2003 SWINE CARE HANDBOOK

National Pork Board

Preface

Animal husbandry is traditionally understood as a blend of the producer's self-interest and duties of humane treatment for the animals on which we depend. A livestock operation cannot prosper without healthy and reproductively fit animals, and thus the profitability of the farm has tended to be regarded as a good indicator of well-being for its animals. Yet while profits provide an economic incentive for husbandry, livestock producers have never evaluated animal welfare solely in terms of dollars and cents. Taking proper care of one's animals has always been understood as an ethical responsibility, as well as a necessary business practice.

The ethical responsibilities of animal husbandry have usually been thought of in terms of duties that individual people—farmers and farmhands—must perform on behalf of the animals in their care. Although it is still true that the husbandry imposes ethical duties on those who practice it, animal agriculture has changed dramatically in scope and complexity over the last few decades. New technologies pose challenges to the way that we understand how animals fare in a given production system. New methods may seem to enhance one dimension of animal health and well-being, while seemingly causing a decline in another. New scales of production can provide opportunities for improvements in overall herd health, reproductive success and profitability, while reducing the amount of care and attention that can be given to an individual animal. Emerging trends in marketing and contracting constrain producers' flexibility and introduce powerful new actors into decision-making roles that affect animal health and well-being.

Science and imagination are needed to assess the overall impact of these trends in animal production, and it is important to ensure that the ethical side of animal husbandry does not lose out. But in a technologically complex world in which a producer's choices are sharply limited, it is no longer appropriate to place the entire burden of ethical responsibility on the shoulders of individual farmers. Above all, consumers must not expect individual farmers to undertake practices that will make them uncompetitive in the marketplace. Livestock producers will do what is necessary to compete, or else they will not be livestock producers for very long. This means that the ethics of farm animal welfare will increasingly come to be seen in terms of industry standards, market structure and government regulation, in addition to individuals' responsibility to the animals in their care.

We are entering a time when the public's demand for ethical treatment of farm animals is starting to register in the form of price premiums and special contracting requirements, as well as pressure for government action. Clearly there is a danger that the emerging system will serve neither animal nor human interests well. Scientifically-validated and ethically-grounded industry standards can provide an alternative to rules and regulations imposed from without, but only if three key conditions can be met. First, it must be clear that the ethical goals and principles place appropriate weight on the welfare and interests farm animals themselves, at the same time that they recognize the role of animal agriculture in satisfying vital human needs. Second, consumers must have confidence that standards are taken seriously and that livestock producers faithfully follow recommended practices. Third, producers themselves must believe that standards are fairly established and administered. Although some mix of market incentives, government regulation and self-administered industry standards may eventually emerge to address the new challenges of ethical husbandry, only a system that meets all three of these criteria can truly said to be ethically justified.

Who will take the lead in formulating and implementing such a system? Producers themselves can seize the initiative, either through existing commodity groups or through some yet-to-be-formed organization that would be one step removed from the day-to-day concern with farm policy and profitability. They will need to work with scientists and government, as well as finding new partners among non-farm groups with an interest in animal care. One thing is certain. If producers undertake a new effort to provide assurance that animal interests are being taken into account in contemporary husbandry, they can be sure that people from outside will be watching carefully, even skeptically. What is more, such an undertaking will almost certainly meet opposition from people whose view of animal protection leaves no room for animal agriculture. At

continued . . .

present, the broader public is caught between these extremists on the one hand, and on the other a farm community polarized by extreme views and reluctant to take any coordinated action at all. Producers can and should accept the challenge of ending that gridlock, for no one is truly served by it and public confidence in the food system is its greatest casualty.

As science and technology advance, we have come to expect that standards for husbandry will evolve, and that periodic updating and revision will be the norm. The complex trade-offs between animal welfare, consumer prices and producer profitability will also be affected by shifting social values and technical change. Ethics itself must come to be seen in terms of responsiveness to change and to what we have learned. The ethics of husbandry will consist as much in how the animal industries adapt to new knowledge and altered circumstances as in the individual performance of age-old duties of animal care. This most recent guide to swine care reflects what we have learned most recently about responsible husbandry, but it also represents a commitment to continue in the search for better knowledge and better practice. Producers can meet their responsibility for ethical husbandry only by practicing what we believe to be right today and by resolving to test those beliefs, to learn and to improve in the future.

Paul B. Thompson, Distinguished Professor
Joyce and Edward E. Brewer Chair in Applied Ethics
Director, Center for Food Animal Productivity and Well-Being
Adjunct Professor of Animal Science
Purdue University, West Lafayette, IN

Table of Contents

PORK PRODUCER CODE OF PRACTICE
Producers take pride in providing proper care to the swine on their farms.

They consider management and husbandry practices for good swine care to include the following:

- Providing facilities to protect and shelter pigs from weather extremes while protecting air and water quality in the natural environment
- Providing well-kept facilities to allow safe, humane, and efficient movement of pigs
- Providing personnel with training to properly care for and handle each stage of production for which they are responsible with zero tolerance for mistreatment of swine in their care
- Providing access to good quality water and nutritionally balanced diets appropriate for each class of swine
- Observing pigs to make sure basic needs for food and water are being met and to detect illness or injury
- Developing herd health programs with veterinary advice
- Providing prompt veterinary medical care when required
- Using humane methods to euthanize sick or injured swine not responding or not likely to respond to care and treatment in a timely manner
- Maintaining appropriate biosecurity to protect the health of the herd.
- Providing transportation that avoids undue stress caused by overcrowding, excess time in transit, or improper handling during loading and unloading

Producers keep themselves updated on advancements and changes in the industry and make decisions based on sound production practices and consideration of the welfare of their pigs. Producers are committed to adhering to this code and the swine care practices provided in this handbook.

Introduction

The purpose of this handbook is to provide pork producers with the latest information available on swine care practices that are recommended for safe, humane, and efficient pork production. Swine can be raised humanely in a variety of production systems. Even though several different types of production systems are used on U.S. farms, they all have some common considerations for animal welfare. But each production system also has specialized characteristics, which this handbook specifically addresses.

This handbook reviews and gives guidelines for many of the various factors that effect animal welfare. Some factors (ventilation rates, noise, manure management, facility considerations, etc.) will have effects in animal husbandry areas other than animal welfare. This handbook does not discuss how various factors effect these other areas. However, it is important to recognize that addressing animal welfare in isolation without consideration of animal health, food safety, and the environment is not wise. Following these guidelines will enable pork producers to provide humane care to their pigs, regardless of the type of production system they manage. However, each of these other areas must also be addressed simultaneously to provide an effective balance and maintain the pork operation's sustainability.

There is no scientific consensus about the 'ideal' criteria to measure animal welfare. It is generally accepted that welfare can be determined by assessing the animals' physiology (for example, immune function and hormonal status or response), its behavior and its production. For an accurate picture of welfare, all three areas must be assessed. Using any one of these parameters as a sole indication of welfare can be misleading.

Research and development of new technologies of production are ongoing in the pork industry. As part of that development and as they are introduced into the industry, it is important that they are evaluated to determine their impact on the welfare of the animal. In some cases, that specific evaluation or the scientific research may not yet be done sufficiently to enable specific welfare guidelines to be developed. When this is the case, some of the recommendations are by necessity the result of consensus-reaching among animal scientists, veterinarians, animal welfare scientists and pork producers. As more information becomes available on improved production practices or facility designs, the recommendations on appropriate swine care practices provided in this handbook will be updated.

Each pork producer's professional judgment, experience and training are the key factors in providing animal care. Proper animal care depends on the interaction among the producer, the producer's management skills, the physical environment, and the pigs.

The National Pork Board's Animal Welfare Committee has reviewed the Swine Care Handbook. The Committee has stated that its mission is to maintain and promote the pork industry tradition of responsible animal care through the application of scientifically sound animal care practices. In support of this mission its objectives are to:

- Advance producers awareness of emerging animal welfare issues
- Provide information and education to improve animal care skills
- Support scientific research to enhance well-being
- Provide information for greater public understanding and awareness about producers commitment to providing humane care

Although difficult to define, the potential for detrimental stress is a significant animal welfare and production concern. A pig may be distressed if it is required to make abnormal or extreme physiological or behavioral adjustments to cope with adverse aspects of its environment or management. When stressful situations in pork production are identified and minimized, the animal's well-being, reproductive efficiency, and growth improves. This yields economic benefits for producers, consumers, and the entire pork industry.

Research is continuing to determine the relationship between physiological and behavioral measures of stress and to determine the causes of stress in pork production. Some pork production practices (i.e., vaccination, weaning, tail docking) can be short-term stressors. However, they provide long-term health and management benefits to individual pigs and their herd mates. Responsible pork producers examine their husbandry procedures for their effects on the short-term and long-term well-being of the pigs and the total management plan.

These guidelines are based on the current research and extension literature for animal science, veterinary medicine, and agricultural engineering. Pork producers, veterinarians, agricultural engineers, and animal scientists then reviewed this information.

As used in these guidelines, "producers" refer to the pig caretakers and include owners and workers.

Summary of Producer Responsibilities

Use this handbook to review your production practices as they relate to welfare. Stay current with developing information on providing the best possible animal care. Utilize experts in this area. America's pork producers must continue to stay on the forefront of advocating and practicing good animal care.

Pork producers must continue to fund research to determine how best to provide for the swine in their care. Science has not yet provided all the answers needed to fully understand animal needs. Research and years of practical experience have provided much information about providing humane swine care that can be applied across a wide variety of pork production systems.

Chapter 1:
MANAGEMENT PRACTICES AND ANIMAL HUSBANDRY

Observation

Pigs should be observed on a routine schedule, at least once a day but more frequently during special events such as farrowing, post-surgical recovery or recovery from illness.

Waterers and feeders must be checked to make sure pigs have adequate access to water and feed. They should be easy for the pigs to use, and should be set up so as to prevent feed wastage, minimize contamination by feces and urine and not injure the pigs. Care should be taken to minimize dust. Techniques to control feed dust include small drop distances and open conveyors and the addition of edible oils to the feed.

Water requirements for pigs vary greatly, depending on air temperature, humidity and feed consumption. Pigs may require water in amounts up to five times the weight of the dry food consumed (Whittemore, 1998). The general water requirements of pigs are presented in Table 1. It is advantageous to design the access to water supply system so that medication can be added if required.

Pigs should be observed for signs of health problems, injuries or physical discomfort. Signs of discomfort include huddling, panting, decreased feed consumption, poor growth rate, etc. (Connor, 1993). Facilities need to be inspected to be sure that they are functioning properly. Producers and employees need to act on these responsibilities during normal working hours, nights and weekends.

Give attention to sick pigs without delay and as soon as possible remove and properly dispose of any that die. In all production systems there should be a facility appropriate for segregation of sick and injured animals. The recovery pen should provide a warm, dry, comfortable draft-free environment where pigs are protected from harassment by others. The effective temperature of this pen may be slightly above that required for healthy pigs because these pigs may have reduced feed intake and a fever (Connor, 1993).

A daily management regimen allows pigs to develop a routine of their own. Producers must pay close attention to all environmental factors that will influence the health of the pigs. Disease organisms are present at low levels in most pig units, but they do not always present a problem because immunity develops naturally. When disease-causing agents are prevented from infecting the preweaned pigs and are excluded from the growing pigs, the pigs will perform better and will be more profitable.

Monitoring for the presence of disease should be a well-established practice in every swine production unit. Some microorganisms can be eliminated from the pigs by specific management procedures, including medication, sanitation, enhanced immunity due to aging, decreasing stocking density and vaccination. Age segregated rearing systems may be particularly useful because the young pigs are separated from the adult breeding herd.

Emergency, Weekend and Holiday Care

In case of an emergency, quick communication is important. Names and telephone numbers of the producer, veterinarian, equipment suppliers and the fire and police departments should be posted near telephones. Suitable alarm systems should be available to warn of power failures or temperature changes. Producers and employees should be given hands-on training in emergency procedures. The

person in charge of the farm should review plans for all types of emergencies that may be encountered.

Daily animal care should be arranged during weekends and holidays, unexpected absences because of illness or similar contingency and other leaves and emergencies. All workers should be qualified to perform assigned duties. A procedure should be established for providing emergency animal health care after hours, on weekends and on holidays.

Identification and Records

Identification is important for maintaining health records and for tracking pigs as they are moved through the farm. Identification methods may include ear notches, ear tattoos, electronic transponders, ear tags, neck chains or pen recognition. Breeding animals should be individually identified with an easily read system.

Regular, frequent and routine systems for review are essential for the improvement of the production system. For this purpose, records of various activities are needed.

Many different types of records may be kept depending on the type of production system. Medical records, production records, and nutritional information, such as sow feed consumption during lactation, may be kept. Nutritional records may also be kept in association with specific pens and rooms for nursery and finishing pigs. Facility records may be kept for performance of routine maintenance procedures. Pigs sold annually per breeding female and feed used per pig sold are the two vital statistics for producers (Whittemore, 1998).

Handling

At all stages, pigs should be handled with care, gentleness and patience. Training of employees and family members to properly handle pigs is very important. Educational materials about this are available from the National Pork Board.

An understanding of the behavioral characteristics of pigs will be helpful for handling, increasing productivity, improving meat quality and helping to reduce undesirable stress (Grandin, 2000a). Pigs are very alert and curious when put into a new situation. Even very small disturbances in their surroundings can frighten them. A pig's range of vision is more than 300 degrees. Although this allows them to see behind themselves without turning their heads, it also causes them to be sensitive to sharp contrasts in light and dark. Pigs may balk and be reluctant to move if they encounter shadows, puddles, bright spots, a change in flooring type or texture, drains, metal grates, or flapping objects (Grandin, 2000b).
If the pig appears distressed during handling, it must be permitted to rest and recover without prodding. The use of electric prods is a stressful event and should be avoided or absolutely minimized. Pigs must never be prodded in sensitive areas such as the eyes, nose, anus, testicles, etc. If regular use of an electric prod is needed, the adequacy of the handling facilities should be examined.

Although walking through the pens at least once daily may help make excitable pigs easier to handle and load on trucks, health and biosecurity issues need to be considered. When loaded onto a truck from inside a building, market pigs will move more readily if moved in groups of 5 or 6. They can be lined up in single file or pairs before they go outside. A short outside approach to the loading chute may facilitate the loading process. A roof over the loading ramp will also help loading. Lights inside a building or inside a truck will attract pigs because they have a tendency to move from a darker to a brighter area. Care must be taken to have the light illuminate the floor and not shine into their eyes. The loading chute should not be positioned to allow the sun to shine directly in their eyes. To avoid potential introduction of disease, once they are loaded pigs should not be permitted to go back to the building.

Funnel-shaped pens should not be used to load pigs because pigs often continue to press forward. There should be an abrupt entrance to the chute. Loading ramps with solid fences are more efficient because they decrease distractions. Cleats to prevent slipping should be spaced to fit the stride length of the size of pig being handled. Twin single-file chutes, side by side, facilitate loading. The two outside fences should be solid, and the divider fence between the two chutes should be transparent to encourage following.

Pigs will stop when a solid barrier is placed in front of them. Small portable panels will allow efficient

moving and sorting. A light aluminum, plastic or wood panel with a hinge in the middle is useful in separating pigs from a pen. Sorting, grouping and moving can be made easier by providing swinging gates in holding pens. Other useable tools for moving pigs include large flags or plastic paddle sticks. Sows in stalls can be backed out of crates if they are tickled on the snout with a broom.

Transportation

Safety and comfort should be a primary concern when transporting pigs. Weak pigs should not be loaded or transported with healthy ones. Appropriate steps should be taken immediately to segregate sick pigs and care for their special needs. Transport is a stressful time for pigs, and even healthy individuals can lose up to 5% of their body weight during a 4-hour transport (McGlone *et al.*, 1993). Loading during the cooler hours of the day or during the night is helpful in reducing stress (Murray, 2000).

When pigs are transported, ventilation should be adequate and the floor should be slip-resistant. Pigs of 50 pounds should have a minimum of 1.5 square feet per pig; 100-pound pigs, 2 square feet; 250-pound pigs, 4 square feet; and 400-pound pigs, 6 square feet (Grandin, 1988; Grandin *et al.*, 1989). Very low stocking density is also not recommended during transportation as pigs might be thrown around during motion (Penny and Guise, 2000). The ramps should be flat with nonslippery floors, solid walls and adequate lighting. Ramps and chutes should be strong, with no gap between the sides of the ramp and the truck. Ramps should not be steeper than 20° (Connor, 1993; Lambooij *et al.*, 1993). The sidewalls must be properly designed to prevent pigs escaping from the vehicle while in transit.

Handling and transportation of boars and sows should be designed to minimize fighting in order to prevent injury and carcass damage. Animals should be shipped in groups of uniform weight and species. If mixing of animals is required, it is best done immediately before loading and transportation since pigs usually do not fight in a moving vehicle. Recommendations of facility design for loading and unloading trucks, restraining animals and handling them in packing plants have been published (Grandin, 2000c).

Adverse weather and wide temperature fluctuations can aggravate transport and handling stresses. Hot weather is a time for particular caution. The Livestock Weather Safety Index contained in the Pork Quality Assurance (PQA) Transporter Guide (Figure 1) is used as the basis for deciding how to handle and ship swine during extremes in the weather. While in transit in warm weather, swine should be protected from heat stress by being shaded, wetted immediately before transport and bedded with wet sand or shavings. Pigs should be checked within the first hour of transportation and

Figure 1:

pork Quality Assurance™

TRANSPORTER'S GUIDE

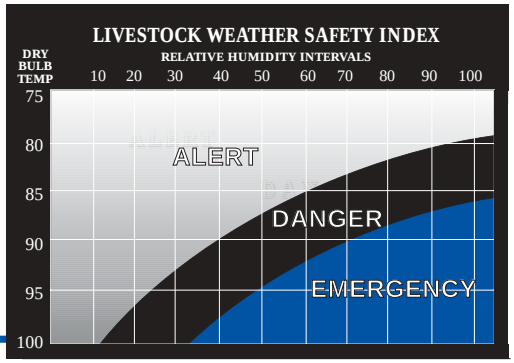
Prior to loading in hot weather, always refer to this table for recommended loading and transport procedures.

Hogs need more room in a truck during hot weather, and you should adjust the size of your load accordingly. Don't overload your truck.

Use this table to find the recommended amount of space each animal needs for safe delivery. When temperatures are in the alert zone, add 10% more square foot per head; add 15% for danger and emergency zones. As a general guide, leave enough space so that every animal can lay down at the same time.

ANIMAL HEALTH

Hogs unable to walk or sick hogs that obviously will not recover should be humanely euthanized on the farm and not transported to market.



RECOMMENDED TRANSPORT SPACE REQUIREMENTS

AVERAGE WEIGHT, LB.	NUMBER HOGS PER RUNNING FOOT OF TRUCK FLOOR (92-IN. TRUCK WIDTH)	SQ. FT. PER HEAD
50	5.0	1.53
100	3.3	2.32
150	2.6	2.95
200	2.2	3.48
250	1.8	4.26
300	1.6	4.79
350	1.4	5.48
400	1.2	6.39

Source: Livestock Conservation Institute

4/97, 12/01-#04126

thereafter every 2-3 hours to ensure that the pigs are comfortable. Prompt unloading in hot weather is essential because heat builds up rapidly in a stationary vehicle. For extended periods when the vehicle is stationary, cooling may be necessary. Transporting pigs during the mid-day on hot days should be avoided or guided by the Livestock Weather Safety Index.

During transportation in cold weather, pigs should be protected from cold stress. Wind protection should be provided when the air temperature drops below 32°F, but ventilation must always be adequate. When trucks are in transit in cold weather for more than a few minutes, pigs should be bedded with chopped straw or other material that has high insulating properties.

Water and feed should be readily available for trips longer than 24 hours. Truck beds should be clean and dry and equipped with a well-bedded, nonslip floor. Injuries can be reduced when the pigs on a truck are held in several small groups.

It is not advisable to transport pigs soon after feeding as it increases mortality (Warris, 1998). Feed may be withheld for 6-8 hours before loading if the pigs are to be slaughtered on the same day; whereas if the animals are to be slaughtered the next day, a light feeding before loading is advised (Ewing *et al.*, 1999). The transporting vehicles and loading ramps should be cleaned between deliveries to prevent cross-contamination between batches.

Handling Sick and Injured Pigs

The position of the National Pork Board is that any pig that is unable to walk or that is ill and will not recover should be humanely euthanized on the farm and not transported to market channels. Veterinary assistance should be sought to determine protocols for treatment or euthanasia for sick or injured pigs. Where the likelihood of recovery is low, even with treatment, the pig should be euthanized. When the likelihood is high, the pig should be removed to a pen where competition for feed and water is lower and where the pig can be monitored and treated regularly.

Swine that become injured in transit should be handled in a humane manner and, depending on condition, be segregated and treated with appropriate veterinary care to facilitate recovery, be immediately euthanized or be transported as quickly as possible to a processing facility. Producers should seek to prevent illness and injuries by feeding nutritionally sound diets, maintaining sound health programs, providing good facilities and proper handling and selecting genetically sound breeding stock.

Breeding Herd Management Systems

Sow Management

Females can be bred to farrow any time of the year. After approximately 115 days of pregnancy, parturition is initiated. Piglets born in the fall and spring may require less thermal control because of mild weather, but piglets born in the winter or summer will need to be protected from temperature extremes.

The stock person has a significant influence on the performance and welfare of the pigs (Ravel *et al.*, 1996a). Consideration should be given to the stock person's attitude toward the sows, since negative attitudes and interactions between people and sows is strongly related to a decrease in litter size (Pederson *et al.*, 1998; Hemsworth *et al.*, 1999). Growth rate, feed conversion efficiency and piglet survival are also affected by unpleasant handling (Seabrook, 1991; Ravel *et al.*, 1996b). Proper training can improve stockpersons' attitudes towards pigs (Coleman *et al.*, 2000).

During parturition, the sow will exhibit periods of passivity and activity. It must be remembered that she will not give attention to piglets in the litter after birth and she does not assist in cleaning and/or drying piglets. Piglets are usually expelled with little trauma, usually at a rate of 1 pig every 20-30 minutes. Gentle assistance may be required for sows having difficulty delivering piglets. Before entering the birth canal, the producer must ensure that his hands and arms, and the sow's genital area, are thoroughly washed and well lubricated. Plastic sleeves should be worn to protect both the sow and the producer. Producers should discuss with their veterinarian how to determine when assistance is needed and should receive the appropriate training. During the farrowing process, maintaining quiet surroundings is important. The sow should be comfortable and at ease.

Several management practices should be carried out as the sow approaches farrowing time to improve

survival and well-being of the newborn piglets. Farrowing areas should be cleaned before the sows are allowed to enter. The farrowing pen should be as calm as possible so that the natural vocalizations of the piglets are audible to the sow. These sounds are helpful in initiating and maintaining normal nursing routines, especially in farrowing gilts (Connor, 1993). Noisy equipment can have a negative effect on teat stimulation by piglets and milk production by the sow (Algers and Jensen, 1991).

Producers should monitor farrowing sows at regular intervals to identify farrowing problems and to aid newborn piglets into the creep areas.

Because all the phases of the reproductive cycle are related, the feeding program in one phase will have significant effects on the performance of another phase. There is a general consensus that a realistic target is for a moderate weight gain during gestation and for a minimum weight loss in lactation.

Many recent studies have established that sows that lose excessive body condition during lactation will have an extended weaning-to-service interval, and will show reduced farrowing rate and embryo survival. This is especially true for those young sows having their first or second litter.

The nutritional requirements of sows increase according to the stage of fetal development. However, there is a negative relationship between the level of feed intake during gestation and the level during the subsequent lactation, so it is important not to overfeed the sows during gestation.

Feed should be provided adequately during lactation to ensure that the sow is not undernourished. Feed should be highly palatable and feeders should be kept clean.

Feeding strategies should aim to minimize weight loss and maintain a sow's body condition throughout her reproductive life. This can be accomplished by establishing a feeding program for gilt development, controlling feed intake during gestation and ensuring optimal feed intake during lactation and during the weaning-to-estrus interval.

The above can be accomplished by:

- Weighing and recording backfat measurements at the time of breeding and specifying a target weight gain and backfat thickness level during gestation and at weaning
- Having trained personnel
- Offering adequate feeders
- Using a multiple feeding schedule, particularly during the cool hours of the day

Facilities

Sows may be housed individually or in groups. The space requirements of the breeding animals are variable depending on age, breed, feeding system, and other management criteria. While data about the effects that animal space have on production is available, research needs to be done in order to develop scientifically-based animal space guidelines that will also address measures of animal welfare and be economically sustainable. For this reason, specific recommendations about sow or boar stall or pen sizes are not given.

Each production system has its husbandry challenges and benefits. The appropriate system takes into account the manager's skills and attitude, the capital investment required, the availability of land and other resources, the genetics and characteristics of the animal, etc.

Many choices are available for gestation and farrowing facilities. For example, sows can gestate and farrow in stalls, indoor or outdoor pens, bedded or non-bedded systems or pasture huts. Each facility requires a different set of management skills and a different level of husbandry input from the producer in order to provide optimal comfort for the sows and piglets. The most important factor in animal welfare is the husbandry skill of the people caring for the animals. Therefore, training in both the care of pigs and the use of the equipment is essential.

For gilts selected to enter the breeding herd, sexual development is hastened when they are kept in groups. Sows and gilts may be housed individually or in groups during the breeding period.

Tether stalls. Tethers come in two forms: neck and girth. The tether uses a canvas belt or a plastic-covered metal device that acts as a collar or strap to confine the sow to a location. Ordinarily, tethered sows have about the same space as in a stall and

they can not turn around. Tether stalls allow sows to be fed and cared for as individuals. The partitions between adjacent tethered sows are shorter in length than typical stall partitions and thus, the relative openness of the tether stall can facilitate human interactions with the tethered sow. Tethers can be used in breeding, gestation or farrowing areas. The barn designs and floors are similar to the stall system.

Scientific studies examining the effects of tethers on physiology have given mixed results. Some of the studies' results indicate that tethering (compared to stalls or group systems) can cause an acute and/or chronic rise in blood glucocorticoid concentrations (Becker *et al.*, 1985; Barnett *et al.*, 1985, 1987, 1989; Janssens *et al.*, 1995a; Janssens *et al.*, 1995b) while other studies do not. (Barnett *et al.*, 1984a, Barnett *et al.*, 1984b). Sows may show less activity and less stereotyped behavior in the tether compared to the stall (McGlone *et al.*, 1994) which is difficult to interpret. Some studies looking at reproductive performance of sows in tethers compared to stalls indicate that the use of tethering in gestation may cause sows to have slightly fewer pigs born alive (Den Hartog *et al.*, 1993; McGlone *et al.*, 1994) and weaned (Backus *et al.*, 1991; McGlone *et al.*, 1994), although other studies found similar litter size for sows in stalls and tethers (Lynch *et al.*, 1984; Hansen and Vestergaard, 1984).

Positive human-animal interaction may reduce the stressfulness of the tether for the pregnant sow. When experimenters spent 3 minutes per day (5 days per week) providing positive human interaction, the elevated glucocorticoid concentrations were reduced compared with sows that experienced minimal or negative human interactions (Pederson *et al.*, 1998) and was lower than that for sows in stalls or group housing in another study (Barnett *et al.*, 1991). Wire mesh or other partitions should be used in fencing between sows to reduce the stressfulness of aggression from neighboring sows. The design of the partitions between sows may also influence the potential for stress in sows housed with tethers (Barnett *et al.*, 1987; 1989; 1991).

Positive human interaction, good stockmanship and good separation among neighboring sows may reduce the stressfulness of the tether stall. Unless these elements are present, tethers are not recommended.

Pens. Pen dividers should be sturdy and well-constructed; proper health care for sows and piglets should be provided; and manure should be removed regularly. Totally solid-floored pens may need to be bedded with straw or other suitable material. The bedding surface should be kept dry by adding more bedding or by changing bedding at regular intervals as needed.

Females in group gestation pens should be of uniform size and temperament. Large groups can be managed if adequate feeding space per female is allowed to reduce competition for feed. Any alternative pen design should be evaluated for performance and animal welfare effects prior to implementation.

Pens and pasture huts allow the sow to move around freely but may result in a higher newborn piglet death rate because the sow may accidentally crush her newborn piglets (McGlone and Blecha, 1987; Stevermer, 1991). Since penned sows typically crush more piglets than sows in stalls, farrowing pens need guard rails to minimize crushing of piglets. Guardrails may be fixed away from the sidewalls. (McGlone and Morrow-Tesch, 1987). Several new farrowing pen designs that minimize pre-weaning mortality have been reported in the literature (McGlone and Morrow-Tesch, 1990; Arey and Sancha, 1996; Phillips and Fraser, 2001). Inclement weather and predators may also significantly contribute to piglet mortality in outdoor systems.

Stalls. Stalls allow the sow to stand, lie, eat and drink, but may not allow them to turn around. It allows the producer to feed and observe each sow individually to meet her needs and it protects her from other aggressive sows.

Varying sizes of gestation stalls can be used without negatively affecting welfare if the size of the stall matches the size of the animal. Research needs to be done in order to develop scientifically-based guidelines that will match specific sow size or weight with specific stall internal dimensions. Sows, whether housed in groups or in stalls, must be able to:

- Lie down without the head having to rest on a raised feeder;
- Lie down without the rear quarters having to be in contact with the back of the stall; and
- Easily lie down in full lateral recumbancy and stand back up.

Sows may be penned in farrowing stalls from late gestation until weaning of the piglets. Restricting

the movement of the sow in some manner during lactation allows the piglets more opportunity to escape being crushed when the sow lies down. As the sow lies down, she slides along the side of the stall, thus allowing the piglet an opportunity to escape to a protected area of the stall. This reduces piglet death from crushing. With this arrangement, each sow and litter can be attended individually. Lower bars used to minimize piglet crushing should not interfere with suckling.

The floors are typically slatted under or to the rear of the sow zone in farrowing stalls. This allows for quick and efficient separation of excreta from the sows and piglets, and keeps the floor and equipment dry. Floors may be solid or partially or totally slatted. Acceptable materials for perforated floors include metal, woven metal, plastic-coated metal, metal bars, fiberglass, concrete, and combinations of these materials. The floor surface should be non-abrasive, nonporous, and slip-resistant (Fritschen and Muehling, 1987). During farrowing, a clean covering may be placed over the flooring immediately behind the sow. This covering may prevent injuries to the piglets. The floor should be free of exposed materials or projections that could cause injury to the udder, legs, feet or hooves of the sows and piglets.

Breeding boars should have an opportunity for exercise. Individual housing of mature boars limits aggressive interactions among them. Fighting will occur when mature boars unfamiliar with one another are penned together. Humane tusk trimming may be practiced to avoid injuries to other pigs and to handlers. Boars living in small groups should be of similar size and it is highly desirable that they be reared together before puberty. Newly purchased young boars, if housed together on arrival, can often be kept as a group.

Huts. When sows farrow in outside huts, special care needs to be taken to minimize the impact of a variable environment on both the sow and the piglets. For summer farrowing, the huts should provide a cool, shady area and be designed to have openings for maximum airflow. For winter farrowing, they should be sheltered from prevailing winds and should be made relatively airtight to retain the sow's body heat. Adequate dry bedding must be maintained during cold weather.

The farrowing huts should be located in naturally well-drained areas, on a concrete slab or on a mounded area of crushed stone or other coarse material. The locations of huts can be rotated to lessen exposure to disease and parasites in the farrowing area.

Historically, sows farrowing on pasture weaned fewer piglets because of higher piglet deaths compared with sows farrowing under more environmentally controlled conditions (McGlone and Blecha, 1987; Stevermer, 1991). Newer outdoor systems may result in pre-weaning mortality similar to indoor systems (Johnson *et al.*, 2001). Piglet mortality can vary with hut design (Honeyman *et al.*, 1998a; Honeyman *et al.*, 1998b; McGlone and Hicks, 2000).

Group farrowing under the outdoor system may cause competition between sows and gilts in the group. An alternative option is individual huts in separate paddocks (Higgins and Edwards, 1997).

Litter Management

Piglets need special attention because they are born with little energy, have low disease resistance, have little ability to regulate their own body temperature and can easily be injured by the sow. They need a warm, draft-free area and they should be protected from injury by the sow.

At birth, under ideal conditions, the lower critical temperature for piglets is 95°F. The area for the sow should be cooler than the area for the piglets, otherwise the sow can become heat-stressed. It is best to provide additional supplemental heat pads, heat lamps or heated floors in a protected area for the piglets. Covers designed to capture body heat may also be used to keep piglets warm while maintaining a cooler environment for the sow. Piglets should have access to colostrum soon after birth. If there is large variation in litter size or birth weights, cross-fostering may be performed, preferably within 24 hours after birth.

After birth, the following procedures may be performed on piglets:

- Clipping needle teeth. A newborn piglet has eight sharp teeth that can cut other piglets when fighting over teats. The teeth can also lacerate the udder of the sow. Within 24 hours after birth, teeth may be clipped to prevent these injuries. The instrument used

should be sharp, clean and disinfected between piglets. Only the tips of the teeth should be removed and care should be taken to avoid splintering or injury to the gums that could lead to infections. It should be noted that if the sow is milking adequately, each pig has a teat to suckle, and fights are minimized then teeth clipping might not be necessary.

- Supplemental iron. Because newborn pigs have a low reserve of iron, and because sow milk also contains little iron, the suckling piglet is in danger of developing anemia. Therefore, for pigs that don't have exposure to iron rich soil, supplemental iron should be given by injection or orally.
- Tail docking. Tails may be docked. Tail docking should be done shortly after birth because the piglet is small, easy to hold and the procedure is less stressful. Littermates are also less likely to bite at the wound on the docked tail at this age. It is essential to use good hygienic practices during the procedure to minimize the risk of infection.
- Identification. Ear notching, ear tattoos, electronic transponders, ear tags or other methods may be used to permanently identify pigs. If ear notching or tattooing is used, it should be done within the first week of life to avoid extra stress to the litter and the risk of infection. Attention must be paid to using proper hygienic practices.
- Castration. Male pigs intended for commercial markets may be castrated within 7 days after birth (McGlone *et al.*, 1991) or at least one week before weaning. Castration should be performed quickly with clean instruments. No suturing is needed. When weaned pigs need to be castrated, a local or general anesthetic should be used under the direction of a veterinarian. Castration is essential to prevent boar taint, which affects the meat's acceptability with consumers.

Lactation Length

Productivity of the sow herd is determined by a number of factors affecting both fertility, management of the dry sow and farrowing space. The current interest in segregated early weaning (SEW) as a management tool is driven in part by its potential advantages in maximizing occupancy and usage of relatively expensive farrowing facilities. Secondly, it can play an integral part in the herd health program. Finally, interest in SEW has been driven by the fact that specific pathogens can be eliminated from the progeny by implementing a pathogen-specific lactation length. This would allow for improved grower/finisher performance. At present, it is accepted that while shorter lactation lengths are invaluable in the control of certain diseases, they do not necessarily eliminate them, especially when the immune status of the sow herd has not been adequately stabilized.

The choice of lactation length depends upon the interests of both the weaned animals and the sow. Weaning at an early age may help control the incidence of specific diseases in the offspring but may facilitate developing vices such as belly-nosing. Weaning may reduce the stress placed on the sows and gilts if they had continued to nurse. Until the sow is weaned, she may not return to estrus. It must be taken in consideration that with a lactation length of less than 14 days, the uterus of the sow has not completed involution; therefore producers can encounter an extended and more variable weaning-to-estrus interval.

Sow Productivity

Sow productivity can be one of the measurements to assess welfare of the breeding herd. A measure of sow productivity is the number of pigs weaned per year. The two main components are:

- Number of litters per year. This depends on the interval between farrowing. Since gestation length is constant, lactation length and wean-to-service interval become the factors that can be influenced through management.
- The litter size at weaning. This depends on the number of pigs born alive and the preweaning mortality.

Mating Management

Three mating options are (1) pen mating (placing a boar with a group of sows without observation of matings), (2) hand mating (attended matings with one boar and one sow in a pen), and (3) artificial insemination (using semen collected from boars).

With pen mating, the primary considerations are to minimize extremes in environmental temperature, rest the boars between mating groups, size boars to match females and be aware of the potential problems of not observing matings.

For pen mating in buildings, the size of the area and the flooring are additional considerations. Pens should be at least 8 feet wide and provide at least 20 square feet per sow or 17 square feet per gilt. One boar per pen is recommended. Maintaining slip-resistant, dry floors is important to prevent injury. For pen mating in outside lots, small enough groups to allow adequate mating behaviors to take place should be used. Typical group sizes are 30 or fewer females.

Care should be taken not to house a young, sexually inexperienced boar in the same pen with older sows. These boars may require assistance in breeding activity.

With hand mating, the sow is usually mated in a specially designed mating pen but may be mated in the sow or boar's pen. The pen should be no less than 8 by 8 feet. Careful consideration as to the type of flooring surface in mating pens is essential during the planning and construction of the facility. In mating pens with an area of solid concrete, floors can be made slip-resistant by applying a wood float, by applying a broom finish, by placing grooves in the concrete or by using a 1-inch diamond pattern (Levis *et al.*, 1989). In pens used for hand mating, absorbent substances or rubber mats may be placed on the floor to allow for better footing.

Artificial insemination (AI) allows more extensive use of genetically superior boars than would be possible with natural service. It provides a way to bring in new genetic material with a minimum of disease risk. Fewer boars are needed because AI makes it possible to breed 10 or more sows in one day with one ejaculation. In addition, when using AI, there is less risk of injury to the sow, the boar and the people handling them. Finally, it allows the use of semen from older, larger boars to inseminate young gilts or small sows without the risk of injury to the females during mating.

Nursery Systems

Weaning is a critical time for piglets because they are developing their immune system and are adjusting to dietary and environmental changes. Typically, pigs stay in a nursery from weaning until they are 8-12 weeks old.

A warm, dry and draft-free environment and proper nutrition should be provided at this stage. A 4-week-old piglet requires an environmental temperature of at least 80°F (Table 2). Most nurseries in the northern part of the U.S. need to be equipped with supplemental heating. Pigs in nursery houses should be protected from drafts and air speeds over 50 feet per minute. Thermometers that record the highest and lowest temperature in a nursery are useful to help reduce temperature fluctuations. Thermometers should be placed at pig level. Weaned pigs exposed to the outdoors should be provided with shelter.

A major challenge with recently weaned pigs is to understand their feeding behavior, particularly if pigs are weaned at young ages such as 5-18 days old. At this age pigs still exhibit the behavior used during lactation, which is that all pigs go to the feeder and try to eat at the same time. Comfort mats or feeding boards may be used for the first week after weaning.

A very important consideration at weaning is to decide if pigs should be grouped by litter or by weight. It is generally accepted that pigs should be grouped by weight and sex, allowing a faster switch to a grain-based diet. It has been indicated that as long as stress is minimal, mixing pigs at weaning has little effect on growth performance. Moving an intact group of pigs to the finisher is not considered remixing; therefore, when planning a production unit, it is prudent to house the same number of pigs in the nursery and in the finisher.

A typical nursery pen in environmentally controlled housing contains about 10 to 20 pigs but larger groups sizes may be acceptable. Floor area recommendations are given in Table 3. Slatted floors allow pigs to be clean and dry and can be made of material similar to those in farrowing areas. If partially slatted floors are used, the waterers should be over the slatted portions. All pigs need free access to clean water, with waterers properly adjusted according to animal size. Water intake is critical in the recently weaned pig because dehydration can easily occur in piglets.

Growing and Finishing Systems

Growing and Finishing Facilities

Growing and finishing pigs are those from about 50 lbs. to market weights. These older pigs can tolerate a wider range of environmental conditions (Table 2).

There are a variety of housing and system types that can be appropriate for raising pigs. Generally, in cold climates environmentally controlled facilities are required and managing during cold weather conditions is the greatest challenge. In more southern climates, outdoor systems are practical for some production stages, and managing heat stress is the greatest challenge.

All facilities should be thoroughly cleaned and disinfected before stocking. Penning materials should be sturdier than those used in nurseries. Space recommendations are presented in Tables 3, 4 and 5. Overcrowding of pigs lessens their opportunity to eat, drink and rest. Aggressive behavior may be more frequent in crowded facilities. Large group sizes may require less space per pig. (McGlone and Newby, 1994).

Although many flooring materials or bedding are acceptable, total or partially slatted floors are suitable for finishing pigs. Attention should be paid when floors are initially laid. Concrete composition and workmanship in solid and slat concrete floors are important because rough, abrasive surfaces may cause foot and leg damage and are difficult to clean. Concrete slats 4 to 8 inches wide with spacing of about 1 inch between slats, are recommended. The edges of the slats should be designed to minimize foot and hoof injuries; sharp edges should be avoided.

Growing and Finishing Pig Flow

Producers generally find it advantageous to operate this stage of production as all-in/all-out production with cleaning and disinfection of facilities between groups of pigs. Mixing and regrouping of different pigs should be avoided as much as possible due to increase an in fighting and decrease in production gains that follows such practices (Stookey and Gonyou, 1994; Tan *et al.*, 1991).

Farrow to Finish Conventional "farrow-to-finish" is used in all climates. These can be two or three-stage systems, meaning farrowing with wean-to-finish for slaughter pigs versus farrowing, nursery, and then finishing for slaughter pigs. The two-stage system benefits pigs by requiring less moving, while the three-stage system offers the counter benefit of matching the environmental needs of the pigs more effectively just after weaning and when pigs are nearing finishing.

Multi-site Multi-site production, where pigs are typically housed in two or three different locations, is an alternative to one-site farrow-to-finish systems. The breeding-gestation complex is in an isolated location. Farrowing may be at the breeding-gestation site or there may be a separate farrowing or farrowing-nursery site. A wean-to-finish or finish site is then commonly used to grow the slaughter pigs to market weight. Multi-site production offers advantages for disease prevention and disease control, and has disadvantages in that pigs must be transported between sites.

Wean-to-Finish This system implies the weaning of pigs into a finisher building. The building essentially works as a nursery for the first few weeks after the pigs are placed in the unit (see Nursery Systems, page 11). The main advantage of this system is that it decreases labor demands from the point of view of pig movement, cleanup and disinfection between groups. There is an enhanced pig performance because there is one less movement and one less group sorting. Another very important advantage is that it reduces transportation effects.

To accommodate this production system, the finishing building is typically modified in the following ways:

- Sealing the building
- Covering parts of the slatted floor
- Offering zone or supplemental heating
- Offering more water sources

Bibliography

Algers, B., and P. Jensen. 1991. Teat stimulation and milk production during early lactation in sows: effects of continuous noise. Can. J. Anim. Sci. 71:51-60.

Almond, G. W. 1995. How much water do pigs need? Proc. North Carolina Healthy Hogs Seminar. North Carolina State Univ., Raleigh NC.

Arey, D. S., and E. S. Sancha. 1996. Behavior and productivity of sows and piglets in a family system and in farrowing crates. Appl. Anim. Behav. Sci. 50:135-145.

Backus, G. B. C., I. S. Bokma, T. A. Gommers, R. De Koning, P. F. M. M. Roelofs, and H. M. Vermeer. 1991. Farm systems with cubicles, tethered sows and group-housing. Report P1.61, pp 1-7. Research Institute for Pig Husbandry, Rosmalen, The Netherlands.

Barnett, J. L., P. H. Hemsworth, G. M. Cronin, E. A. Newman, and T. H. McCallum. 1991. Effects of design of individual cage-stalls on the behavioural and physiological responses related to the welfare of pregnant pigs. Appl. Anim. Behav. Sci. 32:23-33.

Barnett, J. L., P. H. Hemsworth, E. A. Newman, T. H. McCallum, and C. G. Winfield. 1989. The effect of design of tether and stall housing on some behavioural and physiological responses related to the welfare of pregnant pigs. Appl. Anim. Behav. Sci. 24:1-12.

Barnett, J. L., P. H. Hemsworth, and C. G. Winfield. 1987. The effects of design of individual stalls on the social behaviour and physiological responses related to the welfare of pregnant pigs. Appl. Anim. Behav. Sci. 18:133-142.

Barnett, J. L., C. G. Winfield, G. M. Cronin, P. M. Hemsworth, and A. M. Dewar. 1985. The effect of individual and group housing on behaviour and physiological responses related to the welfare of pregnant pigs. Appl. Anim. Behav. Sci. 14:149-161.

Barnett, J. L., G. M. Cronin, P. H. Hemsworth, and G. C. G. Winfield. 1984a. The welfare of confined sows: Physiological, behavioural and production responses to contrasting housing systems and handler attitudes. Ann. Rech. Vet. 15:217-226.

Barnett, J. L., G. M. Cronin, C. G. Windfield, and A. M. Dewar. 1984b. The welfare of adult pigs: The effects of five housing treatments on behaviour, plasma corticosteroids and injuries. Appl. Anim. Behav. Sci. 12:209-232.

Becker, B. A., J. J. Ford, R. K. Christenson, R. C. Manak, G. L. Hahn, and J. A. DeShazer. 1985. Cortisol response of gilts in tether stalls. J. Anim. Sci. 60:264-270.

Coleman, G.J., P. H. Hemsworth, M. Hay, and M. Cox. 2000. Modifying stockperson attitudes and behaviour towards pigs at a large commercial farm. Appl. Anim. Behav. Sci. 66:1-20.

Connor, M. L. 1993. Recommended code of practice for the care and handling of farm animals-pigs. Agric. Can. Ottawa.

Den Hartog, L. A., G. B. C. Backus, and H. M. Vermeer. 1993. Evaluation of housing systems for sows. J. Anim. Sci. 71:1339-1334.

DeShazer, J. A., and D.G. Overhults.1982. Energy demand in livestock production. Proc. 2nd Int. Livest. Environ. Symp. Am. Soc. Agric., pp 17-27.

Ewing, S. A., D. C. Lay, and E. von Borell. 1999. Farm animal well being: stress physiology, animal behaviour and environmental design. Prentice Hall Inc., NJ.

Fritschen, R. D., and A.J. Muehling. 1987. Space requirements for swine. PIH-55, Pork Industry Handbook. Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Grandin, T. 2000a. 1999. Audits of stunning and handling in Federally inspected beef and pork plants. Paper presented at American meat institute conference on animal handling and stunning. February 8-9, 2000, Westin Crown Center, Kansas City.

Grandin, T. 2000b. Improving animal movement. Internet site, http://grandin.com/

Grandin, T. 2000c. Behaviour of cattle, pigs, buffalo and antelope during handling and transport. Internet site. http://grandin.com/behaviour/transport.html

Grandin, T. 1988. Livestock trucking guide. Livest. Con. Inst. Madison, WI.

Grandin, T., K. Ernst, D. Ernst, and J. J. McGlone. 1989. Handling hogs. PIH-116, Pork industry handbook. Cooperative Extension Service, Purdue University, West Lafayette, IN.

Hahn, G. L. 1985. Managing and housing of farm animals in hot environments. In M.K. Yousef, ed. Stress Physiology in Livestock Vol. II: Ungulates. pp 151-174. CRC Press, Boca Raton, FL.

Hansen, L. L., and K. Vestergaard. 1984. Tethered versus loose sows: ethological observations and measures of productivity: I. Ethological observations during pregnancy and farrowing. Ann. Rech. Vet. 15:245-256.

Hemsworth, P. H., V. Pederson, M. Cox, G. M. Cronin, and G. J. Coleman. 1999. A note on the relationship between the behavioural response of lactating sows to humans and the survival of their piglets. Appl. Anim. Behav. Sci. 65:43-52.

Higgins, M., and S. A. Edwards. 1997. The effects on welfare and production using individual or group paddocks for farrowing sows and litters in an outdoor system. Eur. Assoc. Anim. Prod. Publication No 89, 273-276.

Honeyman, M. S., W. B. Roush, and A. D. Penner. 1998a. Pig crushing by hut type in outdoor farrowing. Iowa State Univ., Ext. pp 16-17.

Honeyman, M. S., W. B. Roush, and A. D. Penner. 1998b. Effect of outdoor farrowing hut size on piglet mortality. Iowa State Univ., Ext. pp 18-19.

Janssens, C. J. J. G., F. A. Helmond, and V. M. Wiegant. 1995a. Chronic stress and pituitary - adrenocortical responses to corticotropin-releasing hormone and vasopressin in female pigs. Eur. J. Endocrinol. 132:479-486.

Janssens, C. J. J. G., F. A. Helmond, and V. M. Wiegant. 1995b. The effect of chronic stress on plasma cortisol concentrations in cyclic female pigs depend on the time of day. Domest. Anim. Endocrinol. 12:167-177.

Johnson, A. K., J. L. Morrow-Tesch, and J. J. McGlone. 2001. Behavior and performance of lactating sows and piglets reared indoors or outdoors. J. Anim. Sci. 79:2571-2579.

Lambooij, E., G. Van Putten, and T. Grandin. 1993. Transport of pigs. In: Livestock handling and transport. T. Grandin, ed. pp 213-231. CAB Int., Wallingford.

Levis, D. G., D. R. Zimmerman, A. Hogg, D. E. Reece, M. C. Brumm, and W. T. Ahlschwede. 1989. Swine reproductive management. EC89-212, Coop. Ext. Serv., Univ. Nebraska, Lincoln, NE.

Lynch, P. B., J. F. O'Grady, and P. A. Kearney. 1984. Effect of housing system on sow productivity. Ann. Rech. Vet. 15:181-184.

McGlone, J. J., and T. A. Hicks. 2000. Farrowing hut design and sow genotype (Camborough 15 vs. 25% Meishan) effects on outdoor sow and litter productivity. J. Anim. Sci. 78:2832-2835.

McGlone, J. J. and B. E. Newby. 1994. Space requirements for finishing pigs in confinement: behavior and performance whole group size and space vary. Appl. Anim. Behav. Sci. 39:331-338.

McGlone, J. J., and J. L. Morrow-Tesch. 1990. Productivity and behavior of sows in level vs. sloped farrowing pens and crates. J. Anim. Sci. 68:82-87.

McGlone, J.J., and F. Blecha. 1987. An examination of the behavioral, immunological and reproductive traits in four management systems for sows and piglets. Appl. Anim. Behav. Sci. 18:269-286.

McGlone, J.J., and J. L. Morrow-Tesch. 1987. Productivity and behavior of sows in level vs. sloped farrowing pens and crates. J. Anim. Sci. 68:82-87.

McGlone, J. J., J. L. Salak-Johnson, R. I. Nicholson, and T. Hicks. 1994. Evaluation of crates and girth tethers for sows: Reproductive performance, immunity, behavior and ergonomic measures. Appl. Anim. Behav. Sci. 39:297-311.

McGlone, J.J., J.L. Salak, E. A. Lumpkin, R. I. Nicholson, M. Gibson, and R. L. Norman. 1993. Shipping stress and social status effects on pig performance, plasma cortisol, natural killer cell activity, and leukocyte numbers J. Anim. Sci. 71:888-896.

McGlone, J. J., R. I. Nicholson, and D. N. Herzog. 1991. Development of pain-induced changes in pigs subjected to castration at 1, 5, 10, 15 and 20 days of age. Texas Tech. Univ. Anim. Sci. Res. Rep. T-5-297.

Midwest Plan Service (MWPS). 1983. Swine housing and equipment handbook. 4th ed. Midwest Plan Serv, Iowa State Univ., Ames, IA.

Murray, A. C. 2000. Reducing losses from farm gate to packer. Advances in Pork Production. 11:175-180.

Pedersen, V., J. L. Barnett, P. H. Hemsworth, E. A. Newman, and B. Schirmer. 1998. The effect of handling on behavioural and physiological responses to housing in tether-stalls among pregnant pigs. Anim. Welf. 7:137-150.

Penny, R. H. C., and H. J. Guise. 2000. Effects of welfare on methods of production and the economics of the UK pig industry. Pig J. 45:20-38.

Phillips, P. A., and D. Fraser. 2001. Sow and litter performance in farrowing pens and crates. 6th Livestock Environ. Symp. May 21-24, 2001. Louisville, KY. pp 203-210.

Ravel, A., S. D'Allaire, M. Bigras-Poulin, and R. Ward. 1996a. Psychodemographic profile of stockpeople working on independent and integrated swine breeding farms in Quebec. Can. J. Vet. Res. 60: 241-248.

Ravel, A., S. D'Allaire, M. and Bigras-Poulin. 1996b. Survey of management and housing in farrowing quarters among independent and integrated swine farms in Quebec. Can. J. Vet. Res. 60:21-28.

Seabrook, M. F. 1991. The influence of the personality of the stockperson on the behaviour of pigs. Applied Animal Behaviour Science 30:187-188.

Stevermer, E. J. 1991. 1990 Swine enterprise record. ASB: EJS-185. Iowa State Univ., Ames, IA.

Stookey, J. M., and H. W. Gonyou. 1994. The effects of regrouping on behavioral and production parameters in finishing swine. J. Anim. Sci. 72:2804-2811.

Tan, S. S. L., D. M. Shackleton, and R.M. Beames. 1991. The effect of mixing unfamiliar individuals on the growth and production of finishing pigs. Anim. Prod. 52:201-206.

Warris, P. D. 1998. The welfare of slaughter pigs during transport. Anim. Welf. 7:365-381.

Whittemore, C. 1998. The science and practice of pig production. pp 356-367. Blackwell Science Ltd., Oxford.

Chapter 2: ENVIRONMENTAL MANAGEMENT

Environmental consideration in pork production operations must include the welfare of the pigs and the protection of air and water quality. Consideration must also be given to the work environment of the producer. Proper design and management of production facilities should provide the appropriate environment for raising pigs and also should protect the natural environment. Management practices to ensure environmental quality for all types of production systems need to be implemented.

The range of temperatures best suited for pigs varies (Table 2), depending upon the age and size of the animal, with larger pigs generally tolerating extremes in temperature better than small pigs (NRC, 1981). The temperature must be measured at pig level, as that may differ several degrees from that at higher levels.

Temperature level is important because it interacts with all other factors, except possibly light and sound, to determine the comfort level of the pigs. The thermal comfort zone (Table 2) is close to body temperature for newborn pigs, and it generally declines with age. However, it increases sharply at weaning because of reduced body heat production associated with reduced feed intake. Table 2 shows that the acceptable range of temperature depends upon the size of the animal (NRC, 1981).

Thermal Control

The temperature below which an animal must expend additional energy to maintain normal bodily temperature and function varies. The most important factors responsible for these variations include group size; nutritional status; air movement; solar radiation; type, temperature and wetness of the floor; and age and breed of the animal (Charles, 1994; Ewing *et al.*, 1999). Insulation of walls and roofs, and provision of adequate bedding will prevent excessive heat loss or gain from the body of the animals. Floor condition and type are also important. Preferred temperatures increase when floors are wet or when animals are housed on floors with high thermal conductivity such as concrete (NRC, 1981). Cooling methods such as a wallowing facility, direct water drip, evaporative pad, mist cooling, or direct air currents on the snout, should be used in very hot weather. Materials like straw help in providing thermal and physical comfort in cool conditions.

The preferred effective temperatures for pigs are within the ranges noted in Table 2. However, the actual effective temperature may be temporarily cooler or warmer than the preferred temperature without compromising the pigs' overall well-being.

The thermal environment that pigs actually experience (that is, effective environmental temperature) represents the combined effects of air temperature, air speed, humidity, surrounding surface temperatures and insulating effects of the surroundings. Also to be considered are the pigs' age, sex, weight, adaptation status, activity level, posture, stage of production, body condition, ability to huddle and dietary regimen.

In outside lots or pastures, trees or other natural objects, if available, can provide adequate shade. Facilities to provide shade can be constructed to also serve as protection from wind and cold during winter. Shades with open sides allow for air movement during warm weather. During cold weather, solid sides and bedding can be added for additional protection. A windbreak may be needed under certain environmental conditions.

Ventilation Requirements

Ventilation typically is the primary means of maintaining the desired air temperature, humidity, velocity and air quality in pigs housed in buildings. Ventilation helps maintain air quality in an enclosed animal facility. Because the pigs are the major source of water vapor, heat and odors, ventilation rate is more accurate when it is determined on the basis of pig weight and numbers than on air-exchange rate guidelines. Adequate ventilation is a major consideration in preventing respiratory and other diseases.

Pigs prefer a moderately high level of humidity rather than a dry environment, as the humidity helps to keep their respiratory system healthy (Bogner, 1982). Relative humidity is easily determined and is ordinarily the measure considered when managing the air moisture content.

The amount of ventilation depends on the size, number, type, age, dietary regimen of the pigs, the manure management system and atmospheric conditions. Equipment and husbandry practices that affect heat and water vapor loads inside the animal house should also be considered in designing and operating the ventilation system.

During hot, warm or cool weather, ventilation should keep the pigs comfortable to the extent possible.

During cold weather, ventilation in houses for newborn piglets should control humidity and air quality without chilling the piglets. The air speed past very young piglets should be less than 25 feet per minute.

Cold weather ventilation rates in an enclosed building should be regulated to keep the relative humidity between a high of 80% and a low of 40%, unless air quality or condensation control requires a higher rate (Hinckle and Stombaugh, 1983).

Ventilation rates in enclosed facilities should increase from a cold season minimum to a hot season maximum. The maximum, usually around 10 times the minimum rate, limits the rise in temperature from solar radiation and animal heat production inside the house. The ventilation rate should be high enough to keep the temperature from exceeding that of outdoors by more than 3°F to 5°F on an average daily basis when the atmospheric temperature is above 90°F. Recognizing the need for a 10-fold increase in summer ventilation rate is important.

Ventilation Systems

In animal houses, both environmental temperature and air quality depend on running the ventilation system without interruption. An automatic warning system may be used to open a building or alert animal care and security personnel of power failures.

Recirculating fans can keep the air moving during hot weather if there is too little air movement. Heat stress can also be reduced by sprinkling or dripping water directly and intermittently on the animals. Misters and evaporative coolers reduce air dry-bulb temperature and are also used to reduce heat stress.

Three basic strategies for environmental modification exist and relate to the method that fresh air is introduced. Natural ventilation uses wind and heat energy from animals to ventilate and provide fresh air for pigs. Mechanical ventilation uses fans and planned inlets to provide the required ventilation air. A third strategy called hybrid ventilation, combines features common to both natural and mechanical ventilation.

Natural Ventilation

Wind combined with properly planned vents can provide adequate fresh air to pigs. During cold periods, wind-driven ventilation rates are usually too high. During these periods, openings at the ridge and sides of a building are generally all that is required to deliver the proper amount of fresh air to the barn. For cold weather, fresh air ventilation is driven by rising, heated air from inside the barn escaping at the ridge and being replaced with outside, colder air entering at the building sides. This effect is the same as a fireplace and chimney. Controlling natural ventilation can be challenging. Manually controlling vents will result in moderate control of temperature and humidity. Automatic curtains or vent panels, insulated ceilings and circulating fans help to regulate and enhance natural ventilation systems.

Mechanical Ventilation

Mechanical ventilation provides more protection of the pigs from extreme fluctuations in outdoor climate. Fans combined with planned inlets provide the required fresh air delivery to the barn. Very good control of the climate can be achieved with mechanical ventilation and is especially suited to younger pigs.

Tunnel ventilation systems work on the principle that air is drawn from one end of a building through relatively large openings and at lower velocities than for inlet systems, and is pulled through the room to exhaust fans on the other side. Tunnel systems work best with larger pigs where higher air velocities over pigs in hot weather are desired and where evaporative pads may be used to cool the air before entering the room.

Hybrid Ventilation

Many environmental modification systems combine features common to both natural and mechanical ventilation. Generally, mechanical ventilation is used during cold weather periods and hot, calm periods. During mild and warmer periods with sufficient winds, natural ventilation is used.

Air Quality

Air quality refers to the effects that the air has on the health and well-being of animals. The quality is typically defined in terms of the airs content of certain gases, particulates and liquid aerosols, including those carrying microbes. Gases, dusts and microorganisms can be produced from the animals and from manure decomposition, feeds and building materials that are generally present in and around animals. Undesirable gases and dust in the air must be controlled so that they do not create air quality problems in or around buildings.

The gases of most concern in swine facilities are ammonia, hydrogen sulfide, carbon monoxide and methane (Curtis, 1986). Definitive standards for air quality have not been established for swine. It has been shown that production measures decrease at ammonia levels greater than 50 ppm (Drummond *et al.*, 1980; Drummond 1981a; Drummond 1981b).

A systems approach is most appropriate for achieving adequate air quality in buildings. Acceptable air quality can usually be achieved with proper ventilation and air distribution, regular cleaning and sanitation, feed dust control and manure gas control. Special attention to air quality should be given during periods of weather extremes, rapidly fluctuating temperatures and manure removal. Ventilation rates need to be increased when emptying under floor manure pits because the hydrogen sulfide and methane that may be released can be potentially lethal. If pits must be entered, a separate air supply for the worker should be used.

The concentration of airborne dust is affected by many factors, including relative humidity, animal activity, air velocity, type of feed and method of handling feed. Increased animal activity and high air velocities stir up particles and tend to keep them suspended in air. Microbes and pollutant gases may become attached to airborne particles. Dust levels can be reduced by utilizing combinations of approaches including adding fat or oil to the feed, proper pelleting and feeder adjustments, minimizing feed drop distances and open conveying, wetting feed, decreasing pig activity and frequent cleaning of building and equipment surfaces. Pigs can tolerate levels of inert dust higher than humans with no noticeable effect on their health or well-being (Curtis and Drummond, 1982).

Concentrations of microbes in the air should be minimized, in part through the control of dust, humidity and ventilation rate. Animals infected with highly contagious diseases should be segregated, and the ventilation system should be set to prevent the mixing of air from their environment with that of healthy swine.

The relative air pressure between animal and service areas of a building should be considered when the ventilation system is designed to reduce airborne transmission of disease agents or air pollutants. A qualified agricultural engineer or other specialist can give advice about the design and operation of ventilation equipment.

Noise

Noise from animals and animal care activities is unavoidable in any swine facility. Ordinarily, this noise has little permanent effect on the performance of agricultural animals (Bond, 1970; NRC, 1970). Producers should avoid startling pigs with sudden noises. The noise level of machinery and equipment should be minimized.

Lighting

Lighting should give enough illumination to permit practicing good husbandry, inspecting the pigs adequately, maintaining their well-being and working safely. Recommended levels are 20 foot-candles for special inspection areas; 15 foot-candles for breeding, gestation and farrowing areas; 10 foot-candles for nurseries; and 5 foot-candles for growing and finishing areas (MWPS, 1983).

Compared with some species, the domestic pig is less sensitive to its photic environment. In the wild, swine depend less on vision than on other sensory systems (Kilgour, 1985). When able to control the photoperiod for themselves, pigs prefer some light and some dark every hour of the day and night (Baldwin and Meese, 1977). Their apparent preference for a light-dark cycle is not similar to any natural situation. No particular daily photoperiod is necessary for growing pigs.

Manure Management and Sanitation

Pigs should be kept reasonably clean in comfortable, healthful surroundings. Pig dunging and resting preferences should be considered during the design phase as well as during the day-to-day operation of all swine facilities. Producers should know and apply principles of good sanitation. Building interiors, corridors, storage space, anterooms and other areas should be cleaned. Manure should be removed at intervals specified by Midwest Plan Service (MWPS).

A complete manure management system for swine facilities should accomplish the following:

- Maintain acceptable levels of health and production through clean facilities
- Ensure proper management of water, soil and air resources to protect surface and ground water
- Minimize odors, dust, vermin and parasites
- Develop nutrient management plans specific for their type of operation designed to comply with local, state and federal laws and regulations

Bibliography

Almond, G. W. 1995. How much water do pigs need? Proc. North Carolina Healthy Hogs Seminar. North Carolina State Univ. Raleigh NC.

Baldwin, B. A., and G. B. Meese. 1977. Sensory reinforcement and illumination preference in the domesticated pig. Anim. Behav. 25:497-507.

Bogner, H. 1982. Ethological demands in the keeping of pigs. Appl. Anim. Ethol. 8:301-305.

Bond, J. 1970. Effects of noise on the physiology and behavior of farm-raised animals. In Physiological Effects of Noise. B.L. Welch and A. S. Welch, ed. pp 295-306. Plenum Press, New York, NY.

Charles, D. R. 1994. Comparative climatic requirements. In Livestock housing. C. M. Wathes and D. R. Charles (ed.). pp 3-24. CAB Int., Wallingford.

Curtis, S. E. 1986. Toxic gases. In Current veterinary therapy: Food animal practice 2. J. L. Howard, ed. pp 456-457. W. B. Saunders, Philadelphia, PA.

Curtis, S. E., and J. G. Drummond. 1982. Air environment and animal performance. In Handbook of agricultural productivity, Vol II: Animal Productivity. M. Rechecigl, ed. Pp 107-118 CRC press, Boca Raton, FL.

DeShazer, J. A., and D. G. Overhults. 1982. Energy demand in livestock production. In Livestock environment, Proc. 2nd Int. Livest. Environ. Symp. Am. Soc. Agric. pp 17-27, St. Joseph, MI.

Drummond, J. G. 1981a. Effects of atmospheric ammonia on young pigs experimentally infected with Ascaris Suum. Am. J. Anim. Sci. 42:969-974.

Drummond, J. G. 1981b. Effects of atmospheric ammonia on young pigs infected with Bordetella Bronchiseptica. Am. J. Anim. Sci. 42:963-968.

Drummond, J. G., S. E. Curtis, J. Simon, and H. W. Norton. 1980. Effects of aerial ammonia on growth and health of young pigs. J. Anim. Sci. 50:1085-1091.

Ewing, S. A., D. C. Lay, and E. von Borell. 1999. Farm animal well being: stress physiology, animal behaviour and environmental design. Prentice Hall Inc., NJ.

Fritschen, R. D., and A. J. Muehling. 1987. Space Requirements for Swine. PIH-55, Pork Industry Handbook. Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Hahn, G. L. 1985. Managing and housing of farm animals in hot environments. In Stress Physiology in Livestock, Vol. II: Ungulates. M. K. Yousef, ed. pp 151-174 CRC Press, Boca Raton, FL.

Hinckle, C.N., and D. P. Strombaugh. 1983. Quantity of air flow for livestock ventilation. In Ventilation of agricultural structures. M. A. Hellickson and J.N. Walker, ed. Pp 169-191 Am. Soc. Agric. Eng., St. Joseph, MI.

Kilgour, R. 1985. Management of behavior. In Ethology of farm animals. A. F. Fraser, ed. pp 445-458, Elsevier, New York, NY.

Midwest Plan Service (MWPS). 1983. Swine housing and equipment handbook. 4th ed. Midwest Plan Serv, Iowa State Univ., Ames, IA.

National Research Council. (NRC). 1981. Effects of environment on nutrient requirements of domestic animals. Natl.. Acad. Press, Washington, DC.

National Research Council. (NRC). 1970. An annotated bibliography on animal response to sonic booms and other loud sounds. Natl. Acad. Sci., Washington, DC.

Chapter 3: FACILITIES AND EQUIPMENT

Good animal care depends on the quality of the facility and the management skills of the workers. Its efficiency, economy and smooth functioning are influenced greatly by the design, maintenance and operation of the structure and its equipment. Swine facilities should conform to applicable building codes unless deviations and variances are justified and approved (Muehling *et al.*, 1989). Management and quality of facilities in each system will determine the pigs' comfort. Every type of housing system must provide conditions that are conducive to comfort, good health, growth and performance at all stages of the pig's life.

Materials

Specifications for functional and economical building materials should allow for conditions that are common to various parts of the facility. Quality construction materials will make the building last longer and will limit the investment in repairs (Meyer *et al.*, 1989). Design of facilities should consider the following:

- Animal behavior that may lead to structural damage
- Absence of "stray voltage"
- Control of vermin, rodents and pests
- Manure handling
- Ease of cleaning and sanitizing surfaces
- Lighting
- Moisture and fire resistance
- Protection and safety of personnel
- Contact time with wet and corrosive pig wastes and with cleaning solutions

Building materials should be selected to aid in the efficient and hygienic operation of agricultural animal facilities. Durable, moisture-resistant, flame-spread-resistant materials are most desirable for interior surfaces. Paints, glazes and wood preservatives should be nontoxic, free of lead, and where applicable, resistant to the effects of cleaning agents, scrubbing and high-pressure sprays and impacts. All materials used to which the pigs have access should not contain any chemicals that are harmful to the pig or that may contaminate the meat products. Attention should be paid to the following components:

- Concrete. Concrete should be properly placed and cured to achieve specified strength. The concrete finish should be appropriate for intended use.
- Walls. Due to the relatively warm conditions within some buildings, these walls should be well-insulated and vapor barriers should be used (Meyer *et al.*, 1990).
- Attic. In buildings where ventilation air is not taken from the attic, provide ridge and eave openings. In buildings drawing air from the attic, provide at least one square foot of opening per 400 cfm of ventilation air traveling through the attic space.
- Roof Structure. Trusses should be designed for a roof load that meets local codes and requirements for live loads and dead loads. Truss designs should have a professional engineering seal.
- Interior Surfaces. Materials used on the inside of the building should be selected for their durability and cleanability.
- Electrical. Electrical wiring should meet all applicable codes. Heaters connected to electrical outlet boxes using cords provides a place for corrosion to take place. Permanent heat sources should be hardwired to electricity but have a switch at the heater to interrupt the power during servicing. Temporary heat sources such as covered heat lamps are acceptable. Fans should follow the same recommendation.

Electrical codes for agricultural buildings should be followed closely to prevent stray voltage (Collins *et al.*, 1994; MWPS, 1992a).

Maintenance of Facilities

Physical facilities should be well-maintained and clean. To provide a safe environment for animals and people, on-farm personnel should inspect, repair and maintain facilities and equipment regularly (Johnson and Hall, 1991).

Building Layout

The building should be designed in a way to accommodate growth up to the target weight. The actual stocking density of a pen should be based on the maximum weight that pigs will attain while in the pen (Fritschen and Muehling, 1987). The minimum pen width used in a nursery should be 4 to 5 feet and 8 to 10 feet in finishing facilities to allow free movement of pigs in the pen (MWPS, 1983; MWPS, 1997a; MWPS, 1997b; Meyer *et al.*, 1991; MWPS, 2000). This is particularly of concern when choosing a feeder. Pens using circular feeders in the center of the pens must be wider in order to allow pigs to easily pass behind pigs eating around the circumference of the feeder. Fenceline feeders do not require pens to be as wide because there is only a single row of pigs eating and they take up less of the traffic space, allowing pigs to more easily pass behind them.

Functional Areas

Adequate space is required for the pigs to eat, drink, rest, sleep and move. In addition, there should be enough space for the staff and equipment to provide feed and water, manure removal, medical treatment and other husbandry procedures. Furthermore, provisions should be made for maintaining and repairing the equipment used in the many aspects of effective husbandry. Plans should also be made for delivering feed and water and for removing manure on a temporary basis when the regular equipment fails or is shut down for repair.

Some areas needed for swine care may be used only periodically for their designed function and, at other times, they may be part of a multipurpose area. Professional judgement should be used in designing appropriate functional areas or their substitutes. Operations generally require space for the following:

- Handling, sorting, weighing, loading and unloading pigs
- Breeding and/or semen collection (Hollis *et al.*, 1990; MWPS, 1999; MWPS, 2001, Singleton *et al.*, 1992)
- Veterinary examinations, treatment and supplies storage
- Quarantine or isolation of pigs
- Fenced, penned or enclosed areas with waterers and feeders
- Water supply for drinking, sanitation, fires and emergencies
- Electrical service including an emergency generator and alarm system
- Feed storage between deliveries
- Storage for excreta and contaminated drainage water (MWPS, 1985)
- Storage of equipment used to handle feed and waste
- Storage of small tools for maintaining and repairing equipment
- Bedding storage, which excludes wild animals which can spread disease
- Facilities for timely disposal of swine carcasses through rendering, incineration, composting or burial (Murphy *et al.*, 1995)

Additional areas may be needed for an office, restroom, showers and lockers. A lunchroom, animal or equipment cleaning, feed processing, hazardous waste storage, supplies receiving and shipping and vehicle parking may also be needed.

Corridors and Doors

Corridors need to be wide enough so that animals, personnel and equipment can move around easily. Doors will vary in size according to the function they serve. In an enclosed facility, they should fit tightly within their frames and both doors and frames should restrict the entrance or harboring of vermin.

Floors

Dirt floors are acceptable in sunshades, open ("run-in") sheds, pens or shelters where climate, animal use and management intensity allow the base

support to be firm, relatively dry and easily cleaned. Surfaced floors in barns need to be relatively slip-resistant, not too abrasive to pigs' feet, and resistant to wear, corrosion, moisture and manure (Harmon and Muehling, 1994). Solid floors should slope to promote drainage. Manure-handling systems are considered to be a part of the floor design. Floor openings and gutters should be sized and spaced to prevent hoof or leg injury of pigs. Slatted floors and grates are useful for separating pigs from their excreta. Floors can be concrete, steel or plastic. Concrete is usually preferred for larger pigs, but smaller pigs are normally housed on steel or plastic flooring.

An appropriate concrete finish should be provided for animal areas. Skid-resistant grooves are needed for ramps that slope more than 5% to 15% for concrete breeding floors and for other floors to prevent slipping and falling.

The finish of concrete floors on which pigs walk is critical. A wood float finish with a texture similar to coarse sandpaper is acceptable. Edges on slats should be rounded. Polished steel-troweled finishes are too slippery and are unacceptable.

Walls and Ceilings

Walls and ceilings enclose interior space for security and environmental modification but may be unnecessary or undesirable for some facilities sheltering larger swine and for some climate and weather conditions. The climatic conditions, type of housing and management practices determine the most suitable amount of insulation, moisture permeability and surface finish. Surfaces should be easy to clean and, where necessary, resistant to damage from animal contact and impact.

Feeders and Waterers

Feeders should provide adequate access to feed for each stage of production. The design of the feeder should take into account the eating stance and the size of the pigs using it. Special attention should be paid to the design of sow feeders. There should be adequate headroom for the sow to ensure sufficient consumption to meet nutritional requirements (MWPS 1992b, Stanislaw and Muehling, 1997).

Feeders should be able to be easily cleaned to prevent feed accumulation and spoilage. Feeders should be maintained so there are no rough edges to injure the pigs during feeding. For nurseries, consider the needs of the newly weaned pig and the largest pig which will be in the nursery. The feeder should meet the needs of both animals. Newly weaned pigs tend to eat at the same time. Use feeders that provide space for at least half of the newly weaned pigs to eat at any one time. Use tray dividers to prevent small pigs from getting into the feeder. Select feeders that can be easily removed so they may be washed. Pigs may be fed on boards on the floor the first few days after weaning.

Waterers should be positioned to ensure pigs have adequate access. Flow rates should be such that pigs can easily meet their water intake requirements. Various waterer options exist including many varieties of cups and nipple waters. Specific information about appropriate flow rates can be found in Table 1 and in Midwest Plan Service publications.

Environmental Modification Systems

Environmental modification systems may be as simple as a fenced pasture with no man-made shelter, or they may be much more complex. Whatever the system, it should be appropriate for the age of the pigs and to the local climate. In enclosed structures, the system should be capable of maintaining environmental conditions within an acceptable range (Table 2) (Hoff, 2000).

Level of Environmental Modification

Regardless of the ventilation system used, various levels of environmental modification are achievable, and these in turn depend on local climatic conditions. In cold weather, three basic levels of control can be achieved: cold, modified and warm housing. Proper design of each is critical if each is to provide an acceptable microenvironment. Housing of newborn piglets needs special consideration, particularly during cold periods.

Cold Housing. Cold housing systems modify the outdoor environment, protecting the swine from sun, wind, snow, rain and other hot and cold weather extremes. Cold houses usually provide a temperature that is no more than 10°F above the outdoor temperature. Strategically placed openings throughout the shelter should result in a ventilation rate that can control humidity and provide for adequate air exchange. For hot weather operation, the shelter acts as a sunshade; additional openings then facilitate natural air movement throughout the

animal space. Mechanical fans are seldom used (MWPS, 1989).

Modified Housing. Modified housing involves mostly natural ventilation systems with manual control of vents. Low levels of insulation are generally provided to prevent excessive condensation from forming and to conserve pig heat generated. Usually, some form of supplemental heating is used for both pig comfort and to prevent water lines from freezing (Harp and Huhnke, 1992; MWPS 1990a, Jones *et al.*, 1993).

Warm Housing. Warm housing involves mechanical ventilation with fans and controls, natural ventilation with automatically controlled openings, or combinations of the two. Insulation is needed on the walls, ceilings and perimeter in most climates to conserve heat and to prevent cold spots and condensation. Ventilation should be designed to provide acceptable air quality, humidity and temperatures suitable for the ages of the pigs (MWPS, 1990b; Murphy *et al.*, 1991, Jacobson *et al.*, 1995).

Controls and Sensors

Controllers

Controllers should be staged properly for effective use of heating, ventilating, and cooling equipment. Written instructions for operating and sequencing them should be given to all caretakers and should be readily available. Where the ventilation system depends on fans or power-controlled openings, a warning device is needed to alert the building operator of a power interruption. Back-up generators should be installed to maintain power to critical power-controlled devices.

Sensors

Sensors are used to regulate an environmental modification system. They should be placed where they can monitor conditions representative of the microenvironment. They should be maintained and calibrated regularly.

Bibliography

Collins, E. R, G. R. Bodman, and L. E. Stetson. 1994. Electrical wiring for swine buildings. PIH-110. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Fritschen, R. D., and A. J. Muehling. 1987. Space requirements for swine. PIH-55, Pork Industry Handbook. Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Harmon, J. D., and A. J. Muehling. 1994. Flooring for swine. PIH-53. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Harp, S. L., and R. L. Huhnke. 1992. Supplemental heat for swine. PIH-57. Fritschen, R.D., and A.J. Muehling. 1987. Space Requirements for Swine. PIH-55, Pork Industry Handbook. Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Hollis, G. R., L. B. Driggers, A. J. Muehling, and G. R. Carlisle. 1990. Confinement sow gestation and boar housing. PIH-28. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Hoff, S. J. 2000. The environment in swine housing. PIH-54. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Jacobson, L. D., S. Pohl, and W. G. Bickert. 1995. Troubleshooting swine ventilation systems. PIH-84. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Johnson, D., and M. Hall. 1991. Maintenance and operation of ventilation fans for hog barns. PIH-41. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Jones, D. D., L. B. Driggers, and R. L. Fehr. 1993. Cooling swine. PIH-87. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Meyer, V. M., L. B. Driggers, K. Ernest, and D. Ernest. 1991. Swine growing-finishing units. PIH-11. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Meyer, V. M., R. W. Hansen, B. Holmes, and D. Overhults. 1990. Insulation for swine housing. PIH-65. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Meyer, V. M, G. R. Bodman, and W. H. Friday. 1989. Building materials and equipment for swine facilities. PIH-32. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Midwest Plan Service. (MWPS). 2001. Swine breeding and gestation facilities handbook. MWPS-43. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 2000. Swine wean-to-finish buildings. AED-46. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1999. Hoop structures for gestating swine. AED-44. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1997a. Swine nursery facilities handbook. MWPS-41. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1997b. Hoop structures for grow-finish swine. AED-41. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1992a. Farm building wiring handbook. MWPS-28. 2nd ed. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service (MWPS). 1992b. Swine farrowing handbook. MWPS-40. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1990a. Heating, cooling and tempering air for livestock housing. MWPS-34. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service (MWPS). 1990b. Mechanical ventilating systems for livestock housing. MWPS-32. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1989. Natural ventilating systems for livestock housing. MWPS-32. Midwest Plan Serv., Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1985. Livestock waste facilities handbook. MWPS-18. Midwest Plan Serv. Iowa State Univ., Ames, IA.

Midwest Plan Service. (MWPS). 1983. Swine housing and equipment handbook. MWPS-18. 4th ed. Midwest Plan Serv, Iowa State Univ., Ames, IA.

Muehling, A. J., L. L. Christianson, G. L. Riskowski, L. E. Christenson, and N. F. Meador. 1989. Planning considerations for the construction of a new swine building. PIH-117. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Murphy, D. W., M. J. Estienne, C. N. Dobbins, and K. A. Foster. 1995. Disposing of dead swine. PIH-133. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Murphy, J. P., D. D. Jones, and L. L. Christianson. 1991. Mechanical ventilation of swine buildings. PIH-60. Pork Industry Handbook. Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Singleton, W., G. R. Bodman, and D. Levis. 1992. Individual mating facilities for swine. PIH-69. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Stanislaw, C. M, and A. J. Muehling. 1997. Swine farrowing units. PIH-10. Pork Industry Handbook, Coop. Ext. Serv., Purdue Univ., West Lafayette, IN.

Chapter 4: FEEDING AND NUTRITION

Sound feeding practices that provide for adequate nutrient needs are integral to the health and well-being of pigs in all stages of production. Swine are raised on a variety of feeds. Because of their simple monogastric stomach, pigs require more concentrates and less-fibrous feedstuffs than cattle, sheep or horses. Feed ingredients should be free from harmful molds, mycotoxins or impurities. If the presence of any of these substances or organisms is suspected, samples should be submitted for laboratory testing. Feed with unknown nutritional value and lacking in wholesomeness should not be used. Periodic laboratory analysis of the nutrient composition of ingredients and mixed diets should be performed.

Nutritional Needs

The diet should meet the nutritional needs of the pigs and fit the purpose for which it is being fed (i.e., maintenance, growth, reproduction or lactation). To meet nutritional needs, required nutrients must be supplied in amounts that cause neither deficiency nor toxicity. Examples of publications that list and discuss these nutrients are referenced in the bibliography section of this publication. The NRC (1998) publication, Nutrient Requirements of Swine. 10th rev. ed. Natl. Acad. Press, Washington, DC, is an excellent source of nutritional information. Palatability and digestibility of the feeds also must be considered. Nutritionists can provide specific information on the proper types of feed ingredients to include in diets based on availability, price and feeding value. Feeding pigs for optimal growth and production will also provide for their nutritional welfare. To provide a complete diet, the following nutrients and nutrient groups must be available to swine within balanced ranges:

Energy

Energy requirements are affected by factors such as age, weight, activity of the pigs, level of production and temperature of the environment. Common energy sources are grains (corn, sorghum, barley, wheat, etc.), fats and cereal or processing byproducts.

Protein and Amino Acids

Dietary protein is composed of amino acids. Several amino acids cannot be synthesized by the pig and are essential components of the diet. The amounts and ratios of amino acids, especially the essential amino acids, must be considered when formulating diets. Common sources of protein and amino acids include grains, soybean meal, canola meal and cereal or processing byproducts.

Essential Fatty Acids

Essential fatty acids (i.e., linoleic acid) are adequate in most practical swine diets. Besides serving essential biological functions, fats can serve as important energy sources for the pig.

Minerals

Pigs require many minerals for normal biologic function. Some minerals are present in adequate quantities in grain or other feed ingredients in the diets and others must be supplemented. Not only are minerals essential in the diet, but many of them also may be toxic in excess amounts.

Vitamins

Vitamins are required by the pig to support or stimulate the many chemical reactions that take place in its body as part of normal metabolism.

Water

Water should be of good quality, clean, cool enough to drink in the summer, protected from freezing during the winter, readily available and accessible.

Balanced Diets

Many different nutrients (i.e., 10 amino acids, 13 minerals and 14 vitamins) are essential to swine diets and important both in quantity and relative proportion. The level and bioavailability of these nutrients in feed ingredients also is variable. Producers may choose to purchase complete feed that has been prepared off the farm, may choose to formulate the diet on the farm using purchased ingredients, or may use both purchased and home-grown ingredients to make a complete diet (National Pork Board, 1996, Feed Purchasing Manual. NPB, Des Moines, IA). The complete diet can be provided in meal, pelleted, liquid or other forms.

Producers should be knowledgeable about symptoms of nutritional deficiencies or toxicities. Producers also should know the following information for their type of genetics and production facilities, because they can be signs that their pigs are receiving a nutritionally adequate feed supply:

- The normal weight for pigs of a given age, sex, genetics and productive stage
- Expected ages of puberty, length of estrus cycle, gestation length and litter size
- Expected rate of gain for growing and finishing pigs
- Expected average daily feed consumption and feed efficiencies for all stages of production

If needed, producers can get this information from their veterinarian, nutritionist or land-grant university extension service.

Feed Additives

Swine health products that are approved as feed additives should be used only as recommended by the manufacturer. Such products may help improve the health and well-being of pigs and, when used according to recommendations and regulations, will ensure a safe, wholesome product. These basic rules should be followed:

1. Label instructions must always be read and followed completely regarding level, length of use, weight of pigs and withdrawal intervals before marketing. It is unlawful to use medicated feed products in any manner other than that which is on the label.
2. If used to treat a disease condition, an accurate diagnosis by a veterinarian should be obtained prior to initiation of treatment.
3. Therapeutic medications may be more effective when they are used for the length of time needed to adequately treat the condition and then are removed from the diet.
4. Any product for which clear instructions are not available should not be used.

Feeding Practices

A variety of feeding systems are in use that are consistent with the health and welfare of pigs including feeding for ad libitum intake (feed always available) or timed feedings. Feed may be placed on a clean floor, in a trough or feed pan, in individual feeders or in a self-feeder. The feeding system should be designed to keep noise levels at a minimum for the comfort of both pigs and the producer. In all situations, adequate water should be available (Table 1).

Boars and Gestating Females

Excessive intake of high energy rations may cause excessive weight gain during gestation. Boars and gestating sows allowed access to free-choice feed would become obese. Restriction of feed intake is recommended and required for gestating sow and boar optimal health and welfare. Feeding gestating sows and boars measured amounts one or two times a day can meet nutritional requirements. If mature pigs are fed once a day, feeding during the hottest part of the day should be avoided. Feeding time should be the same each day. The amount of feed given will vary according to body condition (amount of backfat), weight and reproductive stage of the pigs. Adequate levels of nutrition for pregnant sows are needed to ensure normal development of the fetuses and proper maternal weight gain. Feeding space should be adequate in group-housed sows so that all have access to feed. Individual feeding stalls can reduce the competition for feed among group-housed sows.

Farrowing Sows

Before farrowing, feed intake should be limited. After farrowing, feeding two or more times per day is recommended. Feed intake should be maximized in a step-wise fashion adequately to minimize sow weight loss during lactation. Laxatives may be added to the diet or as a top-dress, when needed, to minimize constipation as sows advance in pregnancy, both before and after the sow farrows.

Litters

Some producers creep-feed piglets. If offered, creep feed should be placed in an area where the piglets will be protected from being crushed when the sow lies down.

Nursery Pigs

Weaned pigs should be fed a diet that meets the nutritional needs and is appropriate for their age and weight at weaning. Adequate feeder space and easy access to water is important, especially in the period immediately after weaning.

Growing and Finishing Pigs

For optimal growth rate, pigs should receive a complete and nutritionally balanced diet. The composition of the diet should take into account the stage of production, climatic conditions and level of productivity (rate of protein and fat accretion) of the pigs.

Bibliography

National Pork Board. (NPB) 1996. Feed purchasing manual. NPB, Des Moines, IA.

National Research Council. (NRC). 1998. Nutrient requirements of swine. 10th rev. ed. Natl. Acad. Press, Washington, DC.

Chapter 5: HERD HEALTH MANAGEMENT

Every production unit should have a comprehensive herd health program. Each herd will have a unique program based on the health challenges, facilities, location and finances of that production facility. Consultation with the herd veterinarian is essential for establishing appropriate guidelines for maintaining the health of the swine herd. Input from all farm employees is needed to optimize the successful development and implementation of a cost-effective program.

Pork Quality Assurance™

The Pork Quality Assurance™ (PQA) Program should be used as a basis for information and training about Good Production Practices for pork production. The PQA Program also contains information and forms that can be used in planning and a effective record-keeping system. Record keeping is an important means of monitoring a swine production unit for efficiency and profitability.

Understanding and implementing the PQA Ten Good Production Practices will help develop a herd health program on the farm that will be an important part of providing for the pigs' welfare. To adequately address the welfare of the animals, appropriate care includes availability and judicious use of a range of therapeutic medications at all stages of production. Animals should receive appropriate treatment even if marketing must be delayed or foregone due to withdrawal time as dictated by the product (NPB, 2001a).

On-Farm Disease Control

Health Monitoring, Vaccination and Treatment Protocols

All herds have certain bacteria and viruses that are endemic. Many of these organisms are controlled through proper management and vaccination schemes. Pathogens causing production losses may also be present on the farm. Producers should work with a veterinarian to design a program for monitoring the health status of the herd. Such a program might include routine herd health visits, evaluation of past results from the diagnostic laboratory, serological surveys of the herd, post-mortem examinations and/or slaughter checks.

Vaccination protocols should have sufficient detail so that if an employee is absent, another employee could use and follow the protocol with minimal assistance. Other animal health products that are administered on a regular basis, for example anthelminics, should also have a documented protocol.

The farm veterinarian should be contacted if pigs with symptoms of disease are noticed. Protocols may be written for routine treatments of diseases but the veterinarian should be informed immediately if sick pigs do not respond to treatment.

Biosecurity

Good management practices are essential to preventing entry of new diseases to the herd and spread of diseases among different production stages within the herd. Such practices form the herd's biosecurity program.

Rodent Control Construction and management techniques for rodent control will help to increase the life of the building and preserve insulation and wall integrity. They may include:

- Baiting. The three keys to effective control using rodent baits are: 10 installing fresh baits in the rodent's high activity areas as determined from the inspections and/or rodent signs (droppings, gnaw marks, etc); 2) placing out enough bait points to ensure the rodents readily encounter the baits during their nightly travels to gather food; and 3) matching the right bait formulation (e.g., pellets, vs. blocks, vs. packets, etc) to the specific area needing to be baited. A casual approach of putting out baits in corners of barns and buildings, or simply stuffing rodent bait packets down rat burrows will have little long term effect on rodent population reduction, regardless of the bait brand used. A guide to the use of the rodenticides and formulation is available from the National Pork Board (NPB).
- Holes and Openings. Mice can enter a building through an opening larger than 1/4 inch in diameter and rats through an opening larger than 1/2 inch. Holes should be closed with concrete, steel or heavy hardware cloth. The end of corrugated steel siding can be an entry point also. Angle flashing should be used to prevent rodents from entering through corrugations.
- Vent Openings. Vent openings into the animal room or attic should be covered to prevent rodents and birds from entering. Use 1/2 inch by 1/2 inch hardware cloth to cover ventilation openings. This may not exclude all rodents but will avoid restriction of airflow.
- Exterior Doors. Doors should fit snugly with cracks less than 1/4 inch. Doors should be made of steel or be trimmed with metal flashing to keep rodents from gnawing door edges. Door frames should also be steel or be flashed.
- Foundations. Due to the burrowing capabilities of rats, foundation walls should extend at least 36 inches below grade. Slab-on-grade construction is not a good practice for agricultural buildings, especially ones that hold livestock feed. Maintaining a clean, three-foot-wide weed-free area around buildings will discourage rodents from burrowing. Mowing and keeping any discarded materials cleaned up will also reduce rodent habitat.
- Interior Hiding Places. Avoid designing features that give mice and rats an easy place to hide. For instance, air plenums under the walkways may work well for ventilation but will give rodents a place to congregate.
- Dogs and Cats. Sometimes, rat terriers and cats are kept around swine facilities in attempts to help control rodents. Although dogs and cats will periodically kill a few rats and mice, they cannot control an already established infestation. At best, rodent-aggressive dogs and cats can be effective in preventing infestations from developing if they happen to quickly kill any new rodent immigrants that venture into an uninfested premises.
  But, cats and dogs pose an additional potential for disease transmission around swine facilities, and thus these animals are not encouraged. It is also common for flea infestations to develop around swine operations which house one or more cats. Fleas from cats multiply rapidly and will readily feed on employees, who may in turn, transport fleas to their own homes and companion animals (Corrigan, 2000).

Entering Genetic Material Into Herds Genetic material can be introduced into a herd by purchase of semen (Hutchings and Andrews, 1946; Johnson and Collings, 1971; Lucas *et al.*, 1974; Hsu *et al.*, 1984; Yaeger *et al.*, 1993; Christopher-Hennings 1995; Prieto *et al.*, 1994; Swenson *et al.*, 1994a; Swenson *et al.*, 1994b) or live breeding animals (Dee, 1997a; Dee, 1997b). Either method can result in introduction of disease unless certain biosecurity measures are carefully followed.

No method of introduction of genetic material precludes the possibility of transmission of disease from one herd to another. A major consideration when purchasing breeding stock is the health status of the source herd. To assess the health status of the source herd, communication between the buyer and seller and their respective veterinarians is necessary to determine the health history of the farm.

Isolation of Live Animals All live animals should be isolated for at least 30 days before being introduced to a herd. Directly introducing new purchases to the herd without isolation increases the risk of introducing new diseases. The duration of isolation should be determined with the help of the herd veterinarian. The isolation period provides time to observe any signs of disease in the

purchased pigs and stop their entry into the herd.

Acclimatization Following the isolation period, animals should be exposed in a controlled manner to diseases present on the farm. This exposure is important to build the immunity of these pigs to pathogens endemic in the farm's herd. Examples of exposure methods include vaccination and exposure to cull sows and gilts from the recipient herd.

Other Biosecurity Issues When contact with other pigs is minimized, the primary biosecurity risks to pigs include mechanical vectors such as birds (Farrington and Jorgenson, 1976; Pensaert *et al.*, 1981; Devriese *et al.*, 1994; Zimmerman *et al.*, 1997), rodents (Le Moine *et al.*, 1987), flies, (Tidwell *et al.*, 1972; Stewart *et al.*, 1975; Gough and Jorgenson, 1983; Enright *et al.*, 1987; Medvecky *et al.*, 1988) feed (Smith, 1960; Lee *et al.*, 1972; Harris *et al.*, 1997), people and vehicles. With the advice of the herd's veterinarian and other experts, protocols and procedures to minimize these risks can be developed. A "Biosecurity Guide for Pork Producers" (NPB, 2002) contains a checklist for key biosecurity practices and is available from the National Pork Board.

Euthanasia

Euthanasia is defined as a humane death occurring without pain or distress. Even with the best efforts in every swine production system, animals will become ill, injured, or disadvantaged in such a way that euthanasia may need to be considered.

When making decisions regarding ill, injured, or disadvantaged pigs, producers must consider pig welfare, economics, and public health. The herd veterinarian can often be called upon to assist in making the appropriate decision. The final decision for action usually falls into 4 broad categories:

1. Treatment - If an appropriate medical treatment is available, this may be a viable option.
2. Slaughter - If the animal is suitable for transport and human consumption, this may be a viable option.
3. Sell - This option may be appropriate in case of injured or disadvantaged pigs that may perform adequately in a different production setting.
4. Destruction - Humane euthanasia may be the best option for various pig welfare, economic, and public health reasons.

When destruction is the most viable option, the following must be considered when choosing the best method for humane euthanasia.

1. **Human safety** - The first responsibility is to ensure the safety of the person administering and everyone in the vicinity.
2. **Pig welfare** - The goal of euthanasia is to cause death quickly and painlessly. Methods must be reviewed by veterinarians and animal well-being experts to ensure that they are humane, when administered correctly.
3. **Practicality/technical skill needed** - Different methods require different abilities and equipment. Both must be adequate and available for a particular method to deliver humane euthanasia. If they are not, the safety of the person or the success of the method will be at risk.
4. **Cost** - The cost of the method depends on initial equipment costs, equipment maintenance and cost of labor. To encourage the use of humane euthanasia methods, the cost per procedure must be found, taking into account the other considerations.
5. **Aesthetics** - While, if properly applied, these methods are humane, there may be characteristics of each that make a particular method unpleasant for the administrator or an observer. This factor must be taken into account before method selection.
6. **Limitations** - Other factors such as size of pig, location and the availability of someone to help, must be considered to select a humane, safe method of euthanasia.

The National Pork Board and the American Association of Swine Veterinarians have published the booklet, "On Farm Euthanasia of Swine - Options for the Producer" (NPB, 2001b). It contains explanations and guidelines on humane methods of euthanasia for various sizes and production classes of pigs. It also contains a Euthanasia Action Plan for recording the farm's plan for humane euthanasia.

There can be nothing but zero tolerance for mistreatment of animals during euthanasia procedures.

Bibliography

Corrigan, R. M. 2000. An overview of rodent control for commercial pork production operations. National Pork Board. 2(6)

Dee, S. 1997a. An overview of production systems designed to prepare naïve replacement gilts for impending PRRS virus challenge: A global perspective. Swine Health Prod. 5(231):239 (Abstr.).

Dee, S. 1997b. Gilt development and PRRS: A model program for the U.S. swine industry. The Compendium 19, S228-S237.

Devriese, L. A., F. Haesebrouck, P. De Herdt, P. Dom, R. Ducatelle, M. Desmidt, S. Messier, and R. Higgins. 1994. Streptococcus suis infections in birds. Avian Path. 23:721-724.

Enright, M. R., T. J. L. Alexander, and F. A. Clifton-Hadley. 1987. Role of houseflies (Muscu domestica) in the epidemiology of Streptococcus suis type 2. Vet. Rec. 121:132-133.

Farrington, D. O. and R. D. Jorgenson. 1976. Prevalence of Bordetella bronchiseptica in certain wild mammals and birds in central Iowa. J. Wildlife Dis. 12:523-525.

Gough, P. M. and R. D. Jorgenson. 1983. Identification of porcine transmissible gastroenteritis virus in house flies (Musca domestica Linneaus). Am. J. Vet. Res. 44(11):2078-2082.

Harris, I. T., P. J. Fedorka-Cray, J. T. Gray, L. A. Thomas, and K. Ferris. 1997. Prevalence of Salmonella organisms in swine feed. J. Am. Vet. Med. Asso. 210(3):382-384.

Christopher-Hennings, J., E. A. Nelson, R. J. Hines, J. K. Nelson, S. L. Swenson, J. J. Zimmerman, C. C. L. Chase, M. J. Yaeger, and D. Benfield. 1995. Persistence of porcine reproductive and respiratory syndrome virus in serum and semen of adult boars. J. Vet. Diag. Inv. 7:456-464.

Hsu, F. S., T. H. Liu, and W. B. Chung. 1984. Isolation of pseudorabies virus from semen and reproductive tract of adult boars. In: Proceedings International Pig Vet. Soc. p 24.

Hutchings, L. M., and F. N. Andrews. 1946. Studies on brucellosis in swine. III. Brucella infection in the boar. Am. J. Vet. Res. 7(25):379-384.

Johnson, R. H., and D. F. Collings. 1971. Transplacental infection of piglets with a parvovirus. Res. Vet. Sci. 12:570-572.

Lee, J. A., A. C. Ghosh, P. G. Mann, and G. H. Tee. 1972. Salmonellas on pig farms and in abattoirs. J. Hyg. Camb. 70:141-150.

Le Moine, V., P. Vannier, and A. Jestin. 1987. Microbiological studies of wild rodents in farms as carriers of pig infectious agents. Pre. Vet. Med. 4:399-408.

Lucas, M. H., S. F. Cartwright, and A. E. Wrathall. 1974. Genital infection of pigs with porcine parvovirus. J. Comp. Path. 84:347-350.

Medvecky, I., L. Kovacs, F. Kovacs, and L. Papp. 1988. The role of the housefly, Musca domestica, in the spread of Aujesky's disease (pseudorabies). Med. Vet. Entomology. 2:81-86.

National Pork Board (NPB). Anon. 2001a. Pork Quality Assurance (PQA) booklet.

National Pork Board (NPB). Anon. 2001b. On farm euthanasia of swine: Options of the producer.

Pensaert, M., K. Ottis, J. Vandeputte, M. M. Kaplan, and P. A. Bachmann. 1981. Evidence for the natural transmission of influenza A virus from wild ducks to swine and its potential importance for man. Bulletin of the World Health Organization. 59(1):75-78.

Prieto, C., P. Suarez, R. Sanchez, A. Solana, I. Simarro, S. M. Rolli, and J. M. Castro. 1994. Semen changes in boars after experimental infection with Porcine Epidemic Abortion and Respiratory Syndrome (PEARS) virus. In: Proc. Int. Pig Vet. Soc. p 98. (Abstr.).

Smith, H. W. 1960. The effect of feeding pigs on food naturally contaminated with salmonellae. J. Hyg. Camb. 58:381-389.

Stewart, W. C., E. A. Carbrey, E. W. Jenney, J. I. Kresse, M. L. Snyder, and S. J. Wessman. 1975. Transmission of hog cholera virus by mosquitoes. Am. J. Vet. Res. 36(5):611-614.

Swenson, S. L., H. T. Hill, J. J. Zimmerman, L. E. Evans, R. W. Wills, K. J. Yoon, K. J. Schwartz, G. C. Althouse, M. J. McGinley, and A. K. Brevik. 1994a. Artificial insemination of gilts with porcine reproductive and respiratory syndrome (PRRS) virus-contaminated semen. Swine Health Prod. 2(6):19-23.

Swenson, S. L., H. T. Hill, J. J. Zimmerman, L. E. Evans, J. G. Landgraf, R. W. Wills, T. P. Sanderson, M. J. McGinley, A. K. Brevik, D. K. Ciszewski, and M. L. Frey. 1994b. Excretion of porcine reproductive and respiratory syndrome virus in semen after experimentally induced infection in boars. J. Am. Vet. Med. Assoc. 204(12):1943-1948.

Tidwell, M. A., W. D. Dean, G. P. Combs, D. W. Anderson, W. O. Cowart, and R. C. Axtell. 1972. Transmission of hog cholera virus by horseflies (Tabanidae: Diptera). Am. J. Vet. Res. 33(3):615-622.

Yaeger, M. J., T. Prieve, J. Collins, J. Christopher-Hennings, E. A. Nelson, and D. Benfield. 1993. Evidence for the transmission of porcine reproductive and respiratory syndrome (PRRS) virus in boar semen. Swine Health Prod. 1(5):7-9.

Zimmerman, J. J., K. J. Yoon, E. C. Pirtle, R. W. Wills, T. J. Sanderson, and M. J. McGinley. 1997. Studies of porcine reproductive and respiratory syndrome (PRRS) virus infection in avian species. Vet. Micro. 55:329-336.

Tables

TABLE 1. Water requirements of pigs. Values (liters/day or gallons/day) indicate the range of requirements as presented in the literature[a]

Class of Pig	Liters / pig / day	Gallons / pig/day
Nursery pigs (up to 60 lbs BW)	2.8 (2.5 - 3.0 L/kg of feed consumed)	0.7 (0.3 gal/lb of feed consumed)
Grower Pigs (60 - 100 lbs BW)	12 - 20 (2.5 - 3.0 L/kg of feed consumed)	2 - 3 (0.3 gal/lb of feed consumed)
Finishing Pigs (100 - 250 lbs BW)	12 - 20 (2.5 - 3.0 L/kg of feed consumed)	3 - 5 (0.3 gal/lb of feed consumed)
Nonpregnant gilts	12	3
Pregnant sows	12 - 25	3-6
Lactating sows	10 - 30	2.5 - 7
Boars	20	5

[a] Adapted from Almond (1995): Chapters 1 and 2.

TABLE 2. Recommended Thermal Conditions for Swine

Type and weight	Preferred range[a]	Lower intervention[b]	Upper intervention[c]
Lactating sow and litter	60-80°F for sow; piglets have 900F creep area	50°F for sow	90°F for sow
Prenursery, 10 to 30 lbs	80 to 90°F	60°F	95°F
Nursery, 30 to 75 lbs	65 to 80°F	40°F	95°F
Growing, 75 to 150 lbs	60 to 75°F	25°F	95°F
Finishing, 150 to 220 lbs	50 to 75°F	5°F	95°F
Sows or boars	60 to 75°F	5°F	90°F

[a]Adapted from NRC (1981): Chapter 2; DeShazer and Overhults (1982): Chapters 1 and 2; Hahn (1985): Chapters 1 and 2.

[b]Bedding, supplemental heat, or other environmental modification is recommended when air temperatures approach the lower intervention points.

[c]Except for brief periods above these air temperatures, some form of cooling should be provided when temperatures approach upper intervention points.

TABLE 3. Floor Area Recommended for Growing Swine in Totally Enclosed Housing[a,b,c]

Stage of production	Square feet[d]
12 - 30 lbs	1.7 - 2.5 / pig
30 - 60 lbs	3 - 4 / pig
60 - 100 lbs	5 / pig
100 - 150 lbs	6 / pig
150 - Market	8 / pig[e]

[a]Adapted from MWPS (1983): Chapters 1, 2 and 3; Fritschen and Muehling (1987): Chapters 1, 2 and 3.

[b]Close observation and professional judgment in modern facilities may allow higher stocking densities without interfering with the pigs' welfare. Production practices, such as group size, ventilation equipment and rate, and type of floors (partial versus total slats), have an effect on proper stocking densities. Research is ongoing to study space requirements for different production systems.

[c]Research needs to be done in order to develop scientifically-based breeding swine space guidelines that will address measures of animal welfare and be economically sustainable. For this reason, specific recommendations about sow or boar stall or pen sizes are not given.

[d]Group area allowances for growing pigs.

[e]Space requirement per pig decreases as group size increases (Chapter 1, McGlone and Newby, 1994 reference)

TABLE 4. Space Recommendations for Pigs in Buildings other than Totally Enclosed Housing[a]

Stage of production	Space per pig		
	Housing with Outside Apron		
	Inside	**Outside**	**Bedding systems**
Growing-finishing pigs	6 sq. ft.	6 sq. ft.	10.5 - 12 sq. ft.
Sows	11 - 12 sq. ft.	11 - 12 sq. ft.	24 - 27 sq. ft.
Boars	40 sq. ft.	40 sq. ft	

[a]Adapted from Fritschen and Muehling (1987): Chapters 1, 2 and 3.

TABLE 5. Space and Shade or Shelter Recommendations for Pigs on Pasture[a,b]

Stage of production	Pasture	Shade or shelter
Growing-finishing pigs	50 - 100 pigs / acre	4 sq. ft. / pig to 100 lbs. 6 sq. ft. / pig over 100 lbs.
Sows	10 sows / acre	15 - 20 sq. ft / sow
Sows and litters	7 sows with litters / acre	20 - 30 sq. ft. / sow and litter
Boars	4 boars / acre	40 - 60 sq. ft. / boar

[a]Adapted from MWPS (1983): Chapters 1, 2 and 3; Fritschen and Muehling (1987): Chapters 1, 2 and 3.
[b]Space needs for pigs in outside dirt lots may be less than for pigs on pasture.

The Other White Meat.
National Pork Board

P.O. Box 9114 • Des Moines, Iowa 50306 USA
Phone: (515) 223-2600 • **Fax:** (515) 223-2646
E-Mail: porkboard@porkboard.org
www.porkboard.org

#04010/3-03