, rapid growth may not provide sufficient nutrients to prepare the gilt for a long and productive breeding life. Therefore, where possible, gilts destined to be used in the breeding herd should not be fed the same diets as those fed to market animals.

Nutrition during the rearing period (20-100 kg), through its effects on body weight and backfat levels, can influence the age at which puberty is attained. Several studies have shown that restricting the feed intake of young growing gilts (50-85% of ad libitum intake) will delay the onset of puberty by about 10 to 14 days. To ensure that puberty is not delayed, gilts should be fed ad libitum and receive at least 35 MJ DE/day (8361 kcal/day) between selection and mating.

Severe protein restriction or an amino acid imbalance will also significantly delay the age at which a gilt reaches puberty. Therefore, it is important that producers not cut back on the use of protein supplements during the developmental period to ensure that puberty is not delayed. However, diets formulated to meet the protein and amino acid requirements of slaughter animals will typically provide more than enough protein to allow gilts to express their potential in terms of minimizing age at puberty. Therefore, producers should not be unduely concerned about protein restriction during this period. A diet formulated to contain 15% crude protein (466 g/day)and 0.7% lysine (217 g/day) should be adequate.

Diets formulated expecially for replacement gilts should contain higher levels of calcium and phosphorus compared with diets fed to feeder pigs. The levels of calcium and phosphorus that result in maximum growth rate are not necessarily adequate for maximum bone mineralization. Feeding of dietary levels of calcium and phosphorus sufficient to maximize bone mineralization in gilts during early growth and development have been shown to improve reproductive longevity in some studies. Therefore, dietary calcium and phosphorus requirements, expressed as a percentage of the diet, are higher for gilts than for barrows and diets fed to replacement gilts should be formulated to provide a minimum of 0.82% calcium (25.4 g/day) and 0.73% phosphorus (22.6 g/day).

Genetic programs over the past 10-15 years have placed considerable emphasis on selection for leanness in gilts. The effects of these genetic changes, combined with earlier mating, mean that gilts now start their breeding lives with less body reserves than in the past. This reduction in fat reserves could adversely affect the long-term reproductive performance of genetically improved strains of pigs. Australian workers have observed that gilts which entered the breeding herd with greater fat reserves were retained in the herd longer and had a shorter average farrowing interval than gilts with less fat reserves. It may therefore be desireable to encourage potential replacement gilts to deposit more body fat. Alteration of the lysine/energy ratio could achieve this goal.

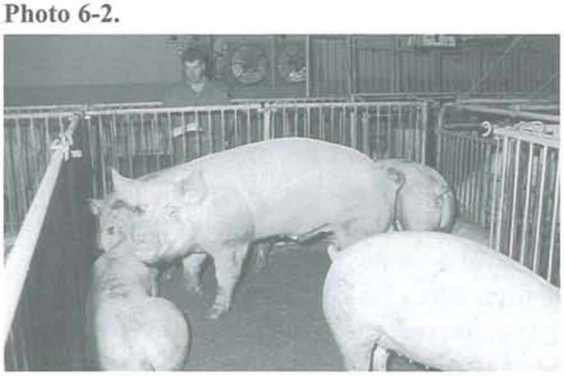
Puberty Induction

Age at successful mating is largely dependant on the age at which the gilt reaches puberty. The mean age at puberty for non-stimulated gilts is about 200 days of age, with a range of 135 to 250 days. Canadian data indicate that fewer than 1% of gilts, housed and managed under typical commercial rearing conditions, will reach puberty by market weight. Therefore, unless special steps are taken to induce early puberty, most gilts will have a prolonged interval between the age at which they attain market weight and when they are able to be successfully bred. The aim of successful management should be to keep this unproductive time to a minimum.

Although the normal pubertal age of a gilt is under genetic control, there are various factors that have been shown to delay or advance the age at which a gilt reaches puberty. Factors known to influence the age of puberty include the breed of the gilt, the housing conditions under which the gilt is raised, the lighting regime and the degree of stress experienced by the gilt (mixing and relocation). As a consequence, most producers could take steps to reduce the average age of puberty in their herd.

The most potent stimulus for inducing early puberty in gilts is boar exposure. Fence line contact is not adequate as there must be direct physical contact between the boar and the gilt. The best response is obtained by taking the gilt to the boar pen, not vice versa. This is likely due to the fact that boar odors are stronger in the boar pen providing a greater degree of stimulation for the gilt. However, in order to stimulate puberty, the gilt must be placed in the boar pen at least 20-30 minutes a day, usually for a minimum of 10 consecutive days.

Photo 6-2.



The most potent stimulus for inducing early puberty in gilts is boar exposure.

With proper stimulation, the mean age of puberty in a herd can be 30 to 40 days earlier than for non-induced gilts. Unfortunately, many producers who have tried boar exposure have been unsuccessful in inducing early puberty. The reason for their lack of success is probably related to the fact that attainment of threshold levels of age and weight are prerequisites for successful boar exposure. The recommended minimum ages and weights for the commencement of boar exposure are 140 days of age and 70 kg body weight. With modern genotypes of swine, age is more likely to be a constraint than is body weight and therefore it is unlikely that gilts fed under commercial conditions will reach puberty much before 90 kg.

It is important that if early puberty is induced, gilts not be bred on their first heat as this practice will result in a reduction in litter size. Research has shown that an extra one or two pigs per litter can be obtained by waiting until the second or third heat before breeding replacement gilts. With induction of puberty at 150 days of age, gilts gaining weight at a rate of 800 g/day should reach the desireable breeding weight of 115-125 kg by their third estrus (192 days). Target backfat levels at mating are 17-20 mm.

A major concern of many pork producers is that if gilts are bred at too light a weight and with too little backfat, the gilts will have a shortened reproductive lifespan. However, recent research has shown that this need not be the case. Lean gilts provide a challenge to the producer, but if managed properly, acceptable performance can be expected from gilts induced to reach early puberty.

Feeding Replacement Gilts Prior to Breeding

Ovulation rate is the principle factor limiting litter size in gilts and there is a great deal of experimental evidence showing that increasing the level of feed intake during the rearing period will significantly increase ovulation rate at puberty. It is also well established that short-term, high level feeding (flushing) during the first estrus cycle increases ovulation rate compared with gilts fed restricted amounts of feed. Dutch researchers have suggested that ovulation rate increases by about two ova in response to increased feed intake during the 14-day period immediately prior to ovulation. As a consequence, should feed intake be restricted for any reason during the rearing period, special precautions should be taken to ensure that gilts are ad lib fed (at least 3 kg/day) for the two week period prior to mating.

Flushing has been shown to increase plasma levels of FSH and increase the pulse frequency of LH suggesting that flushing enhances ovulation rate by stimulating the secretion of gondotrophins. The increase in gonadotrophin secretion is thought to be mediated through plasma levels of insulin and insulin-like growth factor-1 (IGF-1). The increase in ovulation rate likely occurs either as result of increased follicle recruitment or a reduction in atresia.

Feeding Gilts Following Mating.

It has been determined that approximately 30% of all potentially viable embryos die during the first 25 days of gestation. High levels of feed intake following mating have traditionally been associated with an increase in embryo mortality. As a consequence, it is usually recommended that feed intake be restricted to approximately 2.3 kg/day following mating. However, more recent evidence suggests that the practise of feed restriction to reduce embryo mortality may not necessarily result in an increased litter size.

Most of the research which has shown an increase in embryo mortality, as a result of higher feed intakes early in gestation, has involved an increase in feed intake at or very soon after mating. Such a practise would increase ovulation rate and this increase *per se* may lead to an increased embryo mortality since higher ovulation rates are commonly associated with higher embryo loss. The higher ovulation rate followed by a higher embryo loss produces a similar number of embryos (and presumably piglets) to that obtained from gilts fed at a lower level (Table 6-2).

Table 6.2. Influence Of Feeding Level Following Mating On Embryo Survival in Gilts.

	Low Energy (22.9 MJ/day)	High Energy (40.5 MJ/day)
Ovulation Rate	12.3	13.8
Number of Embryos	9.7	10.1
Embryo Survival (%)	78.3	73.2

Adapted from den Hartog and van Kempen, 1980, Neth. J. Agric. Sci. 28: 211-227.

The principle mechanism controlling the development of embryos and their subsequent survival is the secretion of uterine specific proteins. These proteins are stimulated by ovarian steroid hormones, particularly progesterone. A rise in progesterone early in pregnancy enhances the uterine environment and makes it more supportive of the embyro. Increased gestation feed intakes have been shown to be associated with a decrease in plasma progesterone concentration as a result of increased metabolic clearance of progesterone leading to a subsequent reduction in embryo survival (Table 6-3).

Table 6-3. Effect of Feed Level in Early Gestation on Plasma Progesterone Levels and Embryo Survival.

Feed Level (kg/day)	Embryo Survival (%)	Plasma Progesterone Concentration (ng/ml)
1.50	82.8	16.7
2.25	78.6	13.8
3.00	71.9	11.8

Dyck et al., 1980, Can. J. Anim. Sci. 60: 877-884.

Recent data from the University of Alberta suggest that the first 72 hours after mating may be of critical importance in determining the effect of feeding level on embryo loss. Increasing feed intake from 1.8 to 2.5 kg/day during the first 72 hours of gestation significantly increased embryo mortality whereas increasing feed intake after 72 hours did not increase embryo mortality. The increased mortality in the first 72 hours was associated with a 10 hour delay in the normal rise in plasma progesterone. As noted earlier, a rise in progesterone, early in pregnancy, enhances the uterine environment and makes it more supportive of the embyro.

Clearly more research is needed on the effect of feed intake in early gestation on gilt productivity. However, given the current state of our ignorance, producers would be wise to continue the practise of restricted feeding early in gestation, particularly during the first 72 hours following mating.

High feed intakes late in gestation may also be detrimental to gilt productivity as they affect the development of the mammary gland. In swine, total mammary DNA can be used as an estimate of mammary cell number and development. Minimal development of the mammary gland occurs between mating and day 50 of gestation. The period of maximal mammary development occurs between day 70 and 105. During this time, a threefold increase in mammary tissue occurs as measured by total mammary DNA. Recent research at Michigan State University has shown that a high level of dietary energy during this critical period of mammary development reduced total mammary parenchymal DNA (Table 6.4).

Table 6.4. Effect of Energy Intake (day 75 to 105 of Gestation) on Mammary Development in Gilts.

	Adequate Energy (5.76 Mcal/day)	High Energy (10.5 Mcal/day)
Total DNA (mg)	3.22	2.48
Total RNA (mg)	4.07	3.09
Total Protein (g)	.16	0.10
Wt of Parenchymal Tissue (g)	1.12	0.88

Weldon et al., 1991, J. Anim. Sci. 69:194-200.

This reduction in DNA reflects a reduced mammary cell number and may reduce the amount of milk produced by the sow during lactation available for nourishment of the offspring. Therefore, it would appear that feeding a high level of energy during this period of rapid mammary growth impairs development of the mammary gland in gilts and should be avoided.

Summary of Replacement Gilt Feeding

Diets fed to potential replacement gilts should contain 3100 kcal D.E./kg, 15% crude protein, 0.7% lysine, 0.82% calcium and 0.73% phosphorus and be fed ad libitum from the time of selection (50-60 kg) until needed for breeding. Gilts selected for mating should have experienced at least two heat cycles, weigh 115-125 kg and have 17-20 mm of backfat. If feed intake is restricted for any reason during the rearing period, special precautions should be taken to ensure that gilts are ad lib fed (at least 3 kg/day) for the two week period prior to mating. For the first 72 hours following mating, feed intake should be restricted to less than 2.5 kg/day.

Selecting very lean gilts for the breeding herd provides a special challenge to the producer. However, if managed properly, lean gilts can become very productive members of the breeding herd.

Feeding the Sow During Gestation

Introduction

The key to successful sow feeding is built around the broad principle of generous feeding during lactation and strict rationing during gestation. There is now general agreement that 1.8 to 2.7 kg of feed per day (20 to 33 MJ/day) is satisfactory for pregnant sows housed under reasonable environmental conditions when free of heavy parasite infestation and individually fed. Increasing the feed intake of sows above this level would appear to be of little benefit.

The effect of increasing feed intake during gestation on subsequent litter size is shown in Figure 6-1. It is evident that above a threshold level, there is a wide range of feed intake over which there is little effect on the number of piglets born. At higher levels of intake the sow may become overfat and litter size may decrease.

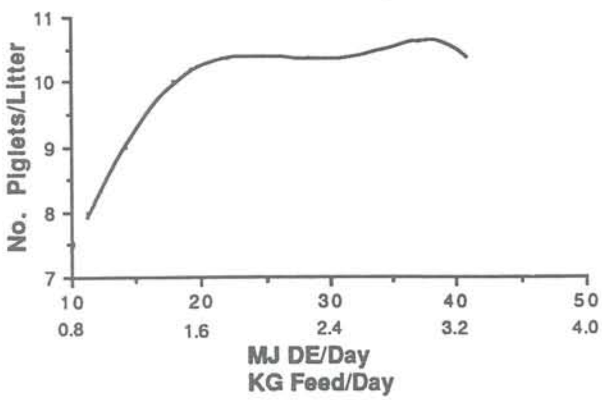


Figure 6-1. Effects of Feed Intake During Pregnancy on Sow Productivity.

Increasing feed intake during gestation will also dramatically increase sow weight gain but has very little effect on the birth weight of the newborn pig. Since these high levels of intake are not improving litter size or birth weight, considerable saving in feed costs can be achieved by restricting the feed intake of sows in gestation.

A reduction in feed costs is not the only benefit from restricting the feed intake of sows during gestation. There is some evidence that embryonic survival and thus litter size may be increased by restricting the level of intake during gestation. In addition, farrowing difficulties may be reduced and fewer piglets may be crushed by the sow.

Many producers believe that providing high levels of feed during gestation will maintain the sow in good body condition. However, research has shown that as the level of feed intake during gestation increases, the level of feed intake during lactation decreases (see Table 6-23). Consequently, sows fed high levels of feed during gestation will eat less during their subsequent lactation and will start to deplete their body reserves. Restricting feed intake during gestation will prevent this loss of body condition and may help to prolong the sow's reproductive lifespan.

Methods of Restricting Feed Intake of Sows During Gestation

Various management systems have been used successfully to limit the energy intake of sows during gestation. These include:

- -Hand feeding using gestation stalls
- -Computer controlled feeding stations
- -Slow feeding systems
- -Self-closing individual stalls
- -Skip a day feeding
- -Self feeding a high fibre ration

Gestation Stalls

Individual daily feeding, utilizing gestation stalls, provides the greatest control over the feed intake of the sow and is the method of choice for most producers. Use of gestation stalls provides the greatest control over the feed intake of the sow as each sow can be fed to condition resulting in a reduction in feed costs. In addition, the elimination of fighting reduces prenatal losses.

Unfortunately, the increased cost of gestation stalls makes the system unattractive to many producers and animal welfare groups have directed criticism at them as well. Unless an automatic feeding system is used, the gestation stall system is very labor intensive. Furthermore, it has been suggested that digestive upset (ulcers, twisted gut) is worse in sows housed in gestation crates. Therefore, alternative methods of restricting feed intake have been sought by some producers.

Electronic Sow Feeders

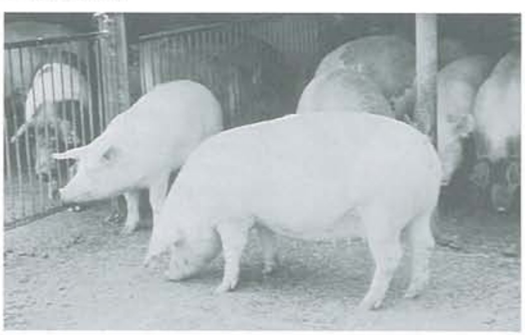
The electronic sow feeder has recently been introduced into Canada, following earlier experiences in Europe. With this technique, 40 sows can be fed using a single feeding station. The amount of feed that a sow gets each day is programmed into the computer. When it enters the station, the transponder the sow carries causes small portions of feed to be released. While the sow is eating, it is protected from other sows by a special crate which ensures that they cannot steal her feed.

In essence, this system allows sows to be group housed but individually fed. The systems most attractive features are that it allows the use of inexpensive, non-specialized buildings to house sows during gestation and produces a daily report on sow feed consumption. Electronic sow feeders also find favor with animal welfare enthusiasts because they are compatible with straw bedding and allow the sow the chance to exercise.

Sows which are placed on the electronic feeder establish a regular feeding cycle. The more dominant sows eat first and the more timid sows wait until later in the cycle. The computer system allows the daily ration to be divided between a number of feedings, but most sows consume all of their daily allotment in one 12-15 minute feeding. If a sow which has already had its full ration returns to the station, no further feed is dispensed.

It does not appear difficult to train sows to use the electronic feeder. One trial conducted in Britian indicated that 50% of sows required no training, while a further 27% required only one assisted visit to the feeding station in order to adapt to the system. The majority of sows seem to learn to use the electronic feeding system within four days although there may be a few sows which never adapt and must be culled.

Photo 6-3.



Sows housed outdoors require additional feed, especially in cold, damp weather.

Use of an electronic sow feeder does not appear to have any detrimental effects on sow performance. In a British study, conception rate, litter size and the incidence of farrowing problems were similar for sows fed using an electronic feeder and those housed under more traditional systems of management (Table 6-5).

Table 6-5. Comparison of Sows Fed with Electronic Sow Feeders or in Gestation Stalls.

	Gestation Stalls	Electronic Sow Feeders
Number of Herds	485	27
Litters/Sow/Year	2.3	2.3
Pigs/Sow/Year	21.8	21.9
Feed/Sow/Year (tonnes)	1.19	1.22
Sow Replacements (%)	19.3	15.9
Sow Mortality (%)	2.0	1.9

MLC Pig Yearbook, 1989

It must be pointed out that electronic sow feeders are not completely fool-proof. Some sows have learned that repeated banging of the feeding station can dislodge a small amount of feed which will not be accounted for on the computer printout. Regular calibration is also necessary in order to correct for differences in density between successive batches of feed. In addition, collars and ear tags can be lost thereby preventing a sow from feeding.

Many producers have expressed concerns about the possibility of sows fighting during mixing and while queuing at the feed station. However, in most cases, the large area available for avoidance and escape has meant that aggression has not been a problem and in fact, sows using the system are extremely docile. Vulva biting has been one of the more persistent problems, prompting modifications in design. If other problems develop, it may be because the feeder has been incorrectly located. It is important that the feeding station be sited to allow free movement about the entry and exit points. The feeder should be placed in an activity/dunging area rather than a lying area as incorrect siting results in sows lying at the station entrance and blocking the access of other sows to the feeder. At this time, it is suggested that straw bedding and not slatted floors be used in conjunction with electronic feeding.

It is important to emphasize that electronic sow feeders are not a replacement for good management. Sow condition must still be monitored and adjustments to daily allotment made. Depending on the system employed, heat detection and repeat breeders can become a serious problem.

Slow Feeding Systems (Biofix System)

Slow feeding systems are not presently available in Canada but have been tested in the Netherlands. Slow feeding systems dispense a continuous supply of a small amount of feed at a predetermined rate. The feed supply must be fast enough to prevent sows from looking anywhere but their own troughs for feed. On the other hand, the dispensing speed must be slow enough that even the most reluctant eater can keep up with the feed dispensed. In this way, all animals in a group will finish eating at the same time. This prevents the sows from fightng for leftover feed. This so called biological fixation makes it unnecessary to lock up the sows in the feeding station. A simple 40-45 cm wide partition between the troughs is sufficient to keep the sows contrained (Figure 6.2).

In the systems tested, feed was supplied twice a day from a volume dispenser and poured into a container with a small mortar in the bottom. The speed at which the mortar turns dictates the amount of feed dispensed. The dosing speed has been investigated in relation to leftover feed and aggressive behavior (Table 6-6). The faster the feed is dispensed, the less aggression develops and the less likely it is that sows will move away from their own troughs. Howver, the amount of leftover feed increases. A dispensing speed of 100 to 120 g per minute is recommended when pelleted feed is fed.

In general, the slow feeding system works well. The advantages of the system are that the sows can be checked during feeding and that they can learn the system without any assistance. A disadvantage is that the sows cannot be fed according to their individual requirements.

Self-closing Individual Stalls (Woldrix System)

With self-closing individual stalls, it is possible to have sows housed as a group and yet feed them temporarily as individuals. The sow pen contains a sufficient number of feeders to allow each sow to eat individually as well as communal lying and dunging areas. A slotted floor is situated at the back of the pen and the sows have free access to all of the feeding stalls at all times except during

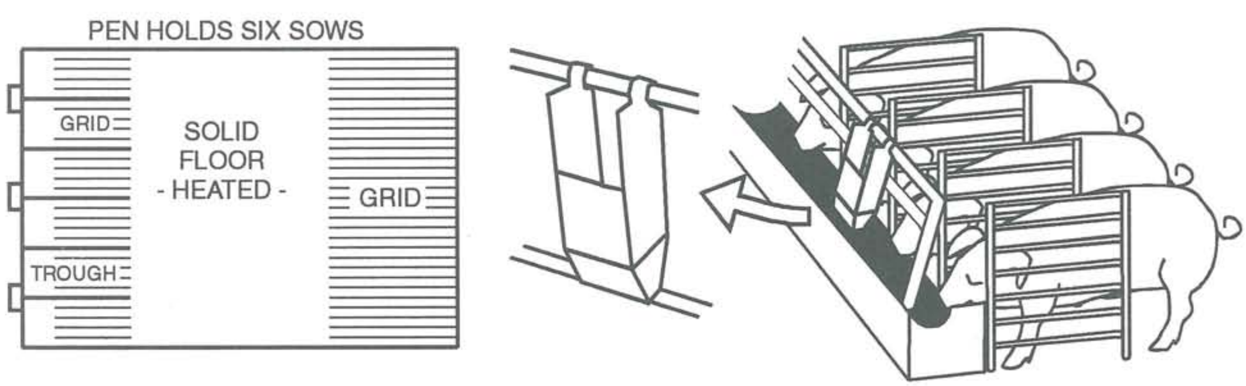


Figure 6.2. Diagram of Slow Feeding System for Sows.

feeding (Figure 6.3). When feeding starts, the entrance to each stall is locked automatically when the sow pushes her head against the trough lid. The stalls can also be locked manually by the stockman as it is important that the entrance to each individual pen be locked immediately after a sow enters to prevent other sows from bullying them and driving them away from the feeder. The feed required for each feeding place is stored in a volume dispenser and feed is poured into all the troughs at the same time by the dispenser. Once all sows have consumed their feed, the doors can be unlocked and the sows are free to wander back to the dunging area.

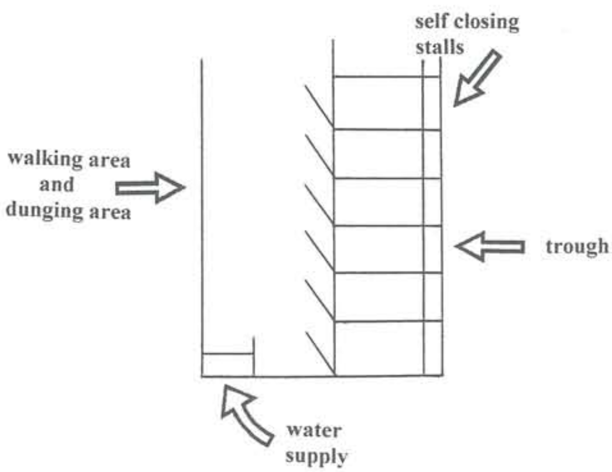


Figure 6-3. Diagram of Woldrix Feeding System for Sows.

These systems have been tested in the Netherlands since 1988. During and after feeding, there are very few signs of aggression between sows. However, reproductive data is not yet available to allow a comparison of the system with more traditional methods of sow housing.

The Hurnick-Morris Housing System

This system was developed as a result of a cooperative study between the University of Guelph and the Ridgetown College of Agricultural Technology. In the system tested, five pens are located across the midsection of the barn (Figure 6.4). Each pen is 1.6 x 6.6 meters in size and six sows can be housed in each pen, providing approximately 2 square meters per sow. Computer-controlled entrance and exit gates are located at the end of each pen. Two water drinkers are located near the exit gates. Two boar pens with space for a breeding area are located adjacent to the group sow pens. Along the walls of the barn is a 1.2 m alleyway for approaching and departing the feeding compartments. The slatted areas extend along the walkways and approximately 1.8 m into the pens at the drinking/dunging end of the pens. The remainder of the pen floor is solid and is suitable for use with bedding.

Table 6-6. The Influence of Dispensing Speed on the Behaviour and Feed Intake of Sows Using the Slow Feeding System.

	Dispensing Speed (g/minute)					
	<80	81-100	101-120	121-140	141-160	161-180
Changes in Feeding Places	4.2	2.5	0.9	1.6	0.6	0.6
Aggressive Interactions	2.0	1.1	0.4	0.6	0.6	0.6
Feed Remainders						
-none (%)	96	97	84	81	75	60
-a little (%)	3	2	13	15	14	15
-a lot (%)	1	1	3	4	11	25

Hoofs, 1990, Pig Production Trends for the 1990's pp 14-23.

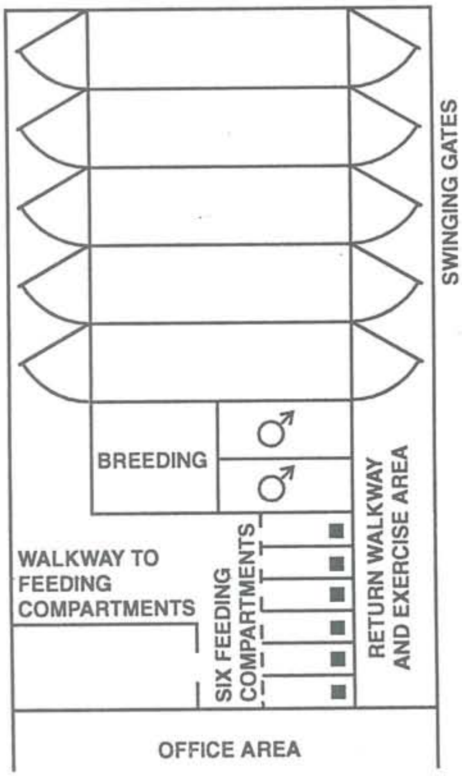


Figure 6.4. Diagram of Hurnick-Morris System for Gestating Sows.

The feeding station consists of six individual feeding compartments. Each compartment is fitted with an interogating antenna near the feeding trough which functions to identify individual sows. The sows are fitted with passive transducers. Each sow's identification is transferred to the system's computer for proper proportioning and delivery of feed. Sows are fed three times a day, but this can vary depending on the objectives of the manager. At feeding time, the computer activates and opens the exit gate to the first pen of sows, and the sows quickly move to the individual feeding compartments. Once in the compartments, the exit gate closes and the sows are identified by the computer and fed according to their respective needs. Upon completion of feeding, the sows are released through the front gates of the feeders and the entry gate to their pen opens.

Some sows will quickly return to their pen for a drink while others will roam, investigate and socialize either in the pen or the alleyway for 10-20 minutes. After this exercise period, the crowd gate slowly advances, the sows return to their pen and the entry gate closes. The sequence repeats for each successive pen of pigs until all sows are fed. During the exercise period, each sow has the opportunity to vist the boars at the front partition of the boar pen. Interrogating antenna are also located on the boar pens to recognize sows that are spending time with the boar. Future development of this aspect is to use the computer as a tool to assist the manager in detecting sows in estrus.

Preliminary data indicate that sows adjust to this system relatively quickly. Reproductive performance has been at least equal to and in some cases better than sows reared in conventional individual gestation stalls.

Skip-a-day Feeding Programmes

A small proportion of swine producers do not confine their breeding herd, but instead run their sows outside in small groups. When sows are housed in groups and the total feed given to the group is reduced, boss sows will continue to eat to appetite, leaving considerably less feed for the more timid sows. This results in a large variation in the body condition of the sow herd. Therefore, interval feeding has been suggested as a method of limit feeding sows housed outdoors in groups.

With interval feeding, sows are permitted access to a self feeder on a predetermined schedule. A common procedure is to allow sows free access to the self-feeder for eight hours during each of three days of the week. Sows have access to water but no feed during the remaining four days of the week. During one eight hour period, a sow may consume 5-6 kg of feed, but if they only have access to the feeder three days of the week, total weekly feed consumption will only be 15 to 18 kg. When divided by seven days, this averages to 2.1 or 2.6 kg of feed on a daily basis. If consumption is too high, the sow can be limited to less than eight hours access to the feeder per day.

One major requirement of the skip-a-day system is that adequate feeder space be provided. One feeder space should be provided for each sow in the group. In addition, a careful eye should be kept on the condition of the sows to ensure that they are not being left for either too long or too short a time on the self-feeder.

Sows adjust readily to this system and from all research data, there appears to be no reduction in reproductive performance as a result of interval feeding. Most research indicates that sows fed on a skip-a-day program farrow and wean a similar number of piglets as sows fed every day. However, no data on the success of this system is available for herds weaning nine or more pigs per litter. For intensive pork production, skip-a-day programs would not be recommended due to a lack of control over individual sows and also to concerns about the welfare of such systems.

Diet Dilution

A fourth method of restricting energy intake is to dilute the diet with a high fibre ingredients so that the sows may have constant access to the self-feeder. Alfalfa hay, alfalfa meal, chopped straw or oat hulls have been utilized. This system takes less labour than the other methods of limit feeding but is the least acceptable because it costs more to maintain the sow and it is difficult to prevent sows from getting fat, even though the energy content of the feed is lower. In addition, there are problems associated with grinding high fibre feeds and such feeds tend to bridge in the self-feeder. Therefore, the use of high fibre feeds to limit the energy intake of sows during gestation is not recommended.

Factors Affecting the Required Feeding Level During Gestation

Although there are many advantages to restricting intake during gestation, it must be emphasized that the actual feeding level will vary according to individual situations and animals. Factors that should be considered when determining individual feeding levels include the:

- size of the gilt or sow
- condition of the sow
- method of housing
- environment provided
- method of feeding
- health of the herd
- productivity level
- standard of management.

The size of the sow or gilt is going to affect the level of feed required. The heavier the sow, the greater the maintenance requirement and the greater the amount of feed required. Energy requirements increase by about 5% for each 10 kg increase in body weight. The condition of the sow is another factor determining the feeding level required during gestation. A thin sow will have less thermal insulation than will a fat sow. Therefore, it will be less able to adjust to lower environmental temperatures. As a consequence, a thin sow will require a larger increase in feed at a lower temperature than will a sow in good condition.

The environment in which the sow is housed should also be taken into consideration when feed allowances are being set. Sows housed at lower environmental temperatures require more feed than sows housed in their comfort zone. The energy in the excess feed is used to produce heat to enable the sow to maintain a constant body temperature. For individually housed sows, the lower critical temperature (temperature below which feed must be used to produce heat) is about 16-18°C. If the environmental temperature drops below this level, feed intake should be increased by 3-4% for every 1°C below the lower critical temperature. Sows housed in wet or drafty conditions will also require increased feed.

Sows which are housed and fed in groups compete with each other for the available feed. There may be considerable inequality in the feed intake of individual sows. Therefore, sows which are fed in groups should be given feed allowances which are about 15% above that of sows fed individually. This will ensure that those sows which are dominated by others receive feed intakes that are sufficient to prevent reproductive failure.

The health of the herd is also going to affect the feeding level required during gestation. The effect of a disease burden is difficult to quantify in nutritional terms, but represents an important influence on the utilization of feed. For example, sows infected with worms may actually lose weight through gestation and produce smaller litters. This emphasizes the importance of monitoring for worms and deworming when necessary.

Feeding Pattern Throughout Pregnancy

It is often suggested that the nutrient requirements of pregnant sows are higher in early pregnancy when the embryos are being implanted and during the last third of pregnancy when the fetuses are growing very rapidly. As logical as this may appear in theory, several large scale experiments have shown that the performance of sows fed a constant level of feed throughout pregnancy is as good as that achieved by increasing feed intake in early or late gestation (Table 6-7). Since a constant level of feeding does not impair reproductive efficiency, its simplicity should make it the method of choice.

Table 6-7. Effect of Feeding Level During Last 23 Days of Gestation on Reproductive Performance.

	Feed Intake (kg/day)	
	1.8	3.2
Pigs Born Alive	9.9	10.1
Birth Weight (kg)	1.4	1.4
Pigs Weaned (day 21)	8.3	8.5
Weaning Weight (kg)	5.3	5.4
Survival Rate (%)	84.8	84.7
Returns to Estrus (days)	5.7	5.7

Cromwell et al., 1989, J. Anim. Sci. 67: 3-14.
A cooperative research study involving 8 research stations and 1080 litters.

Evaluating Your Feeding Program During Gestation

Since there are so many factors affecting the level of feed to be fed during gestation, producers are advised to evaluate their feeding program to ensure that satisfactory levels of intake are being maintained. Two methods are available, one is to weigh sows to ensure adequate but not excessive weight gain and the second is to employ condition scoring. The former is labour intensive, but objective. The second requires less labour, but is subjective and therefore must be managed well to be successful.

The gilt or sow should gain weight during pregnancy to compensate for the weight of the litter and fetal membranes as well as to allow for a normal increase in sow body weight. Animals losing weight during pregnancy will enter lactation with low body stores of fat which will adversely affect the ensuing lactation and increase the interval between weaning and successful mating. An example of the components of gestation weight gain is given in Table 6-8.

Table 6-8. Components of Gestational Weight Gain.

Piglets (11 at 1.3 kg)	13.9 kg
Membranes	2.5 kg
Uterine Fluids	2.0 kg
Uterus	3.2 kg
Udder	3.4 kg
Sow	20.0 kg
	45.0 kg

Up to about the fifth litter, sows should gain approximately a total of 45 - 50 kg during gestation. This allows for 20 - 25 kg net weight gain by the sow and 25 kg for fetal tissues. After the fifth litter, a 25 kg total gain (0 kg net weight gain) during gestation is sufficient. Sows which are gaining just over 0.4 kg per day (0.2 after 5th parity) will obtain the desired weight gain during the gestation period.

Condition scoring uses a combination of visual assessment of the sow's general appearance and an estimation of its body fat reserves to arrive at a number or score. The chart in Fiqure 6-5 provides illustrations as well as descriptions of the five body condition classifications into which sows are grouped. Body fat is estimated by applying firm finger pressure over the top-rear (H-bones) of the pelvic girdle (Figure 6-5). The amount of fat is judged by estimating the degree of difficulty involved in locating and palpating these structures. It should take no longer than three seconds to feel the H-bones with the fingertips. If it takes longer than this, the sow should be rated either a four or a five.

The first step in assessing the adequacy of your feeding program is to obtain an average score for the dry sows in the entire herd. If the average is less than three, then the daily feeding allowance should be increased. If the average score is greater than three, a decrease is necessary. Table 6-9 indicates how much feed allowances should be altered based on the average condition score of the herd.

Table 6-9. Feed Allowances For Dry Sows According To Body Condition Score.

Condition Score	Change in Feed (kg)
1.0	+ 0.60
1.5	+ 0.40
2.0	+ 0.30
2.5	+ 0.20
3.0	0.00
3.5	- 0.20
4.0	- 0.30
4.5	- 0.40
5.0	- 0.60

Froese, 1987, Manitoba Agriculture Swine Fact Agdex No. 440-22-40.

Nutrients Required During Gestation

Based on the foregoing discussion, it can be concluded that the provision of a high quality diet is essential for sows during gestation. Such a diet is necessary in order to provide adequate levels of nutrients to allow for fetal growth, growth of the uterus and mammary glands and body growth as well as replenishment of the sow's body reserves depleted during the previous lactation. Therefore, producers are encouraged to conduct a feed analysis to confirm that the diet being fed meets the gestating sow's requirements.

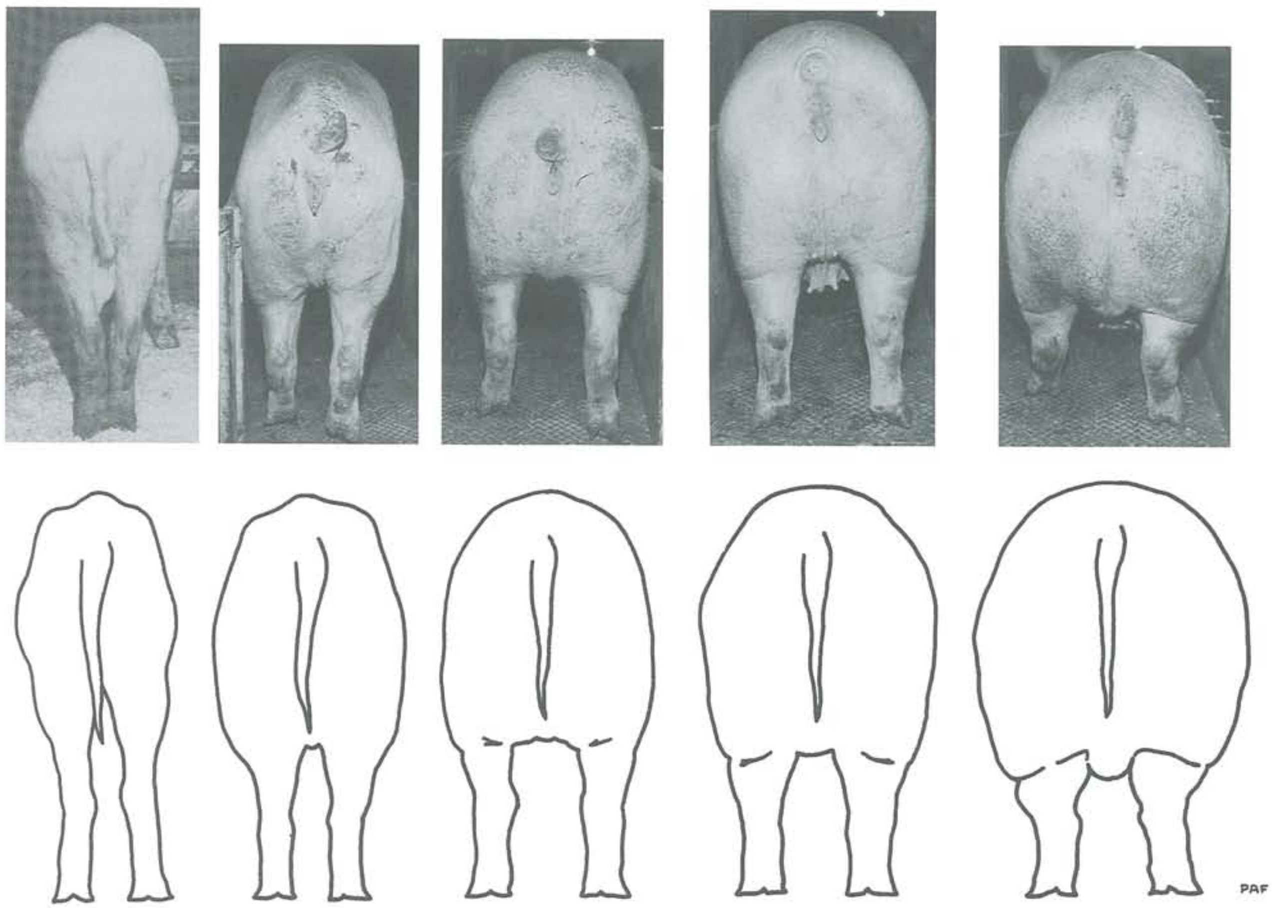
Energy

For the gestating sow, energy is required for maintenance, growth of maternal tissue and growth of the fetus. The maintenance energy requirement is dependant on the size of the sow and has been estimated to be approximately 110 kcal DE/kg$^{.75}$ per day and represents in excess of 75% of a sow's daily energy requirement. To calculate maintenance energy requirements, one must know the weight of the sow at breeding and the expected weight gain during gestation in order to calculate the average weight of the sow during gestation. The traditional thumb rule has been to target for 20-25 kg of maternal weight gain and 20 kg of reproductive tissue per parity at least up until the 5th parity when mature body size is achieved. Table 6-10 converts actual body weight (BW) to metabolic body weight (BW$^{.75}$) A calculator that has a y^x key can also be used.

The energy requirement for maternal growth is set by the desired body weight gain during gestation. The energy cost per kg of maternal gain is approximately 5 Mcal of DE/kg. Therefore, the energy cost/day for a sow with a net weight gain of 25 kg in a 114 gestation period is 1.10 Mcal of DE (125 Mcal ÷ 114 days). The daily energy requirement for the growth of the conceptus has been estimated at 0.19 Mcal of DE resulting in a total energy cost/day of 1.29 Mcal of DE.

Table 6-10. Metabolic Body Weights of Sows and Maintenance Energy Requirements.

Parity	Body Weight at Start (kg)	Body Weight at Finish (kg)	Average Body Weight (kg)	Metabolic Body Weight (kg$^{.75}$)	Maintenance Energy Required (Mcal/day)
Gilt	120	165	142.5	41.2	4.53
1	145	190	167.5	46.6	5.12
2	170	215	192.5	51.6	5.68
3	195	240	217.5	56.6	6.23
4	220	265	242.5	61.4	6.76
5	245	290	267.5	66.1	7.27
6 + up	270	290	280	68.4	7.52



1. POOR - Hips and backbone are prominant
2. MODERATE - Hips and backbone are easily felt without applying palm pressure
3. GOOD - Hips and backbone can only be felt with firm palm pressure
4. VERY GOOD - Hips and backbone cannot be felt
5. FAT - Hips and backbone are heavily covered

Figure 6-5. Guides to Condition Scoring Sows, Including Photographs of Representative Animals.

Table 6-11. Energy Requirements of Sows (Estimated) During Gestation.

	Average Gestation Body Weight[1]		
	142.5 kg	217.5 kg	270 kg
Energy Required (Mcal/day)			
Maintenance[2]	4.53	6.23	7.32
Gestation Weight Gain[3]	1.29	1.29	0.19
Total	5.82	7.52	7.51
Feed Required/day (kg)[4]	1.84	2.38	2.38

[1]Assumes breeding weights of 120, 195 and 260 kg with maternal weight gains of 45, 45 and 20 kg.
[2]The sows daily maintenance requirement is 110 kcal of DE/kg $BW^{.75}$
[3]The requirement for gestation weight gain is 1.10 Mcal of DE/day for maternal tissue plus 0.19 of DE/kg for conceptus gain.
[4]Assuming diet contains 3,150 kcal DE/kg. Allowance should be increased by 300 to 400 kcal for every 5°C below critical temperature (16°C).

Table 6-11 demonstrates how to calculate the daily energy requirements under three different conditions. The first column calculates the energy requirements for a gilt bred at 120 kg and gaining 45 kg during gestation. The 2nd column shows the calculation for a 4th parity sow being bred at 195 kg and gaining 45 kg during gestation while the lastcolumn shows a mature sow bred at 270 kg and gaining only 20 kg (reproductive tissue only) during gestation. However, using the values above, producers can calculate daily energy requirements for any sow under any conditions. Dividing these energy levels by the energy content of the feed will provide an estimate of the daily feed intake required to provide this level of energy (i.e., 5.82 Mcal ÷ 3.2 Mcal/kg diet = 1.8 kg feed/day).

Amino Acids

Amino acids are needed during pregnancy to replace those lost through obligatory sloughing or metabolism, to develop the pregnant uterus and its contents, to develop the mammary gland as well as to add protein to the maternal body. The amounts of the indispensable amino acids needed during pregnancy can be estimated by summing the amounts needed for maintenance and for maternal protein accretion.

During gestation, there is a continous sloughing of cells from tissues such as the skin and intestinal mucosa. These represent obligatory losses of amino acids from the body and this loss must be replaced in order to maintain constant conditions. This is called the maintenance requirement and this loss has been estimated in a number of experiments which have been averaged to produce the numbers in Table 6-12.

The amino acid requirements for growth of maternal tissue can be calculated from the amino acid content of pork. The best available estimates of the protein content of pork suggest a value of 15.3%. Therefore, a sow gaining 45 kg (25 kg maternal and 20 kg reproductive tissue) during a 115 day gestation will be depositing 59.86 g of protein per day (6885 g/115 days). By multiplying this value by the amino acid content of lean tissue, one can calculate the required level of a specific amino acid needed on a daily basis. It has been estimated that amino acids used for growth and the products of conception are used at an efficiency of 63.5% and we can assume that the gestation diet is about 80% digestible. Under these circumstances, the value derived from multiplying the amount of protein deposited daily by the sow by the amino acid content of lean tissue must be divided by a factor of .508 (63.5% efficiency x 80% digestion) to arrive at the daily amino acid pattern required for growth and reproductive tissue. A mature sow (ie one no longer gaining maternal tissue) will only gain 20 kg during gestation and therefore the daily protein deposition will be only 26.6 g/day (3060 g/115 days). For example calculations of the daily amino acid requirements see Table 6-13.

Table 6-12. Daily Amino Acid Requirements for Maintenance of Gestating Sows (g/day).

Sow Weight at Mating (kg)		120	195	260
Sow Weight at Farrowing (kg)		165	240	280
Average Metabolic Weight ($kg^{.75}$)		41.24	56.63	68.44
	Amino Acids Required for Maintenance ($mg/kg^{.75}$)[1]	Amino Acid Required (g/day)		
Arginine	0	-----	-----	-----
Histidine	0	-----	-----	-----
Isoleucine	30	1.23	1.69	2.05
Leucine	20	0.82	1.13	1.37
Lysine	25	1.03	1.41	1.71
Total Sulfur Amino Acids	26	1.07	1.47	1.78
Total Aromatic Amino Acids	46	1.89	2.60	3.14
Threonine	39	1.61	2.20	2.66
Tryptophan	5	0.21	0.28	0.34
Valine	21	0.87	1.19	1.43

[1]Based on Baker et al (1966; J. Nutr. 88: 382-396) and Baker and Allee (1970; J. Nutr. 100: 277-280).

Table 6-13. Daily Amino Acid Reqirements (g/day) for Growth of Gestating Sows (Growth and Products of Conception).

	Amino Acid Content	Estimated Gestation Gain of Sow	
	of Lean Tissue (%)[2]	20 kg (26.6 g/day)	45 kg (59.86 g/day)[1]
Arginine	6.71	----	-----
Histidine	4.29	2.24	5.03
Isoleucine	4.32	2.26	5.07
Leucine	7.38	3.85	8.68
Lysine	7.90	4.13	9.29
Total Sulfur	3.32	1.73	3.89
Total Aromatic	7.48	3.91	9.17
Threonine	4.16	2.16	4.90
Tryptophan	1.01	0.51	1.18
Valine	5.10	2.65	6.00

[1]Numbers in brackets indicate daily protein deposition (g)
[2]Adapted from Speer (1990; J. Anim. Sci. 68: 553-561)

To calculate the total daily amino acid requirements of sows in gestation, one must sum the maintenance requirement and the requirement for growth. Table 6-14 demonstrates how to calculate the daily amino acid requirements under three different conditions. The first column calculates the amino acid requirements for a gilt bred at 120 kg and gaining 45 kg during gestation. The 2nd column shows the calculation for a 4th parity sow being bred at 195 kg and gaining 45 kg during gestation while the last column shows a mature sow bred at 270 kg and gaining only 20 kg (reproductive tissue only) during gestation. However, using the values shown above, producers can calculate daily amino acid requirements for any sow under any conditions.

The above example likely provides more detail than would be required by the average producer and it would be virtually impossible to provide a diet that provides precisely the amino acid balance shown in Table 6-14. However, since lysine is the first limiting amino acid, under these conditions, it is the amino acid we should be most concerned with in diet formulation. Using the estimated daily lysine requirements shown in Table 6-14 and dividing by expected daily feed intakes in Table 6-11, one arrives at the percentage of lysine required in the diet to meet requirements (i.e. 0.56%, 0.45% and 0.24% for the 120, 195 and 270 kg sow, respectively, compared with 0.43% for NRC).

Table 6-14. Estimated Total Amino Acid Needs of Pregnant Sows Under Various Conditions (g/day).

Weight at Mating (kg) Weight Gain During Pregnancy (kg)	120 45	195 45	260 20	Current NRC
Amount of Amino Acid Required (g/day)				
Arginine	---	---	---	---
Histidine	5.03	5.03	2.24	2.8
Isoleucine	6.30	6.76	4.31	5.7
Leucine	9.50	9.81	5.22	5.7
Lysine	10.32	10.70	5.84	8.2
Total Sulfur Amino Acids	4.96	5.36	3.51	4.4
Total Aromatic Amino Acids	11.06	11.77	7.05	8.6
Threonine	6.51	7.10	4.82	5.7
Tryptophan	1.39	1.46	0.85	1.7
Valine	6.87	7.19	3.48	6.1

[1]NRC values are based on a sow with an average gestation weight of 162.5 kg consuming 1.9 kg/day of a diet containing 12% crude protein.

Some flexibility can be obtained by varying the level of feed intake to meet the lysine requirements of sows of different weights. However, larger producers might find it cost effective to formulate at least two diets varying in lysine content and feed one to sows less than five parities and one to sows over five parities.

Minerals

The most commonly used estimates of mineral requirements of gestating sows are those of the NRC (1988) and the Australian Standing Committee on Agriculture (1987). Reasonable agreement exists between these two groups in setting nutritional standards. Where differences exist, it is suggested that the Australian Standards be used because these standards tend to be based on ingredisimilar to those most commonly used in Canada and the predominant breeds in the two countries (Large White and Landrace) are also similar. Current recommendations are shown in Table 6-15.

Table 6-15. Mineral Requirements of Gestating Sows (% or amount/kg of total diet).

	NRC[1]	Australia[2]
Calcium (%)	0.75	0.82
Phosphorus (%)	0.60	0.73
Sodium (%)	0.15	0.12
Chloride (%)	0.12	0.14
Magnesium (%)	0.04	0.04
Potassium (%)	0.20	0.23
Copper (mg)	5.00	4.00
Iodine (mg)	0.14	0.40
Iron (mg)	80.0	60.0
Manganese (mg)	10.0	10.0
Selenium (mg)	0.15	0.15
Zinc (mg)	50.0	45.0

[1]National Research Council, 1989. Nutrient Requirements of Swine.
[2]Standing Committee on Agriculture, 1987. Feeding Standards for Australian Livestock: Pigs.

Table 6-16. Vitamin Requirements of Gestating Sows (Total Supplied in Diet).

	NRC[1]	Australia[2]
Vitamin A (IU)	4,000	2,100
Vitamin D (IU)	200	200
Vitamin E (IU)	22	10.5
Vitamin K (mg)	0.50	0.27
Biotin (mg)	0.20	0.10
Choline (g)	1.25	1.50
Folic Acid (mg)	0.30	0.60
Niacin (mg)	10.00	10.00
Pantothenic Acid (mg)	12.00	12.00
Riboflavin (mg)	3.75	2.70
Thiamin (mg)	1.00	1.40
Vitamin B_6 (mg)	1.00	1.40
Vitamin B_{12} (ug)	15.00	15.0

[1]National Research Council, 1989. Nutrient Requirements of Swine
[2]Standing Committee on Agriculture, 1987. Feeding Standards for Australian Livestock: Pigs.

Vitamins

Vitamins have long been recognized as having an essential role to play in reproduction and a considerable amount of research has been devoted towards determining the vitamin requirements of the gestating sow. Current recommendations are shown in Table 6-16.

Feeding recommendations must continually be modified as more research is conducted and we learn more about the nutrient requirements of animals. In the past few years, new evidence has come to light which suggests that current recommendations are inadequate for several vitamins and it is likely that the next set of requirement tables will show a recommendation for higher levels of supplementation for these vitamins. These changes will likely affect folic acid, beta-carotene and vitamin E.

Folic acid has received considerable attention in the past few years with several experiments showing a response to supplementation at levels greatly in excess of those currently recommended. The most common finding has been an increase in litter size (Table 6.17). As a consequence, folic acid levels of approximately 1 mg/kg or about three times current NRC (1988) levels are recommended.

Table 6-17. Effects of Folic Acid Supplementation of Diets Fed to Gestating Sows.

	Control	Folic Acid (1.00 mg/kg)
Pigs Born Alive	9.51	10.64
Birth Weight (kg)	1.48	1.48
Pigs Weaned (day 29)	8.92	9.24
Weaning Weight (kg)	7.68	7.44
Weaning to Estrus Interval (days)	7.30	6.66

Lindemann and Kornegay, 1989, J. Anim. Sci. 67: 459-464.

The increase in litter size as a result of folic acid supplementation has been attributed to a decrease in embryo mortality. The rate of cell proliferation during embryonic development is extremely high and the intracellular concentration of RNA, a key component, is highly correlated with embryo survival. The synthesis of the nucleic acids DNA and RNA requires purines and pyrimidine bases, the production of which in turn requires single carbon units. As folic acid is an indispensable cofactor in the metabolic transfer of single carbon units, it is logical to assume that an adequate supply is essential for minimizing embryo losses.

Another area of recent research interest has been in the use of beta-carotene injections around the time of mating. Beta-carotene is a natural precursor of vitamin A, but recent evidence suggests that it may have a unique role in reproduction independant of its function as a precursor of vitamin A. The most common finding with beta-carotene injection is a modest improvement in litter size (Table 6-18). The increase in litter size is suggested to result from a decrease in embryo mortality. Dietary supplementation (as opposed to injections) is unlikely to result in an increased litter size because beta-carotene is not absorbed intact from the digestive tract of swine.

Table 6-18. Effect of Injection of Beta-Carotene on Reproductive Performance of Multiparous Sows.

	Control	Beta-carotene[1]
Days to Estrus	4.6	4.5
Farrowing Rate (%)	88.7	88.4
Pigs Born Alive	10.0	10.6
Birth Weight (kg)	1.5	1.5

[1]Sows were given i.m. injection of 200 mg of Beta-carotene on the day of weaning, breeding and day 7 of gestation.
[2]Coffey and Britt, 1993, J. Anim. Sci. 71: 1198-1202.

The mechanism by which beta-carotene enhances embryo survival is not certain. However, it has been shown that beta-carotene can increase the production of uterine specific proteins which support embryo survival. A basic glycoprotein with iron binding capacity and a groups of acidic proteins with immunosuppressive capabilities have been identified. These proteins play a key role in embryo development and could explain the increased litter size observed with beta-carotene injection. Beta-carotene may also increase the production of progesterone during the initial formation of the corpora lutea. which would provide a more favorable environment for embryo survival. Unfortunately, injectable beta-carotene is not currently cleared for use in Canada.

Vitamin E has also received considerable research attention and again there are suggestions that current recommendations (22 IU/kg) may not be adequate for high producing sows. A recent Ohio study examined supplementation with 16, 33 or 66 IU vitamin E for three parities and observed increased litter size at birth and weaning as the vitamin E level increased (Table 6.19). The data suggest that sows housed in less sanitary conditions respond more positively to higher vitamin E levels with reduced incidence of mastitis than those housed in clean facilities.

Table 6-19. Effect of Vitamin E on Sow Productivity.

	Supplemental Vitamin E (IU/kg)			
	0	16	33	66
Pigs Born Alive	9.85	10.87	11.20	10.04
Birth Weight (kg)	1.39	1.31	1.37	1.41
Pigs Weaned (28 days)	6.73	7.00	7.88	8.14
Weaning Weight (kg)	6.51	6.27	6.21	6.49
Piglet Survival (%)	68.30	64.30	70.30	81.00

[1]Basal diet contained 8.4 mg/kg vitamin E. Experiment conducted over 3 parities.
[2]Mahan, 1991, J. Anim. Sci. 69: 2904-2917.

Feeding the Sow Around Farrowing Time

Feeding Levels

Opinions as to the level of feed to be provided immediately prior to and for the first few days after farrowing are divided. Excessive restriction can cause excessive sow excitement due to hunger resulting in an increase in piglet deaths due to crushing. There is also concern about feeding too much. Therefore, a balance has to be kept in relation to the feeding level around farrowing. Before the sow farrows, it is probably best to maintain the same level of feed intake as that normally fed during gestation (2 - 2.5 kg). Following farrowing, a gradual increase in feed intake is recommended, with the objective of getting the sow to maximize feed intake as soon as possible into her lactation.

Use of Laxatives Prior to Farrowing

Many producers add wheat bran, beet pulp or some other bulky feed to the sow's diet before and for a few days after farrowing. It is a believed that this practice helps prevent constipation, reduces the incidence of mastitis and may prevent death loss due to twisted gut. The most recent research on this subject does not support the need for the addition of such bulky feeds as a means of preventing mastitis or improving sow productivity. However, the addition of bulking agents may improve sow comfort and produce a softer stool. If sows are experiencing problems with constipation, producers may wish to consider the addition of 5 to 15% bran or 5 to 7% beet pulp to the prefarrowing diet. Potassium chloride or potassium magnesium sulfate have been used as laxative agents at the rate of 0.5 to 1.5% of the total diet. However, the longterm effect of such salts on the health of the sow are unknown.

Feeding Fat in Late Gestation and Lactation

A topic of recent research interest has been the addition of fat to sow diets during late gestation and lactation in an attempt to improve the survival of baby pigs. Baby pig losses are often high during lactation, with the greatest losses attributed to crushing by the sow. Pigs which are crushed are often hypoglycemic due to low glycogen stores. These low energy stores result in weak piglets which may be unable to move out of the way of the sow and are subsequently crushed.

It has been hypothesized that the incorporation of fat into diets fed during late gestation and lactation will increase both milk yield and milk fat content, thus increasing the energy supply available to the nursing pig. This increase in available energy may result in a reduction in preweaning mortality. Furthermore, the increased energy level in the sow diet may decrease sow weight loss during lactation.

The response to fat inclusion is variable and a beneficial response has not been reported in all cases. The amount of fat fed prior to farrowing affects the response obtained. In general, the greater the amount of fat fed, the greater the response. It appears that sows must be fed at least one kg of fat prior to farrowing in order to obtain any benefit. Therefore, it is usually necessary for fat to be included in the diet at a level of at least 10%. In addition, fat must be fed for at least five days prior to farrowing to obtain a positive response. This time period is required in order to allow the sow time to make the physiological adjustments necessary to absorb the fat and transport it to the mammary glands.

Unfortunately, the inclusion of a high level of fat in the diet is relatively expensive and may result in a very greasy feed. The potential to obtain an economical response is greatest when mortality is high and birth weights are low. Most producers will find it uneconomical to routinely include fat in their sow diets unless preweaning mortality is greater than 25% or the incidence of low birth weight piglets is inordinately high. However, producers should not underestimate the benefits of high fat feeding when environmental temperatures rise above 25°C. Under these circumstances, high levels of dietary fat are beneficial in maintaining energy intakes of lactating sows, increasing sow milk production and thereby increasing survival and weaning weights of piglets.

Most of the early work on fat supplementation of sow diets involved the use of fats made up predominantly of long chain (>C16:0) fatty acids (i.e. tallow or soybean oil). An area of recent research interest has involved the study of fats made up predominately of medium or shorter chain fatty acids (<C:12:0). Coconut oil is one readily available source of medium chain fatty acids. These shorter chain fatty acids are known to more easily digested by swine and have found use as energy sources in creep and starter diets. However, it is only recently that they have been studied as an

Table 6-20a. Examples of Gestation Diets

Ingredients, %	1	2	3	4	5	6
Barley	86.0	87.2	-	-	78.8	-
Corn	-	-	82.0	72.5	-	48.5
Peas	-	-	-	-	10.0	-
Wheat shorts	-	-	-	-	-	40.0
Soybean meal - 47%	4.5	7.8	13.0	-	-	6.5
Canola meal	4.5	-	-	22.5	6.2	-
Premix	5.0	5.0	5.0	5.0	5.0	5.0
Nutrients, minimum %						
D.E., kcal/kg	3,000	3,000	3,390	3,300	3,000	3,250
Crude protein	13.0	13.0	13.1	14.8	13.1	14.3
Digestible lysine	0.43	0.43	0.49	0.48	0.43	0.46
Digestible methionine	0.16	0.16	0.18	0.18	0.16	0.17
Digestible T.S.A.A.	0.20	0.20	0.23	0.22	0.22	0.22
Digestible threonine	0.27	0.27	0.31	0.30	0.27	0.29
Digestible tryptophan	0.06	0.06	0.07	0.07	0.06	0.07
Calcium	0.85	0.85	0.85	0.85	0.85	0.85
Phosphorus	0.75	0.75	0.75	0.75	0.75	0.75
Sodium	0.15	0.15	0.15	0.15	0.15	0.15
Chloride	0.15	0.15	0.15	0.15	0.15	0.15

Table 6-20b. Examples of Lactation Diets

Ingredients, %	1	2	3	4	5	6
Wheat	50.00	-	50.00	-	49.67	-
Barley	26.30	-	21.90	-	25.20	-
Corn	-	76.00	-	71.70	-	70.65
Soybean meal - 47%	11.70	19.50	15.80	23.30	15.10	24.20
Canola meal	7.50	-	7.50	-	3.20	-
Fat/oil	1.00	1.00	1.30	1.00	2.50	1.00
Lysine HCl	-	-	-	-	0.23	0.10
Threonine	-	-	-	-	0.10	0.05
Premix	3.50	3.50	3.50	3.50	4.00	4.00
Nutrients, minimum %						
D.E., kcal/kg	3,250	3,460	3,300	3,415	3,350	3,460
Crude protein	18.6	15.6	19.3	17.2	18.0	17.5
Dig. lysine	0.65	0.65	0.75	0.75	0.85	0.85
Dig. methionine	0.16	0.16	0.19	0.19	0.21	0.21
Dig. T.S.A.A.	0.33	0.33	0.38	0.38	0.43	0.43
Dig. threonine	0.41	0.41	0.47	0.47	0.54	0.54
Dig. Tryptophan	0.10	0.10	0.11	0.11	0.13	0.13
Calcium	0.85	0.85	0.85	0.85	0.85	0.85
Phosphorus	0.75	0.75	0.75	0.75	0.75	0.75
Sodium	0.15	0.15	0.15	0.15	0.15	0.15
Chloride	0.15	0.15	0.15	0.15	0.15	0.15

These are sample diets only and are for illustrative purposes only. While every attempt has been made to present examples that reflect successful commercial formulations, these examples are not intended for actual use without assistance from a qualified nutritionist.

All amino acid concentrations are expressed as apparent ileal digestible amino acids.

ingredient in sow diets. The results of a recent study conducted at the University of Georgia are shown in Table 6-21.

Table 6-21. Effect of Type of Fat Fed During Late Gestation and Early Lactation on Sow Productivity.

	Control	Long Chain Triglycerides	Medium Chain Triglycerides
Pigs Born Alive	11.33	10.79	11.59
Birth Weight (kg)	1.27	1.31	1.21
Pigs Weaned (day 21)	9.06	8.89	10.12
Weaning Weight (kg)	5.48	5.62	5.51
Mortality (%)	20.03	17.61	12.68

[1]Azain, 1993, J.Anim. Sci. 71: 3011-3019.
[2]Fat sources fed at a level of 12% during the last three weeks of gestation and the first week of lactation.

The results of this experiment suggests that medium chain triglycerides are superior to long chain triglycerides in reducing preweaning mortality. The difference in performance would appear to be a reflection of the different ways in which these fat types are metabolized. Medium chain triglycerides are rapidly metabolized to ketone bodies. Because ketone bodies can readily cross the placenta and are used in the developing fetus for the synthesis of lipid and to spare glucose, they have the potential to improve fetal energy stores at birth and thereby improve the piglets chances of survival.

Feeding the Sow During Lactation

Introduction

Lactation is a particularly important stage of the reproductive cycle. Its primary purpose is to successfully rear a large number of healthy, heavy piglets. A lactating sow may need to draw on body fat reserves to obtain the energy she needs for maintenance and milk production. This drain on her body reserves causes a significant loss of body weight resulting in an extended weaning to remating interval, poor conception rates and premature culling. Therefore, particular care must be taken to ensure that sows are properly fed during lactation.

The importance of maintaining high feed intakes during lactation has been clearly demonstrated. The results of a study in which lactating sows were fed between 1.5 and 5.0 kg of feed per day are shown in Table 6-22a. Sows receiving low levels of feed during lactation lost significantly more weight and depleted their backfat reserves to a much greater extent than did sows fed higher levels of feed. Consequently, sows fed low levels of feed during lactation had longer weaning to conception intervals than sows well fed during lactation. In addition, significantly fewer sows fed low levels of feed exhibited estrus within eight days of weaning.

Table 6-22a. The Effect of Sow Feed Intake During Lactation on Subsequent Reproductive Performance.

	Daily Feed Intake (kg)					
	1.5	2.2	2.9	3.6	4.3	5.0
Lactation Weight Loss (kg)	44.5	30.8	27.4	19.6	15.8	9.0
Backfat Loss During Lactation (mm)	8.9	7.1	6.4	5.7	4.2	4.0
Weaning to Conception Interval (day)	29.8	32.4	23.6	16.4	15.5	11.4
Number of Eggs Ovulated	12.2	13.3	10.9	13.3	11.7	12.0
Sows in Estrus Within 8 Days of Weaning (%)	8.3	33.3	50.0	58.3	58.3	83.3

King and Dunkin, 1986, Anim. Prod. 17: 65-75.

The level of feed provided to the sow during lactation will also affect piglet performance. Research has shown that there is a direct relationship between the amount of feed the sow consumes during lactation and the amount of milk produced by the sow (Table 6-22b). As the level of feed intake increases, higher levels of milk production are achieved. This increased milk production also increases the growth rate of suckling piglets.

Table 6-22b. Effect of Feed Level on Milk Yield at 21 Days (kg/day).

	Feed Intake (kg/day)			
	4.5	5.3	6.0	6.8
Parity 1	5.9	5.4	6.7	6.1
Parity 2	5.4	6.0	6.6	6.6
Parity 3	5.5	6.8	7.3	8.0

O'Grady et al., 1973, Anim. Prod. 17: 65-75.

From the foregoing discussion, it should be evident that every effort must be made to maximize the feed intake of sows during lactation. By maintaining high levels of feed intake during lactation it is possible to reduce sow body weight and backfat loss, increase milk yield, increase piglet growth rate, decrease piglet mortality and improve the sow's subsequent reproductive performance. A general rule of thumb is to allow 2 kg of feed per day for the sow and an additional 0.5 kg for each pig in the litter. For example, a sow with 10 nursing pigs should receive at least 7 kg per day (2 + (0.5 x 10) = 7).

Despite knowledge of the benefits of maximizing feed intake, many producers still experience difficulty getting sows to consume sufficient feed to avoid excessive weight loss. A recent survey from the University of Minnesota involving 11,700 sows on 30 farms indicated that lactation feed intakes averaged only 5.2 kg/day. Clearly, a more concentrated effort is needed to increase the average lactation feed intake of sows.

Methods of Increasing Feed Intake During Lactation

One method of increasing feed intake during lactation is to ensure that the sow is not overfed during gestation. Research has shown that there is an inverse relationship between the amount of feed consumed during gestation and the amount consumed during lactation (Table 6-23). As the level of feed intake during gestation increases, the level of feed intake during lactation decreases. Therefore, feed intakes during gestation should be reduced if excessive, since the higher the feed intake during pregnancy the lower the appetite will be during lactation.

Table 6-23. Effect of Feed Intake During Pregnancy on Feed Intake During Lactation.

	Pregnancy Feed Intake (kg/day)		
	1.8	2.25	2.70
Pregnancy Weight Gain (kg)	55.3	70.4	82.7
Lactation Feed Intake (kg/day)	4.76	4.70	3.98
Lactation Weight Change (kg)	-12.2	-19.6	-24.6

Dourmad, 1991, Livestock Prod. Sci. 27:309-319.

The level of dietary protein has also been shown to affect the amount of feed consumed during lactation. The effect of feeding diets varying between 12 and 18% crude protein are shown in Table 6-24. Sows consuming diets containing either 12 or 14% crude protein consumed less feed and lost significantly more weight during lactation than sows consuming diets containing 16 or 18% crude protein. Piglet weaning weights were also higher when the sow received higher levels of dietary protein. The consumption of low protein diets during lactation can also cause excessive delays in heat and poor conception rates after weaning particularly if fed to first litter sows. Therefore, in order to maximize feed intake during lactation and avoid problems with rebreeding, it is recommended that a minimum of 15% crude protein (0.70% lysine) be provided in the lactation diet. For maximum milk production, sows may require diets which contain 0.90% or even 1.0% lysine and a digestible energy content of at least 3250 kcal/kg.

Table 6-24. Effect of Feeding Various Levels of Protein During Lactation on Sow Feed Intake and Body Condition.

	Dietary Protein Level (%)			
	12.0	14.0	16.0	18.0
Sow Feed Intake (kg/day)	3.5	4.6	5.5	5.8
Sow Weight at Farrowing (kg)	152.2	140.9	143.6	145.9
Sow Weight at Weaning (kg)	126.8	130.0	147.3	152.3
Sow Weight Change (kg)	-25.4	-10.9	+3.7	+6.4
Piglet Weaning Weight (kg)	5.5	6.1	6.2	6.8

Mahan and Grifo, 1975, J. Anim. Sci. 41: 1362-1367.

Sows will consume more feed if fed twice rather than once daily. Consumption is likely to increase further if they are fed even more frequently. In a study conducted by the NRC-89 Committee on Confinement Management of Swine, sows were allowed unlimited access to feed either once or three times a day. Sows fed three times a day consumed a total of 108.4 kg of feed during lactation while those fed only once a day consumed 101.6 kg of feed. In addition, weight loss during lactation was reduced for the group of sows fed three times a day (22.5 versus 28.5 kg of body weight lost).

Use of a small feeder fitted to the front of the farrowing crate may allow the sows to be fed ad libitum. However, it is important that the feeder be properly designed. Feeders which are improperly designed may restrict the ability of sows to consume adequate amounts of feed. In general, sows prefer large, open 'bowel type' feeders with no bars, rods or other gimmicks to restrict access to feed.

The method of feeding can also affect intake. For example, use of a pelleted diet has been shown to increase sow feed intake during lactation. Pelleted rations also tend to reduce the amount of feed wastage. Since very few producers have the ability to pellet rations on the farm, the advantages of feeding a pelleted diet are only available to producers purchasing a commercially formulated lactation ration.

It has been well demonstrated that sows will consume more of a wet feed than they will of a dry one. The results of one experiment are presented in Table 6-25 and it can be seen that sows fed a wet feed consumed approximately 10% more feed than sows fed a dry one. Although it would be impractical for most producers to convert their operations to a wet feeding system, the simple act of mounting the water nipple in the farrowing crate directly over the feed hopper can help to stimulate sow feed intakes. However, care should be taken to clean the feeder on a regular basis in order to prevent molds from developing on the wet feed.

Table 6-25. Effect of Method of Feeding on Sow Feed Intake and Weight Change During Lactation.

	Dry Feed	Wet Feed
Feed Intake (kg/day)	4.7	5.3
Energy Intake (MJ DE/day)	62.3	69.3
Lactation Weight Loss (kg)	29.8	23.2

O'Grady and Lynch, 1978, J. Agric. Res. 17: 1-6.

A lactating sow can consume as much as seven gallons of water per day. It is important that the water supply of the sow not be restricted. Inadequate amounts of drinking water will certainly cause the sow to reduce feed intake. Many water nipple drinkers in farrowing crates do not supply adequate quantitites of water. Although some references suggest a minimum flow rate of 2.0 L per minute, recent data suggest that 0.6 L is sufficient. The only difference between the two flow rates is a large waste of water at the 2.0 L per minute flow rate. Waterer type may affect feed consumption. University of Minnesota studies revealed that daily feed consumption was about 0.3 kg less when lactating sows were provided water via nipples compared with a drinking cup.

The use of flavors in animal feeds has increased considerably in the past decade as more attention is being paid to palatability. Many experiments have been conducted using feed flavors in the hope of increasing the feed consumption of sows during lactation. The productsused have ranged from simple spices and tonics to aroma modifiers, sweeteners, flavor intensifiers and artificial flavors as well as certain natural feed ingredients.

The results of two experiements in which sow diets were supplemented with a flavor enhancer are summarized in Table 6-26. Sows fed diets supplemented with a flavor enhancer consumed approximately 7% more feed and lost 30% less weight during lactation than did sows fed the control diet. In addition, there was a slight reduction in piglet mortality as well as an increase in piglet weaning weight as a result of including the feed flavor in the sow's diet. Although these results indicate that flavor additives can be used to attract sows to their diet, increase feed intake and reduce sow weight loss during lactation, producers should be aware that very little is known on what specific flavors pigs find attractive. Since flavours tend to be expensive feed ingredients, considerable caution should attend their use in sow diets.

Table 6-26. Performance of Sows Fed Artificial Flavours During Lactation.

	Control	Flavour
Pigs Born Alive	9.9	9.9
Pigs Weane	8.4	8.9
Mortality (%)	14.9	9.9
Sow Feed Intake (kg/day)	4.8	5.2
Lactation Weight Loss (kg)	15.6	10.9
Weaning to Estrus Interval (days)	7.5	8.3

Moser et al. 1986. Minnisota Swinea Research Report. pp 53-56.

The effective environmental temperature of the farrowing room is one of the most critical factors affecting feed intake in lactating sows and many producers maintain their farrowing room at too high a temperature. Table 6-27 shows the results of an experiment in which sows were housed in farrowing rooms maintained at 27°C or 21°C. Sows maintained at the lower temperature consumed more feed, lost less weight and weaned heavier piglets compared with those housed at the higher temperatures.

In order to stimulate feed intake, attempts should be made to cool down the farrowing room. If building a new barn, producers might consider the installation of snout coolers or drip cooling. Snout coolers with an airspeed of 0.3 m/sec have been shown to increase feed intake by 250 g/day while drip coolers, providing 2 litres per sow per hour (running for 3 minutes in a 10 minute cycle), have also been effective in increasing feed intake. However, it must be remembered that if the temperature of the farrowing room is to be decreased, supplemental heat must be provided for the piglets.

An additional consideration regarding lowering the temperature of the farrowing room is to ensure that the building is properly insulated. The standard insulation specification for the roof is $0.4 W/m^2/°C$ and for walls $0.5 W/m^2/°C$. The maximum ventilation rate of the farrowing room should also be checked to ensure adequate airflow. Although this may not necessarily cool the sows, fresh, non-gaseous air is beneficial in stimulating appetite.

The farrowing floor surface also influences heat loss and therefore could affect feed intake. Sows housed on plastic-coated, expanded metal or woven wire floors consumed about 0.5 kg less than sows housed on highly conductive floor surfaces such as metal (ie Tri-bar) or concrete.

Energy intake can be affected by increasing the caloric density of the diet. Use of high density diets is particularly effective in maintaining energy intakes during hot weather. Incorporating fat or oil as a partial substitute for carbohydrate energy will reduce the heat increment of the diet and thus allow sows to consume more energy in hot weather.

Reducing the protein level of the diet and using synthetic amino acids to provide the proper balance of amino acids can also achieve this purpose.

Table 6-27. Effect of Environmental Temperature on Feed Intake and Weight Loss of the Sow and Weight Gain of the Litter.

	Temperature	
	27°C	21°C
Sow Feed Intake (kg/day)	4.6	5.2
Sow Weight Loss (kg)		
110 Days to Weaning	21.0	14.0
Piglet Weight at 28 Days (kg)	6.2	7.0

Lynch, 1978.

Recent evidence has suggested that sows exposed to longer periods of lighting during the day may have higher feed intakes. Increased weaning weights and improved rebreeding performance have been observed when sows were housed in farrowing rooms with 16 hours of light per day in comparison with 8 hours of light per day. Automatic timing devices are currently available which allow producers to control the duration of lighting in the farrowing room.

To properly monitor lactation feed intakes, it is recommended that producers keep track of the individual feed intake of sows using a card similar to that shown below (Fiqure 6-5). Use of such cards creates an easily interpreted, graphic display of the pattern of intake of each sow. It is only through the use of a proper recording scheme that producers will be able to detect when alterations in feed intake occur and take steps to intervene when reductions occur.

Nutrients Required During Lactation

Energy

The daily energy requirement of the sow during lactation includes a requirement for maintenance and a requirement for milk production. The maintenance energy requirement of the lactating sow is assumed to be the same as that for the gestating sow and is estimated to be 110 kcal of DE per kg of body weight$^{.75}$. This is sometimes a difficult calculation for producers to make and most nutritionists use a thumb rule of 1% of a sow's body weight to estimate maintenance requirements. Therefore, a 165 kg sow requires 1.65 kg of feed for maintenance. If we assume a energy value of the feed of 3200 kcal then this level of feed intake would supply 5.28 Mcal of energy which comes reasonably close to the 5.06 Mcal of energy we would get by using the above equation (See Table 6-11).

The energy level required for milk production is estimated to be 2 Mcal of DE per kg of milk produced. This is calculated by assuming that the gross energy of milk is 1.3 Mcal DE per kg and that the milk is produced with a 65 percent efficiency of utilization (1.3 Mcal ÷ 0.65 = 2.0 Mcal). The milk production of a sow can be estimated from piglet weight gain. Since it takes about 4 g of milk to produce 1 g of piglet gain, total milk production can be calculated by multiplying the daily weight gain of a litter by four. As an example, a litter of 9 piglets gaining 240 g/day would suggest a daily milk production of 8.64 kg (9 x .24 x 4). This level of milk production would require an energy intake of 17.28 Mcal DE (8.64 kg x 2 Mcal/kg milk produced).

It is evident from the above discussion that no single energy level will apply to all sows under all conditions. The following table indicates how daily energy requirements are altered by factors such as sow body weight, litter size and piglet growth rate (Table 6-28).

Table 6-28 indicates that a 142.5 kg sow nursing 12 piglets, gaining 240 g/day will require 8.34 kg of a diet containing 3300 kcal of DE in order to meet its energy requirements. Unfortunately, our modern genotypes of sows will often not consume this amount of food. As a consequence, such sows with a high level of productivity may not consume sufficient feed to meet their energy requirements and will have to "milk off their backs" in order to meet the energy needs of the nursing litter.

Table 6-28. Estimated Daily Energy Requirements of Lactating Sows.

Sow Body Weight (kg)	142.5	142.5	217.5	217.5	280	280
Number of Suckling Piglets	8	12	8	12	8	12
Daily Gain of Piglets (g/day)	200	240	200	240	200	240
Estimated Milk Yield (kg/day)[1]	6.4	11.5	6.4	11.5	6.4	11.5
Energy for Maintenance (Mcal/day)[2]	4.53	4.53	6.23	6.23	7.52	7.52
Energy for Milk Production (Mcal/day)[3]	12.80	23.00	12.80	23.00	12.80	23.00
Daily Energy Requirement (Mcal/day)	17.33	27.53	19.03	29.23	20.32	30.52
Daily Required Feed Intake (kg/day)[4]	5.25	8.34	5.76	8.85	6.15	9.25

[1]Milk yield estimated from litter gain/day x 4
[2]Sow energy needs for maintenance estimated from $BW^{.75}$ x 110 kcal per kg (see Table 6-10)
[3]Energy for milk production estimated from milk yield x 2 MCal/kg milk produced
[4]Feed intake required based on 3300 kcal DE/kg diet

Using the above example, assume that the sow is only consuming 6.5 kg of feed per day. In this situation, the sow will have an energy deficit of 6006 kcal/day (1.82 kg x 3300 kcal). It has been calculated that for every kg of weight loss by the sow, 11,200 kcal of DE equivalent are released. Therefore, to make up the 6006 kcal/day deficit will require a maternal weight loss of 536 g/day or about 15 kg during a 28 day lactation. As a rule, it is desireable to keep maternal weight loss during a 28 day lactation to less than 10 kg and as a consequence, steps would have to be taken to increase lactational energy intake by the sow or reduce the energy demands for lactation through cross fostering.

Amino Acids

The amino acid requirements of lactating sows have been the subject of a considerable amount of research during the past decade and it is now evident that the current estimates of requirements in the NRC tables are inadequate to allow high producing sows to perform to their genetic potential. This is likely a reflection of improvements in sow milking ability due to increased selection pressure on this trait by breeding companies.

An estimate of the amino acids needs of the lactating sow can be obtained by examining the amino acid composition of sow's milk. By using the daily milk yield of the sow (based on piglet

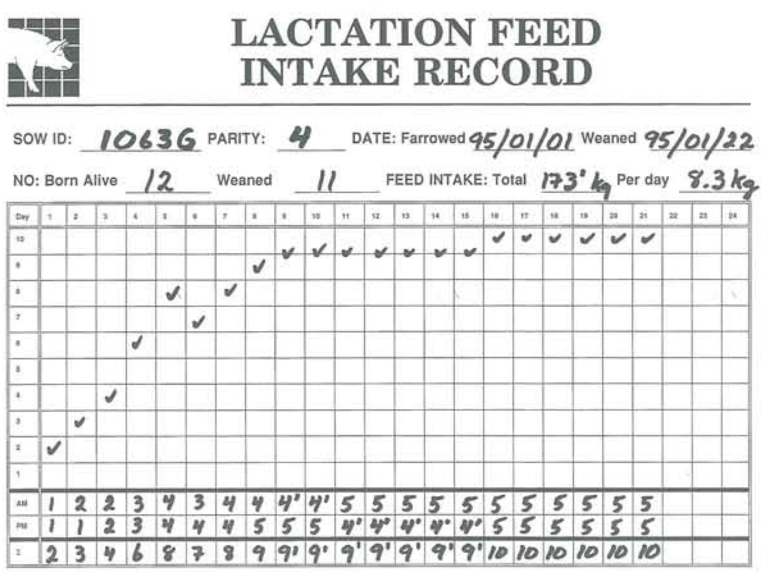


Figure 6-6. Example of a Card for Monitoring Lactation Feed Intake.

weight gain shown above) one can calculate the amounts of the essential amino acids which are secreted in milk on a daily basis. The efficiency of utilization of amino acids for milk production has been estimated at 80% and most lactation diets would have a digestibility coefficient of approximately 80%. Therefore, by dividing the amounts of amino acids secreted into milk by 0.64 (80% efficiency x 80% digestibility), one arrives at the total amount of amino acids required to support this level of milk production. Examples are shown in Table 6-29.

The total dietary amino acid needs of the lactating sow can be determined by adding the amino acids required for maintenance (see table 6-11) to those need for lactation (Table 6-29). Examples are given for three weights of sows and four daily milk yields but can be calculated for any situation using the figures provided.

The most important animo acid for sows in lactation is lysine. Dividing the daily lysine requirement by the expected feed intake of the sows will show the required level of lysine in the diet. For example, a 142.5 kg sow with a litter gaining 2250 g/day (i.e., producing 9 kg of milk per day) will require 55.9 g of lysine per day. If the sow is consuming 7 kg of feed, then the diet will need to provide 0.79% lysine (55.9 g ÷ 7000 g = 0.79%).

Obviously, it is not possible to formulate one diet that will meet the lysine requirements for each and every sow in a herd. In addition, since the objective of lactation feeding is to maximize feed intake, varying the level of feed provided is not available as a means of varying the lysine intake of individual sows. Under practical feeding conditions, it is suggested that producers formulate two rations to be fed during lactation. One to be fed to first and second parity sows (these sows typically cannot consume adequate feed and therefore this diet would be formulated with higher lysine levels) and one for the remainder of the herd.

Table 6-29. Estimated Daily Amino Acid Requirements for Milk Production by the Sow (g/day).

	Composition of Milk (%)[1]	Daily Milk Production (kg/day)[2]							
		5		7		9		11	
		S[3]	R[4]	S	R	S	R	S	R
Arginine	5.1	12.7	19.9	17.8	27.9	22.9	35.8	28.0	43.8
Histidine	2.8	7.0	10.9	9.8	15.3	12.6	19.7	15.4	24.1
Isoleucine	4.5	11.3	17.6	15.7	24.6	20.2	31.6	24.7	38.7
Leucine	8.7	21.7	34.0	30.4	47.6	39.1	61.2	47.8	74.8
Lysine	7.8	19.5	30.5	27.3	42.6	35.1	54.8	42.9	67.0
Sulfur AA	3.3	8.3	12.9	11.5	18.0	14.8	23.2	18.1	28.4
Aromatic	8.3	20.7	32.4	29.0	45.4	37.3	58.4	45.6	71.3
Threonine	4.2	10.5	16.4	14.7	22.9	18.9	29.5	23.1	36.1
Tryptophan	1.2	3.0	4.7	4.2	6.6	5.4	8.4	6.6	10.3
Valine	5.6	14.0	21.9	19.6	30.6	25.2	39.4	30.8	48.1

[1]Adapted from Speer (1990). Partitioning nitrogen and amino acids for pregnancy and lactation in swine: A review. J. Anim. Sci. 68: 553-561.
[2]Daily milk production calculated by multiplying daily weight gain of litter x 4.
[3]Secreted
[4]Required
Based on sow producing milk with 5% protein. Assumed absorbed amino acids used at an efficiency of 80% for milk production and diet had 80% digestibility.

Table 6-30. Estimated Total Daily Amino Acid Requirements of Lactating Sows (g/day).

Sow Weight (kg)	142.5				217.5				280				Current NRC[1]
Daily Milk Yield	5	7	9	11	5	7	9	11	5	7	9	11	
	Amino Acid Requirement (g/day)												
Arginine	19.9	27.9	35.8	43.8	19.9	27.9	35.8	43.8	19.9	27.9	35.8	43.8	21.2
Histidine	10.9	15.3	19.7	24.1	10.9	15.3	19.7	24.1	10.9	15.3	19.7	24.1	13.2
Isoleucine	18.8	25.8	32.9	39.9	19.3	26.3	33.3	40.4	19.6	26.6	33.7	40.7	20.7
Leucine	34.8	48.4	61.9	75.6	35.1	48.7	62.3	75.9	35.4	48.9	62.5	76.1	25.4
Lysine	31.5	43.7	55.9	68.0	31.9	44.0	56.3	68.4	32.2	44.4	56.6	68.7	31.8
Sulfur Amino Acids	13.9	19.1	33.7	29.4	14.4	19.5	24.7	29.8	14.7	19.8	24.9	30.1	19.1
Aromatic	34.3	47.3	60.2	73.2	35.0	47.9	60.9	73.9	35.6	48.5	61.5	74.5	37.1
Threonine	18.0	24.6	31.1	37.7	18.6	25.2	31.7	38.3	19.1	25.6	32.2	38.7	22.8
Tryptophan	4.9	6.8	8.6	10.5	4.9	6.8	8.7	10.6	5.0	6.9	8.8	10.6	6.4
Valine	22.7	31.5	40.2	48.99	23.0	31.8	40.6	49.3	23.3	32.0	40.8	49.5	31.8

[1]Based on a 165 kg sow consuming 689 g/day crude protein.

Vitamins and Minerals

There has been surprisingly little research conducted on the vitamin and mineral requirements of sows during lactation alone. The available data suggests that the lactating sows requirements do not differ appreciably from those of the gestating sow and therefore the nutrient levels suggested in Tables 6-12 and 6-13 are recommended.

Feeding the Sow at Weaning

There is a great diversity of opinion as to how sows should be fed and managed from weaning to rebreeding. Many producers believe that withholding feed and water for 24 to 48 hours after weaning will dry the sow off more rapidly, leading to a shorter interval between weaning and rebreeding. However, others feel that moderate to high levels of feed will give the best results.

A Texas study investigated the effects of feed and water deprivation prior to weaning, on the number of days to successful service. The results of this trial indicate that feed and water deprivation at weaning prolonged the weaning to service interval (Table 6-31). Therefore, it would appear that the most effective way to dry off a sow is to maintain them on a moderate level of feed and allow milk to accumulate in the udder. The resulting increase in intramammary pressure will very effectively and rapidly stop milk secretion and stimulate a rapid return to estrus.

Table 6-31. Effect of Feed and Water Deprevation, Prior to Weaning, on Days to Successful Service After Weaning.

	Hours of Deprivation Prior to Weaning			
Feed	0	48.0	0	48.0
Water	0	0	24.0	24.0
Days to Successful Service	6.0	11.9	9.1	12.8
Number not Showing Estrus Within 21 Days Postweaning	0.0	5.0	3.0	5.0

Orr et al., 1981, Anim. Prod. 15: 259-264.

Feeding the Sow Between Weaning and Rebreeding

The level of feed intake selected from weaning and mating should allow the release of sufficient ova, their successful fertilization and implantation. Many producers find that gilts which have just weaned their first litter are difficult to rebreed. This is generally due to the poor body condition of first litter sows and the stress of competing with older sows after weaning. The best solution is to feed sows better during lactation than to try to catch up later on. However, supplying high levels (3.5 - 4.0 kg/day) of feed to gilts in poor condition from weaning to rebreeding will improve conception rates and reduce the number of days to rebreeding (Table 6-32). After breeding, feed levels should be reduced to maintenance levels in order to prevent a high incidence of embryo mortality.

Table 6-32. The Effect of Feed Intake During the Weaning to Remaining Interval on the Reproductive Performance of Gilts and Sows.

		Feed Intake(kg/day)		
		1.8	2.7	3.6
Weaning/Estrus Interval (days)	Gilts	21.6	12.0	9.3
	Sows	4.9	4.7	5.0
Conception Rate (%)	Gilts	58	75	100
	Sows	100	87	100
Subsequent Litter Size	Gilts	9.4	10.1	11.6
	Sows	12.6	11.8	12.2

Adapted from: Brooks and Cole, 1972, Anim. Prod. 15: 259-264, and Brooks et al., 1975, Anim. Prod. 20: 407-412.

Flushing does not work with older sows. The purpose of a high level of feeding after weaning is to increase ovulation rates and thereby increase the subsequent litter size. However, since ovulation rate is not usually a limiting factor for sows, even if the ovulation rate is increased, an improvement in litter size is not usually forthcoming. A daily feed intake of approximately 2.7 kg between weaning and remating is generally sufficient to allow sows in reasonable condition to achieve high conception rates and good litter size.

During hot weather, conception rates are often reduced. There is some evidence to show that feeding vitamin fortified diets to the breeding herd may improve conception rates during periods of elevated temperatures. In a recent study, sows were fed higher than recommended levels of vitamin A (150% NRC), vitamin B-12, pantothenic acid and choline during periods of hot weather. The conception rate of the vitamin fortified group increased from 52.8% to 76.0%.

Feeding Boars

Introduction

The boar is often the forgotten member of the breeding herd and there has been surprisingly little research conducted to determine their nutritional requirements. Most tables of nutrient requirements group boars together with dry sows and assume that a diet that meets the requirements of sows during gestation will also be satisfactory for the herd sire.

Nutrition of Boars During Rearing (20 - 100 kg)

Young boars are usually selected to be herd sires according to an index which includes such characteristics as growth rate, appetite, feed efficiency, lean tissue growth rate and carcass quality. As a consequence, young boars need to be fed high-energy and nutrient dense diets ad libitum in order to allow for the accumulation of meaningful performance data for use in selection programs. During the period from birth to 50 kg body weight, the boars potential for lean tissue growth appears to be beyond the upper limit of appetite. This means that high energy diets can be fed ad libitum without excessive fat deposition or decline in feed efficiency and energy levels of at least 14 MJ DE/kg (3344 kcal/kg) diet are recommended. From 50 to 100 kg liveweight, the boars potential for protein deposition lies within the limits of appetite and excess energy levels may affect performance. Australian data indicate that the maximum rate of protein deposition occurs with energy levels of 33 MJ DE/day (7883 kcal/day). If the potential ad libitum feed intake of the boar is known, then the required energy content of the diet can be calculated by dividing this energy level by the potential feed intake.

The protein requirement of growing boars is greater than that of barrows or gilts since boars gain faster, are more efficient and have less backfat. Average daily gain and feed efficiency are maximized for growing boars at levels of 20% protein during the growing period (20-55 kg) and 18% crude protein during the finishing period (55-100 kg). In addition, developing boars require 0.15% to 0.25% more lysine than barrows. Data from the University of Kentucky indicate that the lysine requirement of 35-60 kg boars is 0.86% while that of 60-100 kg boars is 0.74%. These levels are higher than those recommended by the NRC.

The developing boar may require higher levels of calcium and phosphorus than the levels fed to market animals since the tendency to show leg weakness may be exacerbated by high growth rates and by feeding to appetite. Calcium and phosphorus levels of 0.75% and 0.60% respectively are recommended during the growing period and drop to 0.65% and 0.50% by the time the boar is ready for breeding. A summary of nutrient requirements for developing boars is presented in Table 6-33.

The experimental evidence suggests that nutrition during rearing can influence both the age of puberty and the rate of sexual development but these are unlikely to be impaired under current feeding regimes and practices. Under normal breeding conditions, boars attain puberty between 5 and 8 months of age when they weigh 80-120 kg body weight. Age is more important than body weight in determining the onset of puberty. Although a 30% reduction in feed intake has been shown to cause a 42 and 30 day delay in puberty for purebred and crossbred boars, unless severely undernourished, this restriction does not appear to impose any long lasting, damaging effects upon reproductive capacity other than the obvious effects on the growth and body size of the animal. In practise, most young boars are offered feed to appetite during rearing and at this feeding level there is unlikely to be any negative effects upon sexual development or subsequent reproductive capacity.

Table 6-33. Nutrient Requirements of Developing Boars (20-100 kg).

	Weight of Boar		
	20-55	55-100	120-Breeding
Energy (MJ/day)	29	33	25
Protein (%)	20	18	14
Lysine (%)	1.0	0.8	0.65
Tryptophan (%)	0.17	0.14	0.12
Threonine (%)	0.65	0.60	0.50
Methionine + Cystine (%)	0.45	0.35	0.40
Calcium (%)	0.75	0.70	0.65
Phosphorus (%)	0.60	0.55	0.50
Salt (%)	0.25	0.25	0.50
Zinc (mg/kg)	75	50	75
Iron (mg/kg)	75	50	75
Manganese (mg/kg)	20	20	20
Copper (mg/kg)	6	5	6
Selenium (mg/kg)	0.15	0.10	0.10
Vitamin A (IU/kg)	3000	2000	4000
Vitamin D (IU/kg)	300	200	400
Vitamin E (IU/kg)	18	15	20
Vitamin K (mg/kg)	1.5	1.0	2.0
Riboflavin (mg/kg)	4.0	3.0	5.0
Niacin (mg/kg)	30	25	35
Pantothenic Acid (mg/kg)	15	12	20
Choline (mg/kg)	400	300	500
Vitamin B_{12} (ug/kg)	15	10	20
Biotin (ug/kg)	50	50	100

Adapted: Wahlstrom, 1991. Swine Nutrition pp 517-526.

Nutrition of the Working Boar

The daily energy requirements for working boars can be assessed as the summation of the following components: maintenance, body gain, semen production, mating activity and the requirement for extra heat production when kept below their lower critical temperature. Estimates have been derived from the factorial principle of nutrient partitioning and range from 29 to 41.5 MJ DE/day with an additional 3% for each 1°C decrease in temperature below an environmental temperature of 20°C.

The energy requirements for maintenance can be calculated in a similar manner to those of the gestating sow using a value of .415 MJ DE per kg body weight$^{.75}$. The energy requirements for growth are more difficult to calculate because there has been very little research conducted to determine the optimum growth rate of working boars. Overfeeding is undesireable because overfeeding may reduce libido and may increase the risk of leg weakness. In addition, overfeeding can increase the size and weight of the boar to the point where the boar is no longer compatible with the sows in the herd and must be culled. Given their high purchase price, early culling of boars is clearly detrimental. However, underfeeding may affect reproductive characteristics such as number of sperm cells and the fertilizing capacity of the sperm cells.

One of the few attempts to suggest an optimum growth rate for working boars comes from recent research at the University of Wageningen. Dutch workers recommend a moderate growth rate (400 g/day) for young boars (150-250 kg) and a reduced weight gain (200 g/day) in mature boars (250-400 kg). Their research suggests an energy cost for growth of 32.8 MJ per kg weight gain. The energy requirements for reproduction (semen production and mating activity) amount to about 18 kJ per kg$^{.75}$ which amounts to less than 3% of the maintenance cost of the boar. Therefore, this energy cost is usually ignored in calculating the daily energy needs of the working boar. The energy requirements of boars of various body weights are calculated in Table 6-34.

The results of these calculations indicate that working boars should be fed between 2.6 and 3.0 kg per day. The exact amount given to the boar will depend on breeding load, climatic conditions, body weight and condition. Boars should be individually fed, twice a day. This allows for a daily check of the health and vigor of the boar and an adjustment in the amount of feed provided where necessary. Fresh water should be provided at all times.

Several studies have indicated the importance of protein and more specifically the amino acids lysine, methionine and cystine on the number of sperm cells produced. There appears to be a minimum level of protein neccessary to ensure maximal sperm production since low protein levels have been shown to reduce the number of sperm cells ejaculated. A crude protein content of 14% with lysine and sulfur containing amino acid levels of 0.65% and 0.44% are recommended.

Calcium and phosphorus are the most important minerals to consider in the context of the nutrition of the working boar as they are crucial not only to optimal growth rate but also to bone mineralization and hence overall soundness of the limbs. It is generally accepted that higher levels of calcium and phosphorus are required for optimum bone mineralization as opposed to maximizing growth rate. Soundness of limbs is an important index to consider as foot-related problems are a major contributory factor to loss of libido and the inability of the boar to mount a sow. It has been reported that boars which were fed 150% of NRC recommenda-

Table 6-34. Energy Requirements of Working Boars.

Liveweight (kg)	150	200	250	300	350	400
Weight gain (g/day)	500	400	300	200	100	50
Maintenance Energy (MJ/day)[1]	17.8	22.1	26.1	29.9	33.6	37.1
Energy for Growth (MJ/day)[2]	16.4	13.1	9.8	6.6	3.3	1.6
Total Energy (MJ/day)	34.2	35.2	35.9	36.5	36.9	38.7
Daily Feed Required (kg/day)[3]	2.6	2.7	2.8	2.8	2.8	3.0

[1]Calculated using .415 MJ per kg BW$^{.75}$
[2]Calculated using 32.8 MJ per kg weight gain
[3]Assumes energy content of feed is 13 MJ/kg
Adapted from Kemp, 1989.

tions for dietary calcium and phosphorus and thicker-walled metacarpals which had greater strength than boars fed 100% of recommendations.

Zinc has an established role in spermatogenesis since zinc deficiencies are implicated in the retardation of the leydig cells, a reduced response to leutinizing hormone and a reduction in testicular steroidogenesis. A level of 100 mg/kg is recommended. Boars show no additional requirements for the other major minerals in relation to sows.

It has also been suggested that the working boar has no additional requirement for vitamins above those of the breeding sow. However, the role of biotin in the diet of boars is becoming increasing important as a result of its association with foot lesions and the attendant implications this has for reproductive performance in the boar. Biotin is an essential water soluble sulfur containing vitamin. Supplementation of the diet with biotin has been shown to significantly strengthen the hoof. The precise mode of action of biotin in the prevention of foot lesions is still uncertain. It is known that biotin increases the compressive strength and hardness of the hoof wall which decreasing the hardness of the heel bulb tissue. A soft heel bulb presumably acts as a cushion, minimizing stresses and absorbing strain energy. There is also the suggestion that vitamins E and C may be of special importance in the diet of stress susceptible breeds.

A major practical problem in feeding boars is that the low level of intake may result in hunger, frustration, abnormal behaviour and generally poor welfare. The use of bulky or fibrous feeds may overcome these problems and improve health, provided they supply sufficient nutrients to meet the dietary needs of the animal. The precise role that fibre may have in reducing hunger and increasing satiety over a prolonged period of time may be two fold. Firstly, the considerable bulking effect that plant fibre produces increases overall gut fill producing a feeling of fullness and satiation. Secondly, there is evidence to suggest that gastric emptying and intestinal transit times may also be prolonged so that the duration of this increased fullness will be extended. There may also be positive health and welfare advantages associated with the feeding of fibrous foods. For example lesions of the esophagus are common in cereal fed animals resulting in a reduced feed intake and poorer reproductive performance. Increasing the fibre content of the diet has been shown to reduce the severity of such lesions.

In summary, the energy and protein needs of a typical boar (i.e., one of 18-24 months and 175-250 kg liveweight maintained in a thermoneutral environment) are satisfied by a daily feed allowance of 2.6-3.0 kg of a diet containing around 13 MJ DE/kg and 140 -160 kg of crude protein. For every 1°C that the house temperature drops below 21°C a boar on a solid unbedded floor should be offered an extra 100g of food daily. For a boar well bedded on straw, this rule would apply below 17°C.

Table 6-35. Composition of Diets for Adult Boars.

	150-200 kg	200-350kg
Dietary Energy, MJ DE/kg	13.0	13.0
Protein, %	15.0	14.0
Lysine, %	0.7	0.55
T.S.A.A., %	0.47	0.40
Calcium, %	0.80	0.75
Phosphorus, %	0.70	0.60

Adapted from Aherne, F. 1995. Pig Letter 15:16.

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