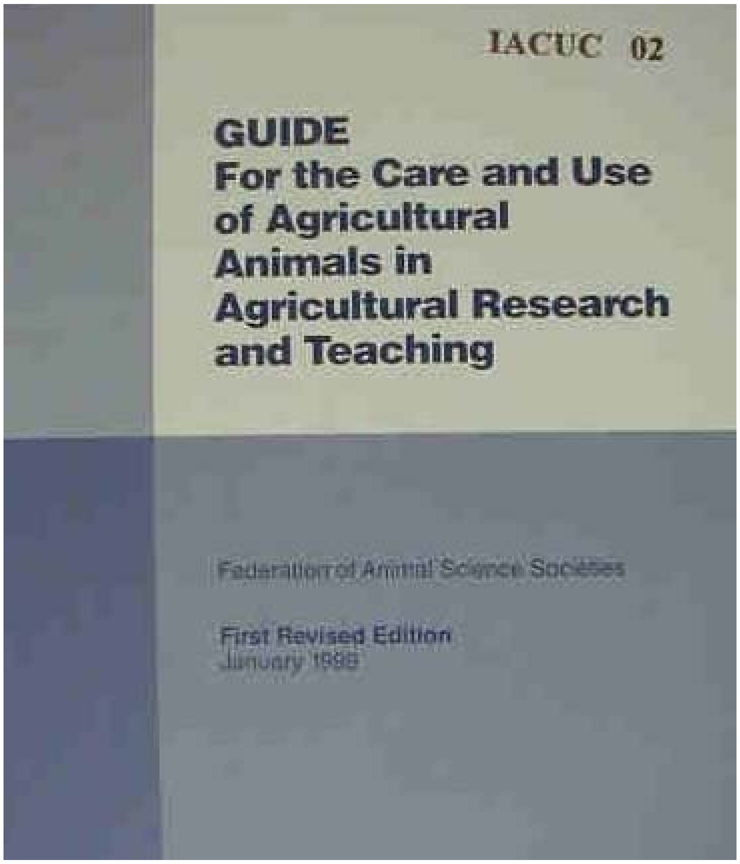

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GUIDE
For the Care and Use of Agricultural Animals in Agricultural Research and Teaching

Federation of Animal Science Societies

First Revised Edition
January 1999

Preface

This is the first revised edition of the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching*. It has resulted from a thorough and deliberative updating—and, where indicated, clarifying and correcting—of the first edition of the *Guide* (1988). The purpose and overall approach and format of the original *Guide* continue in this revised edition. However, the consortium that was organized to develop and publish the first edition has transferred overall responsibility for the publication to the Federation of Animal Science Societies (formerly Federation of American Societies of Food Animal Science, or FASFAS).

In 1993, the FASFAS Executive Committee appointed the *Guide* Steering Committee, which was asked to advise whether and when the publication should be revised. The Steering Committee employed the services of the Survey Research Center of the University of Maryland to conduct a survey of the *Guide's* various stakeholders. It was concluded that the first edition, in general, had stood the test of time well. Its guidelines had been well received and were being used widely. Nevertheless, that committee recommended that revision was in order, primarily for the purpose of updating the *Guide* with respect to recent changes in laws, regulations, policies, and publications.

The FASFAS Executive Committee subsequently appointed a *Guide* Revision Committee as well as appropriate Subcommittees. The Revision Committee first met in Washington, DC in January 1995. It recommended at that time that the revision process be thorough, and where needed, indicated that it go beyond updating; the FASFAS Executive Committee consented to this. The Revision Committee met again in Chicago, Illinois in November 1995, and in San Francisco, California in February 1996. Much of the work of the Revision Committee and Subcommittees was accomplished via mail, teleconferencing, telefacsimile, and electronic mail.

During the revision process, successive intermediate drafts of the revised document were received by representatives of appropriate organizations and stakeholding constituencies. Also, through the efforts of Technical Editor Cheryl K. Nimz, special attention was paid to consistency of style and continuity of the several chapters of the *Guide*.

The first revised edition of the *Guide* thus stands as the product of the work of many people, especially Joy A. Mench and members of the *Guide* Steering and Revision Committees and Subcommittees, and also numerous other individuals, including those who reviewed and commented upon drafts of this revised version and all who participated in development of the first edition. The Federation of Animal Science Societies gratefully acknowledges the commitment of every person who contributed scientific and professional knowledge, experience, and thought to the effort that has resulted in publication of this revised *Guide*. The Animal Welfare Information Center at the National Agricultural Library in Beltsville, Maryland was particularly helpful in providing information and conducting literature searches for the members of the Revision Committee during the preparation of this document.

The Executive Committee of FASS solicits comments and suggestions related to the first revised edition of the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching*. They should be addressed to the following:

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Inquiries regarding purchase of the *Guide* should be directed to FASS at the same address.

STANLEY E. CURTIS
Liaison to the Guide Steering and Revision Committees from the FASS Executive Committee

Acronyms

AAALAC, Association for Assessment and Accreditation of Laboratory Animal Care International
AALAS, American Association for Laboratory Animal Science
ACUC, animal care and use committee
ADGA, American Dairy Goat Association
AMI, American Meat Institute
APHIS, Animal and Plant Health Inspection Service
ARPAS, American Registry of Professional Animal Scientists
ASAE, American Society of Agricultural Engineers
ASIA, American Sheep Industry Association
AVA, American Veal Association
AVMA, American Veterinary Medical Association
CDC, Centers for Disease Control and Prevention
CFR, Code of Federal Regulations
FASFAS, Federation of American Societies of Food Animal Science (defunct)
FASS, Federation of Animal Science Societies
FDA, Food and Drug Administration
HHS, Health and Human Services
ILAR, Institute for Laboratory Animal Resources
INAD, investigational new animal drug
IRAC, Interagency Research Animal Committee
LCI, Livestock Conservation Institute
MWPS, Midwest Plan Service
NAAB, National Association of Animal Breeders/Certified Semen Services
NCBA, National Cattlemen's Beef Association
NIH, National Institutes of Health
NMC, National Mastitis Council, Inc.
NPPC, National Pork Producers Council
NRAES, Northeast Regional Agricultural Engineering Service
NRC, National Research Council
OPRR, Office for Protection from Research Risks
OSHA, Occupational Safety and Health Administration
PHS, Public Health Service
PIH, Pork Industry Handbook
SCAW, Scientists Center for Animal Welfare
UEP, United Egg Producers
UFAW, Universities Federation for Animal Welfare

Contents

Introduction

Enhancement of the well-being of both agricultural animals and humans by agricultural scientists depends directly on research involving experimental animals. Teaching programs to disseminate agriculturally related knowledge may also require the use of animals. The agricultural community has long recognized the scientific and ethical importance of proper animal care and humane treatment of animals. All who use animals in agricultural research of teaching must assume responsibility for the general welfare of the animals in their care. Institutional agricultural animal facilities and programs should be operated in accordance with the requirements and recommendations of this *Guide*, the *Guide for the Care and Use of Laboratory Animals* (ILAR, 1996), and applicable federal, state, and local laws, regulations, and policies as appropriate.

To be eligible for grants from the PHS for research and training projects using vertebrate animals, institutions must file and assurance statement with the Office for Protection from Research Risks. Institutions may choose to restrict their assurance to projects funded by NIH and other agencies or to biomedical research activities in general. However, if an institution files an assurance statement indicating that the total animal care program of the institution will be conducted in accordance with PHS policy and the guidelines put forth in the *Guide for the Care and Use of Laboratory Animals* (ILAR, 1996), then the PHS may scrutinize the entire animal care program—including agricultural research and teaching activities and facilities—if there is an alleged problem in the biomedical area that results in a site visit. Pertinent PHS policy has been published in *Public Health Service Policy on the Humane Care and Use of Laboratory Animals* (PHS, 1996). Agricultural animals used in certain research, teaching, and testing activities are also regulated under the Animal Welfare Act (CFR, 1992), and the facilities and programs related to their use are subject to inspection and review by APHIS.

Both the *Guide for the Care and Use of Laboratory Animals* and the Animal Welfare Act regulations refer specifically and explicitly to agricultural animals in the context of their use in biomedical research and teaching, in which they may serve as models for humans. Scientists at agricultural experiment stations and elsewhere are required to follow the same practices for these animals as those established for nonagricultural species used in similar experiments. The facilities and practices for the care and use of agricultural animals in this category are described and discussed in the *Guide for the Care and Use of Laboratory Animals*.

The recommendations outlined in this *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* refer primarily to agricultural animals in a different category. For the purposes of this *Guide*, agricultural animals include any warm-blooded vertebrate animal used in agricultural research or teaching for which the scientific objectives are to improve understanding of the animal's use in production agriculture and that may require a simulated or actual production agricultural setting consistent with consideration of the animal's well-being. Pertinent systems include range or pasture production in naturalistic settings, various degrees of confinement in certain less extensive production systems, including enclosed buildings. Neither this *Guide*, the *Guide for the Care and Use of Laboratory Animals*, nor the Animal Welfare Act is intended to pertain to animals being produced on farms and ranches for commercial purposes.

Depending on the nature of the research or teaching objective, animal scientists and veterinary scientists may use a number of different kinds of animal facilities. Some projects require a carefully controlled environment, but for others the wide range of variables found on actual farms and ranches is an important component of the research. Some scientific use of agricultural animals involves projects and demonstrations that have agricultural objectives in the ultimate, but that require neither the breadth of stimuli present in farm environments nor the degree of environmental control typical of much biomedical research (Tillman, 1994). For research of teaching activities of this type, a blending of guidelines will be necessary, and here especially professional judgment is required (Curtis, 1994).

This edition of the *Guide* is divided into 11 chapters and five appendixes. The first four chapters deal with general programmatic considerations. Chapter 1 focuses on institutional policies, including those designed to provide oversight and monitoring of the animal care and use program, written operating procedures, occupational health and safety, and personnel training. Chapter 2 provides general recommendations regarding agricultural animal husbandry, including information about thermal environments, air quality, animal waste management, environmental enrichment, animal handling and restraint, and transportation. Chapter 3 discusses the veterinary care program for agricultural animals, and Chapter 4 describes general aspects of facilities construction and maintenance. Chapters 5 to 11 provide specific recommendations for the care and use of beef cattle, dairy cattle, horses, poultry, sheep and goats, swine, and veal calves, respectively.

Appendix 1 provides the United States Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training; Appendix 2 Table A-1 lists common zoonotic diseases of agricultural animals, including their means of spread; Appendix 2 Tables A-2 and A-3 provide information about pre-anesthetic, anesthetic, and analgesic agents suitable for agricultural animals as well as appropriate euthanasia methods; and Appendix 3 provides additional information about organizations mentioned in this Guide that can provide useful information about agricultural animal care.

This *Guide* has been deliberately written in general terms so that the recommendations can be applied in the diverse institutions that use agricultural animals in agricultural research and teaching in the United States. In the context of this *Guide*, the verb *must* is used for considerations or practices that are viewed as imperatives. The verb *should* is a strong recommendation, but one for which alternative strategies might be justified after careful consideration. A *recommendation* connotes a practice or policy that is generally preferred, but for which there are acceptable alternatives. It should be emphasized, however, that professional judgment is essential in the application of these guidelines. Veterinarians, ACUCs, and users of agricultural animals must play a critical role in making specific suggestions regarding animal care and use at their institution. The *U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training* of the IRAC (1985; Appendix 1) are endorsed in this *Guide* as a basis for professional judgments about the appropriate treatment and use of agricultural animals in research and teaching activities. These judgments can be validated by third-party peer review, such as that provided by accreditation through AAALAC International.

Nothing in this *Guide* is intended to limit an investigator's freedom to plan and conduct animal experiments and demonstrations in accordance with scientific and humane principles. Agricultural scientists are also encouraged to continue to seek improved methods of animal care and use. Evaluation of improved and alternative methods of animal housing and care may require temporary easing of these guidelines during the evaluation process.

It is important to recognize that the intent of agricultural research and teaching using animals is to advance knowledge that will be of immediate or potential benefit to agricultural animals, agricultural animal producers, and consumers of the products of animal agriculture. However, scientists should continue to develop, foster, and use scientifically valid adjunct or alternative methods to animal use in agricultural research and teaching.

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Chapter 1: Institutional Policies

Scientific and professional judgment and humane concern are required for the proper care of agricultural animals used in agricultural research and teaching (referred to in this *Guide* as agricultural animal care and use). Because a variety of management systems and physical accommodations may be used for agricultural animals, an understanding of the husbandry needs of each species and of the particular requirements of agricultural research and teaching is essential for an effective institutional program of agricultural animal care and use (Stricklin and Mench, 1994). Critical components of such a program are established lines of authority and responsibility, an active ACUC, and adequate program of veterinary care, and training and occupational health programs for individuals who work with the animals (PHS, 1988). This chapter is intended to aid in the development of institutional policies and programs for agricultural animal care and use.

MONITORING THE CARE AND USE OF AGRICULTURAL ANIMALS

Each institution should establish an agricultural animal care and use program with clearly designated lines of authority in accordance with this *Guide* and in compliance with applicable federal, state, and local laws, regulations, and policies. The responsibility for directing the program may be given to an animal scientist, veterinarian, or other qualified professional with training and experience in the management of agricultural animals.

The chief executive officer or responsible administrative official of the institution should appoint a committee to monitor the care and use of agricultural animals in agricultural research and teaching activities (hereafter referred to as the animal care and use committee, or ACUC). The ACUC should be composed of individuals who are qualified by experience or training to evaluate the programs and proposals under review and should include at least one individual from each of the following categories:

- A scientist from the institution who has experience in agricultural research or teaching involving agricultural animals.
- An animal, dairy, or poultry scientist who has training and experience in the management of agricultural animals.
- A veterinarian who has training and experience in agricultural animal medicine and who is licensed or eligible to be licensed to practice veterinary medicine.
- A person whose primary concerns are in an area outside of science (e.g., a faculty member from a nonscience department, a staff member, a student, or an institutional administrator).
- A person who is not affiliated with the institution and who is not a family member of an individual affiliated with the institution. This public member is intended to provide representation for general community interests in the proper care and treatment of animals and should not be a person who uses animals in agricultural or biomedical research or teaching activities at the college or university level.
- Other members as required by institutional needs and applicable laws, regulations, and policies.

It is strongly recommended that this committee be one that also monitors the care and use of laboratory animals at the institution, providing that the special membership requirements outlined above are met. This recommendation can be fulfilled by a number of different types of committee structures, including a single institutional committee, unit committees (e.g., departmental, college, or program) that review both agricultural and biomedical uses of animals, or an agricultural animal subcommittee of the laboratory animal committee. The overriding goal should be to facilitate centralized, uniform, and high quality oversight of the institution's animal care program.

The ACUC should meet at regular intervals, and at least semi-annually, to ensure that the use of agricultural animals in research and teaching programs is humane, appropriate, and in accordance with this *Guide*. The responsibilities of the ACUC include the following:

- To review and approve or disapprove protocols and other proposed activities, or proposed significant changes in activities, related to agricultural animal care and use in research and teaching.
- To conduct, at least twice per year, an inspection of agricultural animal facilities and study areas, to review the overall agricultural animal care and use program, and to provide a written report to the responsible institutional official regarding the institution's compliance with this *Guide*.
- To investigate concerns, complaints, or reports of noncompliance involving agricultural animals at the facility.
- To suspend an activity involving agricultural animals when it is not in compliance with approved protocols or written operating procedures (see section on Written Operating Procedures).

- To make recommendations regarding the development and implementation of institutional policies and procedures to facilitate, support, and monitor the humane and appropriate use of animals in agricultural research and teaching as well as any other aspect of the agricultural animal care program.
- To perform other functions as may be required by institutional need and by applicable laws, regulations, and policies.

Other useful information about ACUC functions can be found in the *Institutional Animal Care and Use Committee Guidebook* (undated) and the *Public Health Service Policy on Humane Care and Use of Laboratory Animals* (PHS, 1996).

PROTOCOL REVIEW

The review of research and teaching protocols is one of the most important functions of the ACUC. Protocols must be reviewed prior to the initiation of the research or teaching activity to determine whether the proposed care and use of animals is appropriate and humane and then either approved, returned for modifications to secure approval, or disapproved. The ACUC should also conduct continuing reviews of approved activities at appropriate intervals, including a complete review at least once every 3 years. The following topics should be considered in the preparation and review of animal care protocols:

- objectives and significance of the research or teaching activity;
- unnecessary duplication of previous studies;
- availability or appropriateness of alternative procedures or models (e.g., less invasive procedures, cell or tissue culture, or computer simulations) for the proposed research or teaching activity. It should be noted, however, that hands-on training involving animals is a particularly important component of agricultural research and teaching;
- aspects of the proposed experiment or demonstration having to do directly with animal care and use, including
  — justification for the species and (or) strain of animal used,
  — justification for the number of animals used,
  — description of procedures that cause discomfort, distress, or pain and of methods of alleviation including anesthesia, analgesia, and tranquilizers, as well as justification for any procedures that involve unalleviated pain, discomfort, or distress;
- appropriateness of procedures and postprocedural care;
- criteria and process for timely intervention, removal of animals from a study, or euthanasia if painful and stressful outcomes are anticipated;
- unusual husbandry requirements;
- aspects of animal husbandry not covered under written operating procedures (see section Written Operating Procedures);
- method of euthanasia or disposition of the animal; and
- responsibilities, training, and qualifications of the researchers, teachers, students, and animal care personnel involved in the proposed activities.

The US Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training (Appendix 1) state that "Procedures involving animals should be designed and performed with due consideration of their relevance to human or animal health, the advancement of knowledge, or the good of society." Because ACUCs are not ordinarily constituted to function as scientific peer-review committees, the ACUC should be judicious in reviewing the merit proposed research and teaching activities (Prentice et al., 1992). Institutions should consider developing other mechanisms for peer merit review of research projects that have not already been reviewed by outside agencies.

The ACUCs are encouraged to work closely with investigators to help them refine their protocols and proposed animal care and use practices.

The common acceptance and use in animal agriculture of a production system, management practice, or routine procedure does not reduce the responsibility of every animal user to follow applicable laws, regulations, and policies, including the standards outlined in this *Guide.* Exceptions to some provisions, however, may be justifiable in order to obtain new knowledge or to demonstrate methods commonly used in commercial agricultural animal production. For example, applied research and teaching may require the use of production practices that are consistent with those currently in use in the appropriate industry even though those practices differ from those outlined in this *Guide*; research and teaching dealing with infectious diseases, toxins, or products of biotechnology may require special facilities. Exceptions to this *Guide* should be stated explicitly in research and teaching protocols and be reviewed an approved by the ACUC.

WRITTEN OPERATING PROCEDURES

It is good practice to develop written policies or procedures for animal care and husbandry for each operating unit in the program. These written policies should be reviewed as appropriate, filed in the appropriate administrative office and in locations accessible to those individuals involved in carrying out the designated procedures, and monitored regularly by personnel designated by the institution.

There are certain commercial husbandry practices routinely carried out on agricultural animals that may cause temporary discomfort or pain. These standard agricultural practices (see Chapters 2 and 5 to 11) need not necessarily be described separately for each study, experiment, or demonstration, but are acceptable as written operating procedures provided that the practices (1) are warranted to sustain the long-term welfare of the animal and (or) the animal's caretakers or handlers; (2) are performed by or under the direct supervision of capable, trained, and experienced personnel; and (3) are performed with precautions taken to reduce pain, stress, and infection. The written operating procedures for these practices should be reviewed and approved by the ACUC.

Husbandry procedures and production methods at agricultural research facilities should be revised as research demonstrates improvements. Research on improved methods and procedures is encouraged.

ANIMAL HEALTH CARE

Adequate health care must be provided for all agricultural animals used in research and teaching (see Chapter 3). Institutional requirements will determine whether full-time, part-time, or consulting veterinary services are appropriate.

BIOSECURITY

It is essential that the agricultural animal care staff maintain a high standard of biosecurity in order to protect the animals from pathogenic organisms that can be transferred by humans. Good biosecurity begins with personal cleanliness. Showering or washing facilities and supplies should be provided, and personnel should change their clothing as often as necessary to maintain personal hygiene. Disposable gear, such as gloves, masks, coats, coveralls, and shoe covers, may be required under some circumstances. Personnel should not leave the work place in protective clothing that has been worn while working with the animals. Personnel should not be permitted to eat, drink, apply cosmetics, or use tobacco in enclosed animal facilities. Visitors should be limited as appropriate, and institutions should implement appropriate precautions to protect the safety and well-being of the visitors and the animals.

PERSONNEL QUALIFICATIONS

It is the responsibility of the institution to ensure that scientists, agricultural animal care staff, students, and other individuals who care for or use agricultural animals are qualified to do so through training or experience. Training programs should be tailored to institutional needs, but provide information about the humane care and use of agricultural animals, including (1) husbandry needs, proper handling, surgical procedures, and pre- and postprocedural care; (2) methods for minimizing the number of animals used and for minimizing pain and distress, including the proper use of anesthetics, analgesics, and tranquilizers; (3) methods for reporting deficiencies in the animal care program; and (4) use of information services such as the Animal Welfare Information Center at the National Agricultural Library (NRC, 1991; CFR, 1992). Records of participation in training programs should be maintained in the appropriate institutional office.

Employees who provide routine animal care should participate regularly in in-service education and training relevant to their responsibilities. Formal or on-the-job training opportunities should be made available to all technical and husbandry support staff, including those who are temporary or part-time employees. It is recommended that the training program include information provided by experts from a broad range of disciplines such as animal husbandry, behavior, nutrition, environmental physiology, experimental surgery, veterinary clinical and diagnostic medicine, agricultural engineering, and instrumentation. There are also a variety of written reference materials available for use in training programs (Kreger, 1995).

In addition to in-house training, it is desirable for agricultural animal care staff to be professionally trained or certified. Many states have colleges with accredited programs in veterinary technology (AVMA, 1995). Technician and technologist certification is available through AALAS, although that program primarily emphasizes the care and use of laboratory animals rather than agricultural animals. Animal scientists with educational credentials ranging from the baccalaureate through the doctorate who seek recognition of their expertise in the biology and production of agricultural animals can be certified by examination by ARPAS.

OCCUPATIONAL HEALTH

An occupational health and safety program must be established for individuals who work with agricultural animals. The program should be consistent with federal, state, and local regulations and will depend on the facilities, research activities, and hazards involved. The degree of participation of individuals in the program should be based on an assessment of risk by health and safety specialists involving consideration of the hazards posed by the animals and materials used; the duration, frequency, and intensity of exposure; the susceptibility of the personnel; and the history of occupational injury and illness in the particular workplace (Clark, 1993).

General guidelines for such programs have been published by the NRC (1997). The program for individuals working with agricultural animals may include a physical examination prior to placement, periodic medical evaluations for people in some job categories, surveillance to ensure protection from health hazards, and provisions for treating illness or injury. The program should also include an educational component to teach personnel about large animal diseases and zoonoses, physical hazards, personal hygiene, precautions to be taken by individuals who are at unusual risk (e.g., pregnant women), and other considerations as appropriate (e.g., safety precautions with chemicals, radiation, and other hazardous agents that are part of a particular experimental protocol).

An appropriate immunization schedule should be adopted. It is important to immunize all agricultural animal caretakers against tetanus every 10 years. Prior to exposure, immunizations should be offered to people who handle animals and risk infection from certain infectious agents. Prophylactic vaccinations should also be considered when research is being conducted on infectious diseases from which effective vaccines are available.

Allergies and physical injuries constitute health hazards for individuals working with agricultural animals. Institutions should identify high risk areas and tasks and should educate animal care personnel about methods for reducing risk. Injuries can be minimized by providing training in proper animal handling, lifting, and equipment use. Access to first aid and medical treatment should be readily available, and personnel should be trained and familiar with access procedures. Such access may include readily available and properly stocked first aid kits. Cases of animal bites and scratches should be documented, and tetanus prophylaxis should be considered.

Caretakers working with agricultural animals in closed buildings may develop respiratory problems, including chronic and irreversible lung damage (Donham and Leininger, 1984). Appropriate respiratory protection should be provided for these individuals.

Zoonoses can also be a serious risk. Personnel (including animal care staff, technicians, investigators, clinicians, students, maintenance workers, and security staff) who have contact with or an opportunity for contact with animals or their excreta, products, or tissues should be made aware of hazards that have been identified and that are determined to be a risk (Donham, 1985; Acha and Szyfres, 1989). Zoonotic disease in animal populations should be screened for or monitored regularly as appropriate. Appendix 2 Table A-1 is a table of the most common zoonotic diseases found in agricultural animals and the means by which they are spread.

The noise level in some animal facilities may sometimes be high. When personnel are exposed to noise exceeding federal standards, appropriate protection programs should be implemented (CFR, 1995).

Work assignments and health records should be a part of an occupational health program. Records should be kept of individual work assignments and should include the date and time of injuries or unusual illnesses. Personnel should be instructed to notify their supervisor of suspected health hazards.

SPECIAL CONSIDERATIONS WHEN HAZARDOUS AGENTS ARE USED

The use of certain hazardous biological, chemical, or physical agents necessitates compliance with applicable laws and regulations as well as compliance with guidelines issued by granting agencies and organizations. Institutions should have written policies governing experimentation with hazardous agents and should also ensure that staff members conducting and supporting research projects involving hazardous agents are qualified to assess the dangers to animals and humans and are capable of selecting appropriate safeguards. Special facilities and equipment may be required for certain hazardous agents. Further information about recommended practices and procedures can be found in publications by CDC and NIH (1993, 1995) and by NRC (1997).

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Chapter 2: General Guidelines for Animal Husbandry

Proper management is essential for the well-being of the animals, the validity and effectiveness of research and teaching activities, and the health and safety of animal care personnel. Sound animal husbandry programs provide systems of care that permit the animals to grow, mature, reproduce, and be healthy. Specific operating procedures depend on many factors that are unique to individual institutions. Well-trained and properly motivated personnel can often achieve high quality animal care with less than ideal physical plants and equipment.

FACILITIES AND ENVIRONMENT

Environmental Requirements and Stress

Domestic animals are relatively adaptable to a wide range of environments (Hale, 1969; Craig, 1981; Sossinka, 1982; Curtis, 1983; Price, 1984, 1987; Fraser, 1985; Yousef, 1985a,b,c). Domestication is a continuing process. Genetic strains of animals selected for growth or reproduction in various environments under varying degrees of control are used currently for much of the production of livestock and poultry (Siegel, 1995). These strains of animals are sometimes very different from the breeds or strains from which they were originally derived (Ollivier, 1988; Craig, 1994; Havenstein et al., 1994a,b). Agricultural animals may be kept in extensive environments (e.g., pasture or range) where they reside in large areas (e.g., acres or square miles) outdoors. They may also be kept in intensive environments (e.g., in houses, pens, or cages) where they are confined to an area that would not sustain them were the environment not controlled and where food, water, and other needs must be provided to them. Individual animals may be moved during their lives from extensive to intensive systems or vice versa. Species requirements for domesticated animals are thus variable and depend both on the genetic background of the animals and their prior experience.

Criteria of Well-Being

Various criteria have been proposed to identify inappropriate management and housing conditions for agricultural animals. For example, in poultry, significant feather loss that is not associated with natural mating or natural molting is widely accepted as an indication that birds are experiencing stressful conditions. More sophisticated measures of stress are not necessarily superior and may even yield confusing results and lead to inaccurate conclusions (Moberg, 1985; Rushen, 1991). For instance, plasma corticosteroid concentrations of hens residing in spacious floor pens may be similar to those in high density cages, even though other criteria may indicate that the caged hens are adversely affected by their environment (Craig and Craig, 1985; Craig et al., 1986). During stressful social situations, resistance to virus-induced diseases may be depressed, but resistance to bacterial infections and parasites may be increased (Siegel, 1980; Gross and Siegel, 1983, 1985).

Some researchers have placed emphasis on behavioral criteria of well-being (Wood-Gush et al., 1975), although others have pointed out the difficulties of interpretation involved (Duncan, 1981; Craig and Adams, 1984; Dawkins, 1990). In the same way, some researchers (Craig and Adams, 1984) have suggested that depressed performance of individuals, independent of economic considerations, is a relatively sensitive reflector of chronic stressors, but Hill (1983) was less convinced using the same parameters.

Animal well-being has both physical and psychological components (Fraser and Broom, 1990; Duncan, 1993; Fraser, 1993). No single objective measurement exists that can be used to evaluate the level of well-being associated with a particular system of agricultural animal production. There is consensus, however, that multiple integrated indicators provide the best means of assessing well-being (Curtis, 1982; Mench and van Tienhoven, 1986; Rushen and de Passille, 1992; Mason and Mendl, 1993). Indicators in four categories are generally advocated: (1) behavior patterns, (2) pathological and immunological traits, (3) physiological and biochemical characteristics, and (4) reproductive and productive performance of the individual animal. A judgment as to the balance of evidence provided by these indicators has been used, when available, as the basis for the recommendations in this *Guide*.

D. C. Hardwick postulated (Duncan, 1978), and Duncan (1978) developed, the idea that an acceptable level of animal welfare exists over a range of conditions provided by a variety of agricultural production systems, not under just one ideal set of circumstances. Improvements in certain environments may increase animal well-being somewhat, but any point in the range would still be considered acceptable with respect to animal welfare. Good management and a high standard of stockmanship are important in determining the acceptability of a particular production system

(Hurnik, 1988) and should be emphasized in agricultural animal research and teaching facilities.

Macroenvironment and Microenvironment

Animal well-being is a function of many environmental variables, including physical surroundings, nutritional intake, and social and biological interactions (Hafez, 1968; Curtis, 1983; Yousef, 1985a). Environmental conditions should be such that stress, illness, mortality, injury, and behavioral problems are minimized. Particular components of the environment that need to be taken into account include temperature, humidity, light, air quality, space, social interactions, microbic concentrations, noise, vermin and predators, nutritional factors, and water.

Physical conditions in the room, house, barn, or outside environment constitute the macroenvironment; the microenvironment includes the immediate physical and biological surroundings. Different microenvironments may exist within the same macroenvironment. Both microenvironment and macroenvironment should be appropriate for the genetic background and age of the animals and the purpose for which they are being used. Domestic animals readily adapt to a wide range of environments, but some genetic strains have specific needs of which the scientist should be aware and for which accommodation should be made.

Even in relatively moderate climatic regions, weather events such as floods, winter storms, and summer heat waves may necessitate that animals have access to shelter. If trees or geographic features do not provide enough protection, artificial shelters and (or) windbreaks or sunshades should be provided.

Genetic Differences

Some strains of agricultural animals may have requirements that differ substantially from those of other stocks of the same species (Gross et al., 1984). Some strains of pigs, for example, are particularly susceptible to stress because they carry a gene that causes malignant hyperthermia when they experience even mild stress (Bäckström and Kauffman, 1995). Transgenic animals may also have special needs for husbandry and care (J. A. Mench, 1998, in press). Practices to ensure the well-being of special strains should be established independently of those made for the species in general.

Space Requirements

Floor area is only one of the components that determine the space requirements of an animal. Enclosure shape, floor type, ceiling height, location and dimensions of feeders and waterers, features inside the enclosure, and other physical and social elements affect the amount of space sensed, perceived, and used by the animals in intensive management systems (Stricklin et al., 1979; Stricklin and Gonyou, 1995). When possible, animals in stanchions, cages, crates, or stalls should be allowed to view one another, animal care personnel, and other activities where this would not interfere with research or teaching objectives.

Determination of area requirements for domestic animals should be based on body size, head height, stage of life cycle, behavior, health, and weather conditions. All area recommendations in this *Guide* refer to the animal zone (i.e., the space that can be used by the animal). Unless experimental or welfare considerations dictate otherwise, space should be sufficient for normal postural adjustments, including standing, lying, resting, self-grooming, eating, drinking, and eliminating feces and urine. When animals are crowded, body weight gain and other performance traits may be depressed (Gehlbach et al., 1966; Adams and Craig, 1985), and the animals may show altered levels of aggressive behavior (Bryant and Ewbank, 1974; Al-Rawi and Craig, 1975).

Environmental Enrichment

Environmental enrichment may be defined as a modification in the environment that improves the animal's biological functioning (Newberry, 1995) and, hence, its physical, psychological, and (or) social well-being (Curtis and Widowski, 1991). As Dawkins (1990) suggests, it is desirable to determine experimentally whether the animal also perceives as a necessity what is assumed by humans to be a need. Often, the benefits of purported enrichment devices have not been scientifically documented. Nevertheless, some relatively simple enrichment devices may indeed have significant effects in improving well-being. Appropriate enrichment features for agricultural animals might include the following:

- artificial, nonnutritive teats for calves (de Passilé, 1995), which decrease problems with cross-sucking in group-housed calves and are also associated with increased secretion of digestive enzymes;
- rooting materials, straw, and some types of toys for individually housed sows and growing pigs (Fraser, 1975; Pearce et al., 1989; Schaefer et al., 1990; Fraser et al., 1991; Apple and Craig, 1992; Pearce and Paterson, 1993; Beattie et al., 1995), which result in decreases in stereotyped behaviors and aggression and chewing of pen mates;
- cloth tassels or straw for parturient sows, which allow the sow to express nesting behavior (Widowski and Curtis, 1990);
- nestboxes for hens, which decrease the stereotyped pacing and apparent frustration associated with egg-laying in some genetic stocks (Appleby et al., 1992);
- perches for chickens, which increase leg bone strength (Appleby et al., 1992);

- dustbathing material for hens, which can reduce feather damage associated with feather-pecking in stocks with a feather-pecking problem when beaks are not trimmed (Norgaard-Nielsen et al., 1993); and
- hanging objects for caged hens, which decrease aggression and mortality (Gvaryahu et al., 1994).

Enrichment devices should be chosen carefully such that they do not cause injury or become contaminated with dangerous pathogens. The devices should also be monitored for effectiveness, including determining whether they continue to be used by the animals and whether they have beneficial effects on behavior or other aspects of biological functioning. Some forms of enrichment, while improving particular aspects of well-being, may also have undesirable effects that need to be evaluated carefully. For example, although hens use nestboxes, dustbaths, and perches extensively, there are disadvantages in terms of fouling of nests and dustbaths, more dirty and cracked eggs, and a higher incidence of keel bone deformities that apparently are associated with the use of perches (Appleby et al., 1992).

Temperature, Water Vapor Pressure, and Ventilation

Air temperature, water vapor pressure, and air velocity are some of the most important factors in the physical environment of agricultural animals. These factors affect the thermal balance of animals and thus their behavior, metabolism, and performance.

Most agricultural animals are quite adaptable to the wide range of thermal environments that are typically found in the natural outdoor surroundings of various climatic regions of the continental United States. The range of environmental temperatures over which animals use the minimum amount of metabolizable dietary energy to control body temperature is termed the thermoneutral zone (NRC, 1981; Curtis, 1983; Yousef, 1985a). Homeothermic metabolic responses are not needed within this zone. Temperature and vapor pressure ranges vary widely among geographic locations. The long-term well-being of an animal is not necessarily compromised each time it experiences cold or heat stress. However, the overall efficiency of metabolizable energy use for productive purposes is generally lower outside the thermoneutral zone than it is within the zone.

The preferred thermal conditions for agricultural animals lie within the range of nominal performance losses (Hahn, 1985). Actual effective environmental temperature may be temporarily cooler or warmer than the preferred temperature without compromising either the overall well-being or the productive efficiency of the animals (NRC, 1981). Evaluation of thermoregulation or of heat production, dissipation, and storage can serve as an indicator of well-being in relation to thermal environments (Hahn et al., 1992; Eigenberg et al., 1995).

The thermal environment that animals actually experience (i.e., effective environmental temperature) represents the combined effects of several variables, including air temperature, vapor pressure, air speed, surrounding surface temperatures, insulative effects of the surroundings, and the age, sex, weight, adaptation status, activity level, posture, stage of production, body condition, and dietary regimen of the animal.

A ventilation system removes heat, water vapor, and air pollutants from an enclosed animal facility (i.e., a facility in which air enters and leaves only through openings that are designed expressly for those purposes) at the same time that it introduces fresh air. Adequate ventilation is a major consideration in prevention of respiratory and other diseases. Where temperature control is critical, cooling or heating may be required to supplement the ventilation system. For certain research projects, filtration or air conditioning may be needed as well.

Typically, ventilation is the primary means of maintaining the desired air temperature and water vapor pressure conditions in the animal microenvironment. The amount of ventilation needed depends on the size, number, type, age, and dietary regimen of the animals, the waste management system, and atmospheric conditions. Equipment and husbandry practices that affect heat and water vapor loads inside the animal house also should be considered in the design and operation of the ventilation system.

Ventilation rates in enclosed facilities (MWPS, 1989, 1990a,b) should increase from a cold season minimum (to remove water vapor, contaminants, and odors as well as modify inside temperature) to a hot season maximum (usually around 10 times the minimum rate, to limit the rise in temperature inside the house that is due to the solar radiation load and sensible animal heat). It is important to recognize the approximately 10-fold increase in ventilation rate from winter to summer that is required in a typical livestock or poultry house. Because the animals themselves are the major source of water vapor, heat, and (indirectly) odorous matter, ventilation rate calculated on the basis of animal mass is more accurate than that based on air-exchange rate guidelines.

Relative humidity is ordinarily the parameter used to manage the air moisture content. Cold weather ventilation rates should be sufficiently high in order to maintain the relative humidity below 70 to 80% in an enclosed animal house (Curtis, 1983; Hinkle and Stombaugh, 1983). Conversely, ventilation rate during cold weather should be sufficiently low to ensure that the relative humidity does not fall below 40%, unless needs for air quality or condensation control necessitate a higher rate. Atmospheric humidity does not ordinarily become a significant factor in effective environmental temperature until the air temperature approaches the temperature of the animal's surface, in which case the animal will depend almost entirely on evaporative heat loss to maintain thermal equilibrium with the environment.

The use of fans to promote air movement can be beneficial during hot weather if there is too little natural air movement. Direct wetting is effective in decreasing heat stress on cattle and pigs; however, it can cause the death of poultry. Wetting is best accomplished by water sprinkled or dripped directly on the animals. Misters and evaporative coolers specifically designed to reduce air dry-bulb temperature are also used to reduce heat stress on agricultural animals.

Correctly designed and maintained sunshades protect animals from heat stress by reducing solar radiation load. Trees, if available, are ideal sunshades. Artificial, roofed shades are acceptable.

Mechanical ventilation requires proper design and operation of both air inlets and fans for proper distribution and mixing of the air and thus for creating uniform conditions throughout the animal living space. Mechanical ventilation, with fans creating static pressure differences between inside and outside the house, brings in fresh air and exhausts air that has picked up heat, water vapor, and air pollutants while passing through the building. Mechanical ventilation, if properly designed, provides better control of air exchange for enclosed, insulated animal houses in colder climates than does natural ventilation. The effectiveness of natural ventilation in cold climates will depend on the design and orientation of the enclosure, as well as the species and number of animals housed and the stage of their life cycle.

Natural ventilation uses thermal buoyancy and wind currents to vent air through openings in outside walls or at the ridge of the building. Natural ventilation is especially effective for cold animal houses (i.e., houses in which no heat is supplied in addition to animal heat) in moderate climates; however, insulated walls, ceilings, and floors are often recommended to minimize condensation. The air exchange rate needed to remove the water vapor generated by animals and evaporation of water from environmental surfaces often brings air temperature inside such houses down to values near those outdoors. If waterers and water pipes are protected from freezing, the practical low operating temperature is the point at which manure freezes, although this temperature would be too cold for some species or stages of the life cycle. Automatic curtains or vent panels, insulated ceilings, and circulating fans help to regulate and enhance natural ventilation systems.

During cold weather, ventilation in houses for neonatal animals should maintain acceptable air quality in terms of water vapor and other pollutants without chilling the animals. Air speed should be less than .25 m/s (50 ft/min) past very young animals. There should be no drafts on young poultry or pigs.

During hot, warm, or cool atmospheric conditions, ventilation of animal houses should maintain the thermal comfort of the animal to the extent possible. Ideally, the ventilation rate should be high enough to prevent indoor temperature from exceeding outdoor temperature (temperature rise limit; Curtis, 1983) by more than 3ºC (5ºF) when the atmospheric temperature is above 32ºC (90ºF) for small animals and above 25ºC (78ºF) for larger ones. In arid and semi-arid regions where the potential for evaporative heat loss is great, air temperature may peak at over 43ºC (110ºF) for 1 or 2 days or longer without affecting animal well-being if animals have been acclimatized by chronic exposure.

Ventilation system design should be based on building construction and the rates of water vapor and heat production of the animals housed (Curtis, 1983; Hinkle and Stombaugh, 1983). The frame of reference is the animal microenvironment. For example, the outdoor calf hutch is a popular accommodation for dairy replacement heifer calves in most parts of the continental United States. Although the hutch provides a cold microenvironment for calves during winter in northern latitudes, the calf is nonetheless comfortable if cared for correctly (MWPS, 1995). In closed houses during hot periods, additional ventilation capacity (up to 60 or more air changes/hr) may be necessary.

In enclosed animal houses, both environmental temperature and air quality depend on the continuous functioning of the ventilation system. An automatic warning system is desirable to alert animal care and security personnel to power failures and out-of-tolerance environmental conditions (Clark and Hahn, 1971), and consideration should be given to having an on-site generator for emergency use.

The relative air pressures between animal areas and service areas of a building housing animals should be considered when the ventilation system is designed to minimize the introduction of airborne disease agents or air pollutants into the service area. Advice of a qualified agricultural engineer or other specialist should be sought for the design of and operating recommendations for ventilation equipment.

Air Quality

Air quality refers to the nature of the air with respect to its effects on the health and well-being of animals and the humans who work with them. Air quality is typically defined in terms of the air content of certain gases, particulates, and liquid aerosols, including those carrying microbes of various sorts.

Good ventilation, waste management, and husbandry usually result in acceptable air quality. Ammonia, hydrogen sulfide, carbon monoxide, and methane are the pollutant gases of most concern in animal facilities (Curtis, 1986). In addition, OSHA (1995) has established allowable exposure levels for human workers with 8 hr of exposure daily to these gases. The ammonia concentration to which animals are exposed ideally should be less than 10 ppm and should not exceed 25 ppm, but a temporary excess should not adversely affect animal health. Comparable concentrations for hydrogen sulfide are 10 and 50 ppm, respectively. The concentration of carbon monoxide (arising from unvented heaters) in the air breathed by animals should not exceed 150 ppm, and methane (which is explosive at certain concentrations in air) should not exceed 50,000 ppm. Special ventilation is required when underfloor waste pits are emptied because of the potentially lethal hazards to animals and humans from the hydrogen sulfide and methane gases that are released.

Many factors affect airborne dust concentration, including relative humidity, animal activity, air velocity, and type of feed. Dust concentration is lower at higher relative humidities. High animal activity and air velocities stir up more particles and keep them suspended longer. Fat or oil added to feed reduces dust generation (Chiba et al., 1985). Microbes and pollutant gases may attach to airborne dust particles.

The allowable dust levels specified by OSHA (1995) are based on exposure of human workers for 8 hr daily without face masks; allowable dust levels are 5 mg/m3 for respirable dust (particle size of 5µm or less) and 15 mg/m3 for total dust. Although animals can tolerate higher levels of inert dust with no discernible detriment to their health or well-being (Curtis and Drummond, 1982), the concentration of dust in animal house air should be minimized.

Concentrations of microbes in the air should be minimized. Dust and vapor pressure should be controlled. The ventilation system should preclude the mixing of air from infected microenvironments with that from microenvironments of uninfected animals.

Lighting

Lighting should be diffused evenly throughout an animal facility. Illumination should be sufficient to aid in maintaining good husbandry practices and to allow adequate inspection of animals, maintenance of the well-being of the animals, and safe working conditions for personnel. Guidelines are available for lighting systems in animal facilities (MWPS, 1987b).

Although successful light management schemes are used routinely in various animal industries to support reproductive and productive performance, precise lighting requirements are not known for the maintenance of good health and physiological stability for most animals. However, animals should be provided with both light and dark periods during a 24-hr cycle unless the protocol requires otherwise. Red or dim light may be used if necessary to control vices such as feather-pecking in poultry and tail-biting in livestock.

Provision of variable-intensity controls and regular maintenance of light fixtures helps to ensure light intensities that are consistent with energy conservation and the needs of animals (as they are understood), as well as providing adequate illumination for personnel working in animal rooms. A time-controlled lighting system may be desirable or necessary to provide a diurnal lighting cycle. Timers should be checked periodically to ensure their proper operation.

Excreta Management and Sanitation

A complete excreta management system is necessary for any intensive animal facility. The goals of this system are as follows:

- To maintain acceptable levels of worker health and animal health and production through clean facilities.
- To prevent pollution of water, soil, and air.
- To minimize generation of odors and dust.
- To minimize vermin and parasites.
- To meet sanitary inspection requirements.
- To comply with local, state, and federal laws, regulations, and policies.

The planning and design of livestock excreta management facilities and equipment are discussed by MWPS (1993).

A plan should be followed to ensure that the animals are kept reasonably dry and clean and are provided with comfortable, healthful surroundings. Good sanitation is essential in intensive animal facilities, and principles of good sanitation should be understood by animal care personnel and professional staff. Different levels of sanitation may be appropriate under different circumstances, depending on whether manure packs, pits, outdoor mounds, dirt floors, or other types of excreta management and housing systems are being used. In some instances, animals may be intentionally exposed to excreta in order to enhance immunity. A written plan should be developed and implemented for the sanitation of each facility housing agricultural animals. Building interiors, corridors, storage spaces, anterooms, and other areas should be cleaned regularly and disinfected appropriately.

Waste containers should be emptied frequently, and implements should be cleaned frequently. It is good practice to use disposable liners and to wash containers regularly.

Animals can harbor microbes that can be pathogenic to humans and other species. Hence, manure should be removed regularly unless a deep litter system or a built-up manure pack is being employed, and there should be a practical program of effective disinfection to minimize pathogens in the environment.

For terminal cleaning, all organic debris should be removed from equipment and from floor, wall, and ceiling surfaces. If sanitation depends on heat for effectiveness, the cleaning equipment should be able to supply water that is at least 82ºC (180ºF). When chemical disinfection is used, the temperature of wash water may be cooler. If no machine is available, surfaces and equipment may be washed by hand with appropriate detergents and disinfectants and with vigorous scrubbing.

Health and performance of animals can be affected by the time interval between successive occupations of intensive facilities. Complete disinfection of such quarters during the unoccupied phase of an all-in, all-out regimen of facility management is effective for disease management in some situations.

Programs of pasture-to-crop rotation for periodically resting the pasture and programs that permit grazing by other animal species can aid in the control of soilborne diseases and parasites. Spreading of manure on pastures as fertilizer is a sound and acceptable management practice but may spread toxic agents and infectious pathogens (Wray and Sojka, 1977). Caution should be exercised with manure of animals infected with known pathogens, and other methods of waste disposal should be considered.

Animal health programs should stipulate storage, handling, and use criteria for chemicals designed to inactivate infectious microbes and parasites. There should be information about prevention, immunization, treatment, and testing procedures for specific infectious diseases endemic in the region.

Where serious pathogens have been identified, the immediate environment may need to be disinfected as part of a preventive program. Elimination of moist and muddy areas in pastures may not be possible, but prolonged destocking is an available option. Drylot facilities may need to be scraped and refilled with uncontaminated materials. Thorough cleaning of animal housing facilities may be followed by disinfection. Selection of disinfection agents should be based on knowledge of potential pathogens and their susceptibilities to the respective agents (Meyerholz and Gaskin, 1981a,b).

Some means for sterilizing equipment and supplies (e.g., an autoclave or gas sterilizer) is essential when certain pathogenic microbes are present and for some specialized facilities and animal colonies. Except in special cases (e.g., specific pathogen-free animals), routine sterilization of equipment, feed, and bedding is not necessary if clean materials from reliable sources are used. In areas where hazardous biological, chemical, or physical agents are being used, a system for monitoring equipment should be implemented.

FEED AND WATER

Animals should be provided with feed and water in a consistent manner, on a regular schedule, and according to the requirements established for each species by the NRC (1985, 1988, 1989a,b, 1994, 1996) and as recommended for the geographic area, unless the experimental or instructional protocol dictates otherwise. Feeders and waterers should be designed and situated to give animals easy and complete access (NRAES, 1990; Lacy, 1995; Pirkelmann, 1995; Taylor, 1995). Water quality should be tested regularly by an approved agency or laboratory. Large supplies of feed should be stored in appropriate, designated areas (MWPS, 1987a). Bulk feed tanks must be well-maintained, and the lids should be kept securely in place to prevent water contamination and mold growth. Tanks should be cleaned on a regular basis, as should the auger boot area. Feed in sacks and drums should be stored off the floor on pallets or racks, and each container should be labeled. An effective program of vermin control should be instituted in feed storage areas. Toxic compounds (Osweiler, 1985) should be stored outside of the feed room and animal quarters.

SOCIAL ENVIRONMENT

All agricultural animals are social by nature, and social isolation is a stressor (Gross and Siegel, 1981; Marsden and Wood-Gush, 1986). Where possible, agricultural animals should be housed in pairs or groups. Considerations involved in implementing social housing for agricultural animals are discussed by Mench et al. (1992). If social housing is not feasible because of experimental protocols or because of unpreventable injurious aggression among group members, singly housed animals should be provided with some degree of visual, auditory, and (or) olfactory contact with other members of their species. Socialization to humans and regular positive human contact is also beneficial for agricultural animals (Gross and Siegel, 1982; Hemsworth et al., 1986, 1993).

HUSBANDRY

Animal Care Personnel

The principal scientist or animal management supervisor should make all animal care personnel aware of their responsibilities both during normal work hours and emergencies. A program of special husbandry procedures in case of an emergency should be developed.

Observation

Animals in intensive accommodations should be observed and cared for daily by a trained and experienced caretaker. Animals may need to be observed more frequently under some circumstances (e.g., during parturition, postsurgical recovery, confinement in a metabolism stall, and recovery from illness). In enclosed accommodations, illumination 1 m above the floor at an intensity of 100 lux facilitates inspection. Observation procedures should not, of course, interfere with the objectives of the experiment or demonstration. Under range and pasture conditions, observations should be frequent enough to ensure animal health, to recognize the need for emergency action, and to ensure continuity of feed and water supplies. A disaster plan should be developed for responding to emergency weather or health situations (see Chapter 4).

Emergency, Weekend, and Holiday Care

There should be a means for rapid communication in case of an emergency. In emergency situations, institutional security and fire personnel should be able to contact the staff members responsible for the care of agricultural animals. Names and telephone numbers of those people should be posted prominently in the animal facility and listed with the security department or telephone center. The institution should provide for emergency services that can be contacted at any time by staff members.

In the event of weather conditions that make animal feeding temporarily impossible, every attempt should be made to provide animals with a continuous supply of water. Absence of feed for up to 48 hr during such weather conditions is not desirable, but should not irreversibly endanger the health of healthy, well-nourished juvenile and adult cattle, sheep, and swine. Feed should be provided within 24 hr to very young animals.

There should be continuity of daily animal care that includes weekends and holidays, unexpected absences of assigned personnel because of illness or other contingencies, other leave situations, and emergency conditions. Weekend staff should be qualified to perform assigned duties. A procedure should be established for providing emergency veterinary care after work hours, on weekends, and on holidays.

Animal Identification and Records

Animals should be identified by a permanent means. When possible, the identification system should be one that can be easily read. Birds may be wing-banded or leg-banded for individual identification, but in applied experiments they may instead be identified by group, cage, or pen. Several methods may be used for individual identification of larger animals. They may be ear-notched. Ear tattoos are permanent and effective but cannot be read without restraint of the animals. Electronic transponders require special sensor stations. Ear and neck chain tags are readable at some distance but can become lost. Neck chains and straps should be avoided in situations in which the animal could become inadvertently entangled in a fence, rock outcropping, or other feature of the environment. Cattle and horses may be identified permanently using freeze-branding on the hip, shoulder, rear leg, or side. Some states require that cattle be permanently identified by branding with a hot iron. However, this procedure is more stressful for the animals than freeze-branding (Lay et al., 1992). Details on methods of identification of cattle are presented by Absher et al. (1976), Battaglia and Mayrose (1981), and Ensminger (1983). The use of implanted electronic sensors to identify animals should be considered.

Individual records are needed for some animals. These records may include information such as birth date, sex, pedigree, origin, owner, location, body weight on specific dates, milk or egg production and composition, reproductive information, young produced, semen production and collection, and ultimate disposition. The records should also include vaccination dates, parasite control measures, blood tests, castration or spaying, and veterinary treatments, including dates, names of medications, and amounts and routes of administration, surgical procedures, and veterinary clinical information. Current nutritional information and previous nutritional history, when known, may be recorded. Pens, rooms, and other items may be identified to associate them with specific studies. The research protocol often dictates that other information be recorded as well.

Vermin Control

Programs should be instituted to control infestation of animal facilities by vermin (e.g., flies, mosquitoes, lice, mites, ticks, grubs, rodents, skunks, and pest birds such as starlings, pigeons, and sparrows). The most effective control in enclosed facilities prevents entry of vermin into the facility by screening openings and ceilings; sealing cracks; eliminating vermin breeding, roosting, and refuge sites; and limiting access of vermin to feed supplies and water sources. Building openings should be screened with 1.3-cm (.5-in) mesh, and ceilings with ridge vents should be screened with 1.9-cm (.75-in) mesh to minimize rodent and bird entry. Smaller mesh sizes are recommended where they will not interfere with airflow. Mesh may need to be installed along foundations below ground level, especially with wood foundations.

Pesticides should be used only as approved (Hodgson, 1980). Particular caution should be exercised with respect to residues in feedstuffs, which could injure animals and (or) eventually pass into the meat, milk, or eggs (Willett et al., 1981). Pesticides should be used in or around animal facilities only when necessary, only with the approval of the scientist whose animals will be exposed to them, and with special care. A pesticide applicator or a commercial service may be used.

In some regions, wildlife (e.g., skunks, raccoons, and foxes) and stray cats and dogs may spread zoonotic diseases, including rabies, to agricultural animals. In high risk locations, institutions should implement an educational program that includes training scientific and animal care personnel to recognize the signs of rabies in both wildlife and agricultural species and how to handle and report potentially rabid animals. Inoculation may be advisable for humans who may come into contact with animals in regions where rabies is endemic.

STANDARD AGRICULTURAL PRACTICES

Sometimes procedures that result in temporary distress and even some pain are necessary to sustain the long-term welfare of animals or their handlers. These practices include (but are not limited to) comb-, toe-, and beak-trimming of chickens; bill-trimming of ducks; toenail removal, beak-trimming, and snood removal of turkeys; dehorning and hoof-trimming of cattle; tail-docking and shearing of sheep; tail-docking, neonatal teeth-clipping, hoof-trimming, and tusk-cutting of swine; and castration of males and spaying of females in some species. Some of these procedures reduce injuries to humans and other animals (e.g., cannibalism, tail-biting, and goring). Castration, for example, reduces the chances of aggression against other animals. Bulls and boars also cause many serious injuries to humans (Hanford and Fletcher, 1983). Standard agricultural practices that are likely to cause pain should be reviewed and approved by the ACUC. Recommendations regarding these practices for the different species are found in Chapters 5 through 11.

The development and implementation of alternative procedures less likely to cause pain or distress are encouraged.

HANDLING AND TRANSPORTATION

Animal Handling and Restraint

Some aggressive behaviors of larger farm animals pose a risk to the health and well-being of both herdmates and human handlers. These behaviors may be modified or their impact reduced by a number of acceptable restraint devices (e.g., hobbles, squeeze chutes, and stanchions) and practices. Only the minimum restraint necessary to control the animal and to ensure the safety of attendants should be used.

Training of animal care personnel in handling procedures should include consideration of the well-being of the animals. During the handling and restraint of animals, care should be exercised to prevent injury to animals or personnel. Animals should be handled quietly but firmly. Properly designed and maintained facilities operated by trained personnel greatly facilitate efficient movement of animals.

Prolonged restraint of any animal must be avoided unless such restraint is essential to research objectives. The following are important guidelines for the use of animal restraint equipment:

- Animals to be placed in restraint equipment ordinarily should be conditioned to such equipment prior to initiation of the project, unless the preconditioning itself would increase the stress to the animals.
- The period of restraint should be the minimum required to accomplish the research or teaching objectives.
- Restraint devices should not be considered normal methods of housing, although they may be required for specific research and teaching objectives.
- Attention should be paid to the possible development of lesions or illness associated with restraint, including contusions, knee or hock abrasions, decubital ulcers, dependent edema, and weight loss. Health care should be provided if these or other serious problems occur, and, if necessary, the animal should be removed either temporarily or permanently from the restraint device.

Animals should be handled and restrained in facilities and by equipment appropriate for the species and procedure. For cattle, for example, a chute facility should be available (particularly one suited to obstetrical procedures, if appropriate). Unless they are very young or tame, calves restrained for routine procedures should be handled by means of a calf chute equipped with a calf cradle.

When animals refuse to move through facilities, use of a slapper, rattle paddle, streamers tied to the end of a stick or whip, or—as a last resort—an electric prod is appropriate, but efforts should be made to minimize the force required to move the animal. If excessive slapping or electric prodding is required routinely, then the personnel involved may be too anxious or inadequately trained in proper animal handling techniques; the facility may be designed improperly, having shadows, puddles, high contrasts in color or light, or other conditions that frighten the animals; or the animal may be sick or injured. When animals are being moved, a slow walk is preferred, especially during hot or humid weather or on slippery floors. In lanes and alleyways, special care should be taken to control the speed of the group and to prevent crowding or crushing at corners, gates, and other narrow features of the facility. The advantages and disadvantages of having sharp corners in the facility should be considered when new facilities are being built.

Roping of the cattle is necessary under certain conditions (e.g., in pastures when an animal needs treatment and no restraining facility is conveniently available). However, roping should be performed by trained and experienced personnel and in a manner that minimizes stress to both the individual and the total herd. For head restraint of cattle, a properly fitted rope halter is recommended. Nose tongs may be used on fractious animals in conjunction with other means of cattle restraint (e.g., squeeze chute), but nose tongs can slip and tear out of the nose, causing injury to both animal and personnel, and therefore are not recommended as a sole means of restraint. Electroimmobilization must not be used as a method of animal restraint; cattle and sheep find this procedure very aversive (Pascoe and McDonell, 1985; Grandin et al., 1986; Rushen, 1986).

Floors should provide secure footing to minimize slipping. Abrasive floor, chute, and wall surfaces should be avoided. However, concrete flooring may need to be grooved or roughened to provide secure footing (Albright, 1995). Animals should not be forced to walk toward apparent dangers that are likely to cause fear (e.g., change in light intensity, motion of people up ahead). Care should be exercised when mixing animals to minimize fighting, especially when animals are grouped together for the first time.

Animal handling facilities should be regularly cleaned after use and maintained in good working condition. Injuries and accidents can happen to animals and handlers from equipment lockup or other problems that can occur with build-up of filth, breakage, or wear and tear. Managers should routinely inspect the facilities to ensure cleanliness and to maintain a regular maintenance schedule based on use.

Transportation

The transport of livestock involves a complex of operations including handling, loading and unloading, unfamiliar environments, and—in some cases—isolation, social disruption, confinement, loss of balance, fluctuations in environmental temperature and humidity, exposure to pollutants (e.g., truck exhaust), feed and water deprivation, and other factors (Tarrant and Grandin, 1993). Hence, it is often difficult to determine with precision which component or combination of components is most responsible for transportation stress. Therefore, it becomes important to pay attention to all components and the potential for cumulative effects on the well-being of the animals to be transported. An in-depth review of livestock handling and transport research and recommendations for each species of livestock has been published (Grandin, 1993).

The safety and comfort of the animal should be the primary concerns in the transportation of any animal. Nonambulatory, weak, and unhealthy animals must not be loaded or transported unless necessary for medical attention. If animals become injured or nonambulatory during the course of transport, appropriate steps should be taken immediately to segregate such animals and care for their special needs. Specialized carts and sleds, canvas tarpaulins, or slide boards are recommended for off-loading nonambulatory animals. Animals must not be dragged, hoisted, or dropped from transport vehicles. If the animal cannot be removed with the use of recommended devices, then the animal should be euthanatized (see chapters 3 and 5 through 11) prior to removal (Grandin, 1991).

When animals are transported, they should be provided with proper ventilation and a floor surface that minimizes slipping. When possible, animals should be shipped in groups of uniform weight, sex, and species. Stocking densities affect stress-related plasma constituents and carcass bruising as well as behavioral parameters of cattle (Tarrant et al., 1988; 1992). Similar results have been found for swine (Lambooij and Engel, 1991) and other species. The minimum areas per animal for animals of different weights when shipped in groups are given in Table 2-1.

Animal injuries, bruises, and carcass damage can result from improper handling of animals during transport. Grandin (1980a) identified rough handling, mixing of animals of different sexes, horned animals, and poorly designed, maintained, and broken equipment as major causes of carcass damage in cattle. Recommendations for facility design, loading and unloading trucks, restraint of animals, and animal handling in abattoirs have been published (Grandin, 1980b; 1983a,b; 1992).

Transport and handling stresses can be aggravated greatly by adverse weather conditions, especially during rapid weather changes. Hot weather is a time for particular caution. The Livestock Weather Safety Index is used as the basis for handling and shipping decisions for swine during periods of weather extremes; values would be conservative for cattle (Grandin, 1981).

Animals should be protected from heat stress while in transit. Means of protection include shading, wetting, and bedding with wet sand or shavings when livestock are at high density (e.g., on a truck) and air speed is low (e.g., the truck is parked) during hot weather.

Table 2-1. Recommended Area Allowance in Transportation Accommodations for Groups of Animals Used in Agricultural Research and Teaching.[a]

Species	Average body weight		Area per animal			
	(kg)	(lb)		(m^2)	(ft^2)	
Cattle (calves)	91	(200)		.32	(3.5)	
	136	(300)		.46	(4.8)	
	182	(400)		.57	(6.4)	
	273	(600)		.80	(8.5)	
			Horned		Hornless	
			(m^2)	(ft^2)	(m^2)	(ft^2)
Cattle (mature fed cows and steers)	364	(800)	1.0	(10.9)	.97	(10.4)
	455	(1000)	1.2	(12.8)	1.1	(12.0)
	545	(1200)	1.4	(15.3)	1.4	(14.5)
	636	(1400)	1.8	(19.0)	1.7	(18.0)
			Winter		Summer	
Swine	45	(100)	.22	(2.4)	.30	(3.0)
	91	(200)	.32	(3.5)	.37	(4.0)
	114	(250)	.40	(4.3)	.46	(5.0)
	136	(300)	.46	(5.0)	.55	(6.0)
	182	(400)	.61	(6.6)	.65	(7.0)
			Shorn		Full fleece	
Sheep	27	(60)	.20	(2.1)	.21	(2.2)
	36	(80)	.23	(2.5)	.24	(2.6)
	45	(100)	.26	(2.8)	.27	(3.0)
	55	(120)	.30	(3.2)	.31	(3.4)
			Dimensions		Area	
			(m)	(ft)	(m^2)	(ft^2)
Horses	250 to 500	(550 to 1100)	.7 x 2.5	(2.3 x 8.2)	1.75	(18.8)
Foals (<6 mo)			1.0 x 1.4	(3.3 x 5.4)	1.4	(15.1)
Young Horses (6 to 24 mo)			.6 x 2.0	(2 x 6.6)	1.2	(12.9)
			1.2 x 2.0b	(3.9 x 6.6)	2.4	(25.8)

[a]Adapted from data of Grandin (1981, 1991, 1992, 1993) and Cregier (1982).

[b]For a journey longer than 48 hr, extra width for lying is required.

During transportation, animals should also be protected from cold stress. Wind protection should be provided when the effective temperature in the animal's microenvironment is expected to drop below the lower critical level. Adequate ventilation is always necessary. During cold weather, trucks transporting livestock should be bedded with a material having high thermal insulative properties (such as chopped straw) if the time the animals spend in the transport vehicle will exceed a few minutes.

Truck beds for livestock transport ordinarily should be clean, dry, and equipped with a well-bedded, nonslippery floor. Animals should be loaded and unloaded easily and promptly. Chutes should be well-designed for the animals being handled (Grandin, 1981, 1994). Animals should be transported at appropriate densities to reduce the chances of injury. The type of transport vehicle is also important with regard to differences between and within species of livestock. For example, depending on breed type, horses often have special transport requirements (Houpt and Lieb, 1993). Livestock should not be transported on trucks that do not have sufficient clearance to accommodate their height, as would be the case for horses transported on double-decked cattle trucks (Houpt and Lieb, 1993; Grandin, 1994).

Many teaching and research activities require the frequent transport of animals for short distances. As with transportation in all instances, vehicles should be of adequate size and strength for the animals carried and have adequate ventilation. Stock trailers and pickup truck beds fitted with stock racks are the most frequently used vehicles for short distance transport. The inside walls and lining of the vehicles should have no sharp edges or protrusions that would be likely to cause injury. Animals may be transported either loose in these vehicles or may be haltered and tied in the case of cattle, sheep, and horses. Only animals that have been previously trained to a halter and that are of a quiet disposition should be tied when transported. Animals should be tied with a quick release knot to the sides of the vehicle at a height that is approximately even with the top of the shoulder (withers). The tie should be short enough so that animals cannot step over the lead.

The condition of the animals should be checked periodically during transit. Drivers should start and stop the vehicle smoothly and slow down for curves and corners.

Unlike the loading ramp and chute system used for livestock, poultry are caught manually and loaded into transport crates that are then stacked on an open bed truck. Special attention to developing skilled staff for the catching, loading, and transport of poultry is important. Increased fear (Jones, 1992), leg breakage (Gregory and Wilkins, 1992), and mortality have been associated with poor catching and loading techniques (Nicol and Saville-Weeks, 1993). Also, poorly feathered birds have greater body heat loss than well-feathered birds. The thermal neutral zone ranges from 8 to 18ºC and 24 to 28ºC for well-feathered chickens and poorly feathered chickens, respectively, under typical transit conditions of low air movement and high humidity (Webster et al., 1993). Increased time in transit, feed and water deprivation, and fatigue cause increased death loss and stress. Therefore, these factors should be minimized.

SICK, INJURED, AND DEAD ANIMALS

Sick and injured animals should be segregated from the main group when feasible, observed thoroughly at least once daily, and provided veterinary care as appropriate. Incurably ill or injured animals in chronic pain or distress should be humanely euthanatized (see Chapter 3 and Chapters 5 through 11) as soon as they are diagnosed as such. Dead animals are potential sources of infection. Their disposal should be accomplished promptly by a commercial rendering service or other appropriate means (e.g., burial, composting, or incineration) and according to applicable ordinances and regulations. Post-mortem examination of fresh or well-preserved animals may provide important animal health information and aid in preventing further losses. When warranted and feasible, waste and bedding that have been removed from facilities occupied by an animal that has died should be moved to an area that is inaccessible to other animals.

SPECIAL CONSIDERATIONS

Noise

Noise from animals and animal care activities is inherent in the operation of any animal facility. Although acceptable noise levels are not well established, there are species and individual differences in the perceived loudness of the same sound (Algers et al., 1978a,b).

Noise ordinarily experienced in agricultural facilities generally appears to have little permanent effect on the performance of agricultural animals (Bond, 1970; NRC, 1970), although Algers and Jensen (1985, 1991) found that continuous fan noise disrupted suckling of pigs. Sudden loud noises have also been reported to cause hysteria in certain strains of chickens (Mills and Faure, 1990).

Metabolism Stalls and Other Intensive Procedures

Animals that are subjected to intensive procedures requiring prolonged restraint, frequent sampling, or other procedures experience less stress if they are trained to cooperate voluntarily with the procedure. Cattle, pigs, and other animals can be trained with food rewards to accept and cooperate with various procedures, such as jugular venipuncture (Panepinto, 1983; Calle and Bornmann, 1988; Grandin, 1989; Grandin et al., 1995).

Many studies of the nutrition and physiology of agricultural animals use a specialized piece of equipment, the metabolism stall. Successful designs have been reported for various species (Mayo, 1961; Welch, 1964; Baker et al., 1967; Stillions and Nelson, 1968; Wooden et al., 1970). These stalls give the animal research and care personnel easy access to the animal and its excreta.

The degree of restraint of animals housed in metabolism stalls is substantially different from that of other methods that restrict mobility (e.g., stanchions and tethering). Animals in metabolism stalls are often held by a head gate or neck tether and are restricted in their lateral and longitudinal mobility. These differences may exacerbate the effects of restriction on animals housed in metabolism stalls (Bowers et al., 1993). Metabolism stalls should be used only for approved studies, not for the purpose of routine housing. Researchers should consider appropriate alternatives to metabolism stalls (such as determination of digestibility by marker methods) if such alternatives are available.

There should be a sufficient preconditioning period (usually at least 5 days) to ensure adequate adjustment and comfort of the animal to the metabolism stall before sample collection starts. The length of the preconditioning period should be subject to approval of the ACUC. At least enough space should be provided in the metabolism stall for the animal to rise and lie down normally. When possible, metabolism stalls should be positioned so that the animal is in visual, auditory, and olfactory contact with conspecific animals to minimize the effects of social isolation.

Thermal requirements of animals may be affected when they are placed in metabolism stalls. For example, the lower critical environmental temperature of an animal held individually in a metabolism stall is higher than when residing in a group because the single animal cannot obtain the heat-conserving benefits of huddling with groupmates.

Animals in metabolism stalls should be observed more frequently than those in other environments, and particular attention should be paid to changes in behavior and appetite and the condition of skin, feet, and legs. The length of time an animal may remain in a metabolism stall before removal for exercise should be based on professional judgment and experience and be subject to approval by the ACUC. The species and the degree of restraint imposed by particular stall types should be taken into consideration in making such judgments. Recommendations for particular species can be found in the appropriate chapters of this *Guide*.

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Chapter 3: Agricultural Animal Health Care

Adequate agricultural health care involves a written and implemented program for disease prevention, surveillance, diagnosis, treatment, and end point resolution. The agricultural animal health care program is the responsibility of the attending veterinarian. The objectives of such a program are to minimize pain and suffering and to maintain animal health and production. Secondary objectives include the prevention of zoonoses and the avoidance of contaminants and residues in animal products. The program should include provisions for training animal users regarding humane restraint, anesthesia, analgesia, surgical and postsurgical care, and euthanasia.

The institution should provide investigators and teachers with access to a veterinarian who has experience in agricultural animal medicine. The veterinarian can be full-time or part-time and should have appropriate authority to ensure that the provisions of the program are sustained.

A mechanism of direct, frequent, and regular communication should be established among the personnel who are responsible for daily animal care and observation, the principal scientist, and the veterinarian. This mechanism will help to ensure that timely and accurate information on animal health problems is communicated among those concerned.

An important component of an agricultural animal health program is keeping records that can be used to monitor animal health events, levels of production, and the signs of injury and disease. The record system should include summaries of animal health and performance. The fundamental requirements include the following (Radostits et al., 1994b):

- Positive identification of individual animals or groups of animals.
- Suitable animal records for recording preventive medicine processes, signs, diagnoses, prognosis, treatments, major surgical procedures, and resolution of events, including necropsy observations and laboratory results.
- Maintenance of records that include treatment medications, dates of administration, medication names, dosage, route of administration, name of caretaker, and withdrawal times for any agents administered to the animals. Prescriptions should be attached to the records. It is advisable to retain a record of all medications purchased that documents the vendor supplying the products, date of purchase, production lot serial numbers, and expiration dates. This information is useful when it is necessary to appraise the cause of adverse reactions or product failure.
- Record of euthanasia, including the method and agent used.

The record system must be structured so that the information is easily collected, gathered, analyzed, summarized, and available to the principal scientist, the veterinarian, and the ACUC.

SIGNS OF PAIN AND DISTRESS

Pain is a sensation of discomfort that may lead to distress and feelings of urgency resulting from the stimulation of specialized nerve endings. In animals, pain is a condition that can often be measured by an observer with a knowledge of signs evidenced by the animal, although animals can experience pain without it being apparent to observers.

Pain is one of the earliest signs of disease or distress. The sensation depends on receptors located in the skin and deeper structures. The skin is sensitive to pricking, cutting, and heat or cold, whereas visceral pain is caused by local trauma or an engorged or inflamed mucosa, distention or spasm of smooth muscle, and traction upon mesenteric attachments. Local ischemia and prolonged contraction of muscles may also cause pain (Breazile and Kitchell, 1969).

Animals in pain may become listless, move constantly, continually get up and lie down, refuse to stay in one place, go off feed, grind their teeth, or vocalize in a particular manner. Some animals show a sluggish temperament, and others have a frightened expression, resist handling, and favor the painful area. Acute abdominal pain may cause an animal to assume an abnormal stance in an attempt to alleviate the pain.

Pain may not be noticed until a normal physiological act is induced, such as swallowing, coughing, chewing, defecating, or any bodily movement. The attendant should determine whether the pain is associated with a normal physiological act or is constant, even in the absence of a provoking act. Sudden acute pain is usually associated with fractures, rupture or torsion of visceral organs, acute inflammation, or the abrupt loss of blood (Sodeman and Sodeman, 1984).

There are a number of aspects to the problem of relieving pain in agricultural animals. Relief of the causative factor is important, and the attending veterinarian should institute remedial medical treatment when the causative factor can be accurately identified. Relief of pain should be one of the first tasks of the attending veterinarian, adhering to the following principles (Radostits et al., 1994a):

- Relief of pain is a humane act.
- Analgesia should not be used if it will obscure clinical signs that may be necessary to observe, to properly diagnose, or to maintain surveillance of a case. Relief

of pain must be initiated promptly following an accurate diagnosis.
- It may be necessary to protect the animal from massive self-injury.
- A major problem in the clinical management of pain is for cases of severe, slowly healing, infected traumatic wounds of the musculoskeletal system, especially in cattle and horses.

Tolerance of and response to pain vary widely, and the severity of a disease process, or of trauma, should not be judged only by the pain response of the animal. Detecting pain and monitoring the animal's attempts to alleviate the pain are ways of following the course of a disease process. The cause of pain should be determined, and the pain must be ameliorated. When possible, the animal care program should be altered to prevent or minimize the inciting cause of pain in agricultural animals used in research and teaching.

ANESTHESIA AND ANALGESIA

The proper provision of anesthetics and analgesics to research animals is necessary for both humane and scientific reasons. A veterinarian with extensive experience in the care of agricultural animals should advise research and teaching scientists concerning the choice and use of these drugs, including recommendations as to times for withholding food and water to minimize anesthetic risk. After being trained and subsequently supervised by a qualified scientist or veterinarian, qualified technical personnel may administer anesthetics and analgesics as part of a research or teaching protocol. If a painful experimental procedure must be conducted without the use of an anesthetic or analgesic because such use would defeat the purpose of the experiment, the procedure must be outlined and justified in the use protocol and approved by the ACUC.

Paralytic drugs (e.g., succinylcholine or other curariform drugs) are not anesthetics. They must not be used unless animals are under deep anesthesia and entirely unconscious. The use of paralytics must be justified in the research protocol and reviewed and approved by the ACUC.

Tranquilizers are psychotropic substances that alter mental processes or behavior but do not produce anesthesia (Upson, 1985). These medications should only be used to allay fear, anxiety, and nervous tension. Their application may render restraint less stressful and irritating and enable animals to adapt more easily to different or novel situations.

Tables of pre-anesthetics, anesthetics, anlagesics, and antiinflammatory substances that are appropriate for use in agricultural animals are provided in Appendix 2 Table A-2.

Certain animal husbandry procedures may be conducted without anesthetization of animals. (These standard agricultural practices are discussed in Chapters 1 and 2.) When conducted by trained and experienced personnel, those procedures are usually less stressful and painful than the trauma and risk of injury from restraint and anesthetization. All of these procedures should be conducted early in the life of the animals. These procedures should only be performed after the careful consideration and approval of the ACUC. When such procedures are to be performed on older animals, appropriate anesthesia should be induced, trauma minimized, and hemorrhage controlled. It is important that the husbandry guidelines be established to minimize stress, to prevent infection, and to ensure the comfort of the animals during the recovery period. Specific recommendations for each species are provided in Chapters 5 through 11.

SURGERY PERSONNEL

Inappropriate or inadequately performed surgical techniques or postoperative care constitutes unnecessary pain. Experimental surgery on agricultural animals should be performed or supervised by an experienced veterinary surgeon or animal scientist. Institutions must provide basic training and practice before experimental surgery is conducted. Training opportunities should be available to research assistants and animal care personnel to facilitate the upgrading of surgical skills and techniques. The training program should be under the direction of the experienced attending veterinarian or animal scientist, and documentation of the training provided must be maintained.

SURGICAL FACILITIES AND ASEPTIC TECHNIQUE

Major surgeries are those that penetrate and expose a body cavity or produce substantial impairment of physical or physiologic function. Major survival surgeries should be performed in facilities designed and prepared to accommodate surgery, and standard aseptic surgical procedures should be employed. Good surgical practice includes the use of surgical caps, masks, gowns, and gloves as well as appropriate site preparation and draping. Sterile instruments should be used. For nonsurvival surgeries, during which the animal is euthanatized before recovery from anesthesia, it may not be necessary to follow all of these techniques, but the instruments and surrounding area should be clean.

Minor surgical procedures that do not penetrate a body cavity or produce substantial impairment (e.g., wound suturing and peripheral vessel cannulation) may be performed under less stringent conditions if performed in accordance with standard veterinary practices (Brown et al., 1993).

Therapeutic and emergency surgeries (e.g., Caesarean sections, bloat treatment, and repair of displaced abomasum) are sometimes necessary in agricultural situations that are not conducive to rigid asepsis. However, every effort should be made to conduct minor and emergency surgeries in a sanitary and aseptic manner, and appropriate anesthetics, analgesics, and sedatives should be used commensurate with risks to the animal's well-being. Research and teaching protocols that carry a high likelihood of the need for emergency surgery should contain provisions for handling anticipated cases. Surgical packs and equipment for such events should be prepared and be readily available for emergency use.

POSTSURGICAL CARE

Appropriate facilities and equipment should be available for animals that are recovering from general anesthesia and major surgery. The following are required:

- Segregation from other animals.
- Clean and sanitary recovery area.
- Adequate space, with consideration for physical comfort and well-being of the animal in a place suitable for recovery from anesthesia without injury, including protective flooring.
- Environmental control sufficient to provide environmental temperature within the thermoneutral zone during postsurgical recovery.
- Trained personnel for postsurgical observation to help to ensure an uneventful recovery.

MULTIPLE MAJOR SURGICAL PROCEDURES

Performance of more than one major survival surgical procedure on a single animal is discouraged. Multiple survival surgical procedures might be justified when they are related components of the same project (e.g., cannulation of the digestive tract at several locations). Multiple procedures on an animal should be allowed only when scientifically necessary, justified in the protocol, and approved by the ACUC.

ANIMAL PROCUREMENT, QUARANTINE, AND STABILIZATION

When animals are acquired, particular attention must be paid to applicable regulations, especially those dealing with transportation and health. It is advisable to assess the health status of a vendor herd or flock prior to acquiring animals. Animals of unknown origin or from stockyards may pose special health risks and should be handled accordingly.

Quarantine is the separation of newly received animals from those already in the facility until the health of the new animals has been evaluated and found to be acceptable. Effective quarantine minimizes the introduction of disease agents into established animal flocks or herds. The principal scientist and attending veterinarian should formulate written policies to evaluate the health status of newly received animals under quarantine in accordance with acceptable veterinary practices and applicable regulations. Skilled personnel should perform the initial visual examination and subsequent daily observations.

Quality control by the vendor and knowledge of the history of the animals are part of an institutional quarantine program. Some experiments, such as studies of shipping fever, may require newly received animals. Other newly received animals, however, should be given a stabilization period prior to their use to permit physiological and behavioral adaptation.

When feasible or appropriate, animals should be observed in an isolated facility or a separate area or room for a quarantine period before being introduced into a herd or facility. Exceptions to this practice should be reviewed and approved by the attending or facility veterinarian. The quarantine period should be long enough to permit the appearance of disease signs or serologic titer in animals that may have been recently infected with a disease agent. The quarantine period should also allow time for treatment of potential diseases and parasites. Quarantine and testing of animals before introduction is particularly important for herds or flocks that have attained specific pathogen-free status. Attempts should be made to minimize the risk of introducing disease agents.

If the history of newly received animals is incomplete, the quarantine should be more comprehensive and of sufficient duration to allow expression of diseases present in the incubation stage.

BIOSECURITY

Research facilities should consider instituting rigorous biosecurity measures. Such measures will vary in rigor depending on the status of the animals housed (e.g., more rigor will be required for animals known to be free of specific infectious disease), but might include the following (Radostits et al., 1994b):

- Security fences and (or) entry alarm systems.
- Appropriate signs posted indicating restricted entry.
- No visitors allowed unless absolutely necessary.
- A shower-in and shower-out facility, with work clothing furnished by the institution.
- Rodent and bird abatement programs.
- Stray and wild animal trapping and relocation.
- A requirement that personnel coming into contact with the animals or facilities do not own or come into contact with animals that may harbor infectious disease agents that may be transferred to the research animals.
- A requirement that personnel who have delivered animals to markets or slaughterhouses must not enter the research facility for at least 24 hr.

SEPARATION BY SPECIES, SOURCE, AGE, AND HEALTH STATUS

Animals should ordinarily be separated into different pens according to species to reduce anxiety from interspecies conflict and to meet experimental and instructional requirements. In extensive production situations, mixing of compatible species (e.g., sheep and cattle) may be appropriate. Some species carry subclinical or latent infections that, when transmitted to other species, can cause clinical disease and sometimes death.

Separation of individuals or groups of the same species from one another is advisable when animals are obtained from multiple sources because those animals often differ in microbiological status.

Separation of groups of animals of different ages may be advisable for disease control or control of social interactions, particularly when there is a large difference in the size of the animals. Groups of the same age or same size may allow more uniform access to feed and may also reduce injuries. All-in, all-out schemes are examples of age group separation and are designed to minimize disease risks. However, group housing and mixed age groups are acceptable if disease risk is low or disease is being controlled by other means and if social interaction is acceptable or desirable.

RESIDUE AVOIDANCE

Drug administration to experimental animals destined to enter the food chain requires special consideration. Before animals may be slaughtered for human food purposes, time must be allowed for medicaments, drugs approved by the FDA, or substances allowed by the FDA for experimental testing under the INAD exemption to be depleted from the tissues. Such use is only permitted when it adheres to the regulations in the Animal Medicine Drug Use Clarification Act of 1994 (Federal Register, 1996). A record of the product used, dose, route of administration, duration of treatment, name of caretaker, and period of withdrawal must be maintained, and the proper withdrawal time must be ensured, before the animals are transported to the auction market or the abattoir. In addition, records of all potentially harmful products used in the facility, their storage, their use, and their disposal must be maintained. Such record keeping should be similar to the quality assurance programs used by responsible farmers and ranchers in the food animal industries. Records should be maintained for 3 mo.

Food animal industries have developed quality assurance programs (e.g., the Milk and Dairy Beef Quality Assurance Program, the Beef Quality Assurance Program, the United Egg Producers Five Star Quality Assurance Program, the Pork Quality Assurance Program, and the Veal Producer Quality Assurance Program). Agricultural researchers and teachers using animals that may be slaughtered for human consumption should institute quality assurance programs that are equivalent or superior to those used in the food animal industries.

Residues of three groups of chemicals must be prevented from occurring in research animals if those animals or their products are going into the human food chain. They are (1) approved drugs used according to directions on the label, (2) drugs used in an extralabel fashion, and (3) other chemicals such as some drugs, herbicides, pesticides, and wood preservatives.

The FARAD is a project sponsored by the USDA and Extension Service that originated with the Residue Avoidance Program in 1982 (Crosier et al., 1996). The FARAD Compendium of FDA Approved Drugs provides information about drugs that are available for treating animal diseases and the withholding times for milk and eggs and preslaughter withdrawal times for meat. Information about the drugs approved for use in food animals in the US is included in this on-line database. The Compendium allows the selection of over-the-counter products that satisfy particular needs or alerts to the need for veterinary assistance with prescription drugs.

If used in accordance with the label and with allowance for the correct withdrawal time, approved drugs should not leave violative residues beyond the stated withdrawal time. Record keeping and management should confirm on audit that the drugs are not outdated and that the directions on the label have been followed.

In the event that animals are given a new animal drug for investigational purposes, no meat, eggs, or milk from those animals may be processed for human food unless authorization has been granted by FDA or USDA and an appropriate INAD exemption from FDA has been obtained for use of the investigational drug. In such cases, the investigator must follow specifications outlined in the INAD. The authorization to process meat, eggs, or milk from such animals for human food will depend on the development of data to show that the consumption of food from animals so treated is consistent with public health considerations and that the food does not contain the residues of harmful drugs or their metabolites. In the event that animals are given a new animal drug (21CFR 511 and 514; CFR, 1987), no meat, eggs, or milk from those animals may be processed for human food consumption under any circumstances. Proper methods of disposal of such meat, eggs, and milk may include incineration, burial, or other procedures ensuring safety, sanitation, and avoidance of the human food supply.

The use of different dosages, formulations, or routes of administration, or the treatment of animals for conditions not specifically mentioned on the product label, constitutes extralabel use. Such use may be considered by licensed veterinarians when the health of animals is immediately threatened and when suffering or death would result from failure to treat the affected animals. Such use is only permitted when it adheres to the regulations promulgated by the FDA under the Animal Medicinal Drug Use Clarification Act of 1994. The major principles guiding such use are that (1) there must be a valid relationship between veterinarian, client, and patient, and (2) there must be an adequate safety margin in the withdrawal time that is based on the most complete pharmacokinetic data available.

Additional criteria that need to be met and precautions to be observed are detailed in FDA Compliance Policy Guide 7125.06 *Extra-Label Use of New Animal Drugs in Food Producing Animals* (1992; regulations to be issued as part of the Animal Medicine Drug Use Clarification Act of 1994).

There are many chemicals used on farms and in agricultural research establishments that could potentially result in residues in the meat, milk, or eggs of animals exposed to these chemicals. Examples are pesticides for insect control, herbicides, poisons for rodent control, wood preservatives, disinfectants, and many other compounds. Harmful products should be properly labeled and stored, a record of their purchase and expiration dates should be kept, and personnel should be informed of potential hazards and wear appropriate protective equipment. Chemicals should be stored, used, and disposed of in a manner to prevent contamination of animals and residues in milk, meat, or eggs.

PHYSICAL RESTRAINT

Brief physical restraint of agricultural animals for examination, collection of samples, and a variety of other experimental and clinical manipulations can be accomplished manually or with devices such as restraint stocks, head gates, stanchions, or squeeze chutes. It is important that such devices be suitable in size and design for the animal being held and be operated properly so as to minimize stress and to avoid pain and injury (Battaglia and Mayrose, 1981; Ensminger, 1983; Grandin, 1983). Refer to Chapter 2 for additional information.

EUTHANASIA AND SLAUGHTER

Euthanasia is the procedure of killing an animal rapidly, painlessly, and without distress. Euthanasia should be carried out by trained personnel using acceptable techniques in accordance with applicable regulations and policies. The method used should not interfere with post-mortem evaluations. Proper euthanasia involves skilled personnel to help ensure that the technique is performed humanely and effectively and to minimize risk of injury to people. Personnel who perform euthanasia must have training and experience with the techniques to be used. This training and experience must include familiarity with normal behavior of agricultural animals and how handling and restraint affect their behavior. The equipment and (or) materials required to perform euthanasia should be readily at hand, and the attending veterinarian or a qualified animal scientist should ensure that all personnel performing euthanasia have demonstrated proficiency in the use of the techniques selected.

The techniques for euthanasia should follow current guidelines established by the AVMA (1993), and these guidelines should be made available to all personnel who euthanatize animals. The agents and methods of euthanasia appropriate for agricultural animals are listed in Appendix 2 Table A-3 and are also detailed in Chapters 5 through 11.

Acceptable methods of euthanasia are those that initially depress the central nervous system to ensure insensitivity to pain (Canadian Council on Animal Care, 1980). Euthanasia techniques should result in rapid unconsciousness followed by cardiac or respiratory arrest and the ultimate loss of brain function. In addition, the technique used should minimize any stress and anxiety experienced by the animal prior to unconsciousness (AVMA, 1993). For this reason, anesthetic agents are generally acceptable, and animals of most species can be quickly and humanely subjected to euthanasia with the appropriate injection of an overdose of a barbiturate. Certain other methods may be used for euthanasia of anesthetized animals because the major criterion (humane treatment) has been fulfilled (Lucke, 1979).

Physical methods of euthanasia (e.g., penetrating captive-bolt devices for large animals) may be used. Every attempt should be made to minimize stress to the animal prior to euthanasia.

Electrocution is an acceptable means of euthanasia if the electrodes are placed so that the current travels through the brain and through the heart. Methods in which the current is directed through the heart only are not acceptable. It is important to ensure that the animal is indeed dead (i.e., no heartbeat and no possibility of recovery).

Agents that result in tissue residues cannot be used for euthanasia of animals intended for human or animal food unless those agents are approved by the FDA. Carbon dioxide is the only chemical currently used for euthanasia of food animals (primarily swine) that does not lead to tissue residues. The carcasses of animals euthanatized by barbiturates may contain potentially harmful residues and should be disposed of in a manner that prevents them from being consumed by human beings or animals.

Slaughter of animals entering the human food chain must be accomplished in compliance with regulations promulgated under the Federal Humane Slaughter Act (CFR, 1987).

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Chapter 4: Physical Plant

Sound animal care depends on a well-planned and properly maintained animal facility. The efficiency, economy, and functionality of the facility are influenced greatly by the design, maintenance, and operation of the structure and its equipment. The scope and types of planned agricultural research and teaching activities have an important impact on the size and design of a facility. Factors include the physical relationship of the facility to the institution or firm, animal species to be accommodated, and geographic location.

An agricultural engineer, professionally registered or eligible to be registered and with training and experience with agricultural animal facilities, should provide input on major construction and remodeling projects to design a workable and efficient physical plant. Animal scientists and veterinarians should also contribute to the design process. An agricultural engineer should be available for advice on maintenance and operation of the physical facilities.

Agricultural animal facilities should conform to applicable building codes unless deviations and variances are justified for research and teaching.

Security should be provided to protect facilities against break-ins by people and break-outs by animals. In addition, security alarms are needed to protect animals against equipment failures, power outages, and threatening environmental conditions such as smoke or temperature extremes.

LOCATION OF FACILITIES

Where agricultural animals are housed in fully enclosed buildings and there is need for nearby personnel facilities (e.g., offices, conference room, or preparation laboratory), animal houses and personnel facilities should be separated for expansion space and odor and pest control. Where agricultural animals are confined using fences or open shelters, enclosed buildings for staff and students may not be needed. Regardless of the degree of animal housing and environmental modification used, animal facilities should be designed to provide sound animal husbandry, maximal safety for animal care personnel, and efficient animal care. Vehicle access, feed and water supply, utility services, drainage, manure containment, expansion space, and aesthetics are other important considerations in locating facilities (MWPS, 1983).

FUNCTIONAL AREAS

Most research and teaching uses of agricultural animals require space for the animals to eat, drink, rest, sleep, and move about. In addition, space should be sufficient for the staff and equipment necessary for feeding and watering, waste removal, medical treatment, and other husbandry procedures. Provisions should be made for maintenance and repair of the equipment used for effective husbandry. Planning should also include provisions for delivering necessary husbandry services (e.g., feed, water, and waste removal) on a temporary basis when the regular equipment fails or is shut down for repair.

Some functional areas needed for the care of agricultural animals may be used only periodically for their designed function, but, at other times, may be part of a multipurpose area. Additionally, some situations do not require space for all possible operations. Professional judgment should be used when facilities are being designed to provide the appropriate functional areas or their substitutes. Nonetheless, agricultural animal operations generally require space for the following:

- animals (fenced, penned, or enclosed areas with waterers and feeders);
- water supply (animal, sanitation, fire, and emergency);
- feed storage between deliveries;
- electrical service (including an emergency generator);
- waste storage (excreta and contaminated drainage water);
- animal shelter (from excessive solar radiation, wind, rain, and snow);
- storage of equipment to handle feed and waste;
- storage of small tools and repair of equipment;
- veterinary examination, treatment (including surgery and necropsy), and supply storage;
- quarantine of animals;
- handling, sorting, weighing, loading, and unloading animals;
- research activities (instruments, laboratory, office, record keeping, and specific protocol needs);
- teaching activities (observing, individual handling, and discussion); and
- young animals.

In some facilities, space may also be needed for the following:

- bedding storage;
- storage of toxic materials and hazardous substances;
- semen collection, storage, and artificial insemination;
- experimental surgery (including preoperative preparation and postoperative recovery);
- chick hatching;
- work animals (e.g., horses and dogs);
- maternity care;

- species separation;
- sick and injured animals;
- slaughter and processing facilities; and
- carcass composting.

Additional functional areas may be needed when the teaching and research facility is remote, when required by local codes, or when needed for institutional efficiency. Such areas may include administrative offices and reception area; toilets, showers, and lockers; lunch room; animal or equipment cleaning; feed processing; hazardous waste storage; supplies receiving and shipping; and vehicle parking.

CONSTRUCTION GUIDELINES

Publications of the MWPS, the NRAES, and other organizations provide guidance on planning, specifications, cost estimation, and construction of commercial agricultural animal facilities in different parts of the United States. Appropriate local codes and zoning provide additional guidelines.

The selection of and specifications for functional and economical building materials should consider conditions of use common to various parts of the facility, including the following:

- animal impacts and behavior that may lead to structural damage (e.g., chewing, mounting, fighting, kicking, and escape attempts);
- animal traction and safety;
- contact time with wet and corrosive animal wastes, acidic silage, or cleaning solutions;
- moisture and fire resistance;
- personnel protection and safety;
- light reflectance;
- surface cleanability and sanitation;
- absence of stray voltage and proper grounding of electrical equipment;
- vermin control;
- waste handling; and
- sanitary requirements for food products (e.g., milk, meat, and eggs).

MATERIALS

Building materials should be selected to facilitate efficient and hygienic operation of agricultural animal facilities. Durable materials that are resistant to moisture and to fire are most desirable for interior surfaces. Unpainted wood is acceptable for most applications, except when treatment for structural damage and insects is not possible and the wood is in direct contact with the ground. 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 (MWPS, 1983).

MAINTENANCE OF FACILITIES

Physical facilities that support agricultural research and teaching programs should be well-maintained. The physical plant should be in good repair, and the grounds should be free of trash, which injure animals (e.g., foot trauma or hardware disease).

CORRIDORS AND DOORS

When used, corridors should be wide enough to facilitate the movement of animals, personnel, and equipment. Doors vary in size according to the function they serve. In enclosed facilities, doors should fit tightly within their frames, and both doors and frames should prevent the entrance or harboring of vermin. Exterior doors should be equipped with locks.

FLOORS AND WASTE HANDLING

Dirt floors are acceptable in sunshades, open (run-in) sheds, pens, or shelters where climate, animal use, and management intensity permit a firm, dry, easily cleaned base support. Floors in barns should be relatively slip-free; not excessively abrasive to animals' feet; and resistant to wear, corrosion, moisture, and manure. Uniform slopes (1 to 4%) for drainage and an appropriate concrete finish should be provided for animal traffic areas. Slip-resistant grooves should be provided for ramps (sloping 5 to 15%), for concrete floors, and for other floors where slipping and falling may take place. Cleat spacing is an important factor in determining appropriate ramp slopes (Phillips et al., 1988, 1989; Grandin, 1993).

The finish of concrete floors on which animals walk is critical. Diamond grooves 1.3 cm deep × 10.2 cm (.5 in deep × 4 in) are preferred. A coarse wood float finish with the approximate texture of coarse sandpaper is acceptable. Polished steel-troweled finishes are slippery and only acceptable for dry areas (Applegate et al., 1988; MWPS, 1989a).

Waste handling systems should be considered as part of the floor design. Manure slots and gutters should be sized and spaced to prevent hoof or ankle injury of animals occupying the facility. Slotted floors and grates separate animals from their excreta and are an integral part of several acceptable and desirable waste handling systems. Other systems utilize mechanical scrapers or hydraulic flushing to clean the floors, gutters, or manure channels. Open lagoons and waste storage ponds should be surrounded by a security fence.

Solid floors used as resting or recovery areas for some species should be covered with a cushion of dry, absorbent bedding or rubber mat to reduce skin irritation from concrete, urine burn, or manure caking on the body surface. The amount and type of bedding used should be compatible with the waste-handling system.

Acid-resistant plastic overlays or ceramic tiles may be desirable for silage mangers, milking room floors, and other special areas. Resilient plastic or rubber mats are desirable for areas such as work stations, animal-holding stalls, and treatment pens.

WALLS AND CEILINGS

Walls and ceilings enclose interior space for security and environmental modification but may be unnecessary or undesirable for some animal shelters or storage buildings. The degree of environmental modification specified by the user directly affects the thermal resistances; moisture permeabilities; surface finishes; openings for doors, windows, vents, and fans; and lighting equipment chosen by the designer for walls and ceilings. Surfaces should be easy to clean and resistant to damage from animal contact and impact where these normally occur.

ENVIRONMENTAL MODIFICATION SYSTEMS

Environmental modification systems for agricultural animal facilities range from negligible (e.g., fenced pasture with no additional shelter) to complex. The system should be appropriate for the animal species and ages and the local climatic conditions. In enclosed structures, the system should be capable of maintaining environmental conditions within an acceptable range (Chapter 2 and Chapters 5 though 11; MWPS, 1983).

There are two basic housing categories for cold weather housing of agricultural animals, cold housing and warm housing. Proper design of each is critical to provide an acceptable microenvironment. Although all species can be housed in either kind of house, certain species normally receive better husbandry in one kind than in the other in a specific climatic region. In some parts of the United States, cattle, horses, sheep, and goats are better served year-round by cold housing systems, and poultry and swine are better served by warm housing systems. Newborn animals of all species have special environmental requirements, especially during cold periods.

Cold Housing

Cold housing systems provide primary environmental modifications and are designed to protect the animals from solar radiation, wind, snow, rain, and other hot and cold weather extremes. Cold houses usually provide the animals with a microenvironmental temperature that is no more than 5°C above the outdoor temperature. Strategically placed openings throughout the shelter must be provided to ensure that ventilation is adequate to control water vapor. For hot weather operation, the shelter acts as a sunshade, and additional openings then facilitate natural air movement through the animal space. Mechanical fans are sometimes used to augment air movement in hot weather (MWPS, 1989b).

Warm Housing

Warm housing involves either mechanical ventilation with fans and controls, natural ventilation with controlled openings, or combinations of the two. Ventilation is designed to provide acceptable air quality, humidity, and thermal conditions for a specific species (MWPS, 1990).

Sensors. Sensors used to regulate an environmental modification system should be located and operated to monitor conditions representative of the animal microenvironment. Sensors should perform satisfactorily in agricultural animal environments and be calibrated and maintained regularly.

Controllers. Controllers should be staged properly for effective use of heating, ventilating, and cooling equipment. Written instructions for the proper operation and sequencing of controllers should be provided to animal care personnel and be readily available near the controllers. When the ventilation system depends on fans or power-controlled openings, a warning device is needed to alert the building operator to a power interruption. A standby, automatic electric generator or automatically opening wall ports are needed to protect animals if the warning device does not reliably reach personnel who can attend to the animals' survival. It is important that electric generators and other emergency equipment be checked regularly to ensure that they are operational.

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Chapter 5: Guidelines for Beef Cattle Husbandry

Beef cattle refers to all animals of the genus *Bos* and their close relatives that are raised primarily for meat production (see Chapter 11 for veal calf production). As ruminants, beef cattle are capable of utilizing a wide range of feedstuffs and consequently are maintained in an array of situations ranging from extensive grazing to confined feedlot pens and intensive laboratory environments. Regardless of the housing system, basic needs for food, water, shelter, and comfort should be met.

FACILITIES AND ENVIRONMENT

Range and Pasture Systems

Systems for grazing beef cattle on pasture and rangeland vary widely; hence, establishing uniform guidelines for the care of such animals is difficult. Locally accepted standards of care for grazing beef cattle should be given consideration, but the standards for herd health, husbandry procedures, and cattle working facilities that are discussed in other sections of this chapter are appropriate guidelines for grazing beef cattle.

Availability of fresh water is critical for grazing beef cattle, and distance to water should be given consideration in pasture and range systems. If cattle are required to travel long distances to water in hot, dry climates, animal performance and utilization of pasture forage can be affected (Fusco et al., 1995). Holechek et al. (1995) recommended that distance to water be no greater than 1.6 km (1 mi) in rolling, hilly country and in undulating, sandy terrain. This recommendation was decreased to .8 km (.5 mi) in rough country; increased to 2.4 km (1.5 mi) in smooth, sandy terrain; and increased to 3.2 km (2 mi) in areas with flat terrain.

Special consideration needs to be given to environmental factors that affect grazing beef cattle. In areas where heat stress is common, provision of shade (preferably trees) to decrease the solar heat load is the most practical intervention in pasture and range systems. The need for artificial shade should be assessed after careful consideration of naturally occurring sources. Heat stress typically is evidenced by increased mean and amplitude of body temperature (Hahn, 1995). Decreased feed intake (Robertshaw, 1987) and changes in body weight and condition can be used as indicators to monitor prolonged heat stress of grazing livestock. In areas where exposure to extreme cold is likely, provision of shelter for grazing beef cattle may be desirable. Grazing beef cows decrease grazing time and forage intake as ambient temperature decreases below 0°C (Adams et al., 1986), although such changes are small in adapted beef cows (Beverlin et al., 1989). Cattle use windbreaks to decrease wind chill and prevent exposure to blowing snow, although it has not been clearly established that windbreaks improve animal performance (Krysl and Torell, 1988). Supplementary feed is needed during periods of heavy snow cover that preclude grazing.

An adequate supply of forage should be available to grazing cattle. Intake and performance may be decreased when the amount of standing forage is low (NRC, 1987), but the appropriate quantity of forage dry matter per hectare varies with the pasture or range type and the stocking rate. Guidelines for acceptable amounts of standing forage per unit of body weight at given stocking rates (herbage allowance) are available (NRC, 1987), but additional research is needed with a variety of pasture and range types. Locally accepted standards of available forage and stocking rate should be considered. Grazing beef cattle should be provided with supplements for nutrients that are known to be deficient in pasture and range forage in particular localities.

Observation and monitoring of range cattle often occur less regularly than for other livestock. When supplemental feed is provided, cattle are usually observed at least two or three times weekly. Unsupplemented cattle on open range may be observed less frequently. It is recommended that range cattle be observed at least once per week or more often as dictated by local standards and existing environmental conditions. The use of implanted electronic sensors should be considered.

In certain areas, grazing beef cattle may be affected by predators and poisonous plants. Careful attention should be given to such problems, and efforts should be made to decrease or eliminate these adverse conditions.

Feedlot and Housing Systems

Beef cattle used in research or teaching may be housed in intensive management systems, either indoors or in open lots, with or without shelter. Facilities for beef cattle should provide cattle with opportunities for behavioral thermoregulation (e.g., access to a windbreak, sunshade, mound, or roofed shelter).

Proper airflow and ventilation are essential in intensive facilities. In feedlots, cable or wire fencing has minimal effect on natural airflow in summer. However, high airflow rates are undesirable during periods of low temperature, and tree shelterbelts and other types of windbreak can decrease the rate of airflow past the cattle. An 80% solid windbreak 3 m high (10 ft; minimum recommended height) decreases wind speed by half for about 45 m (150 ft) downwind and controls snow for about 8 m (25 ft); a similar windbreak 4 m high (13 ft) decreases wind speed by half for about 65 m (200 ft) downwind and controls snow for about 10 m (30 ft). A windbreak is recommended in mounded, south-sloping feedlots in the northern United States to provide dry resting areas with low air velocities.

During extreme heat, some means to provide cooling may be needed. Direct wetting of cattle during extreme heat is a very effective practice and is often used as an emergency measure. As a routine protective practice, wetting can be efficiently accomplished by sprinkler nozzles that have a capacity of 10 to 20 L/hr (2.6 to 5.3 gal/hr) and are controlled by a timer to provide 5 to 10 min of spray during each 20- to 30-min period. Fogger nozzles are often mistakenly recommended for wetting animals, but fogger nozzles are less effective than sprinkler nozzles because the fine droplets cling to the outer hair coat of the animal, causing the heat for evaporation to come from the air rather than from the body.

Sunshades for cattle can provide the margin of survival for animals that are unconditioned to a sudden heat wave (Hahn, 1995). Shades should be 3.6 to 4.2 m (12 to 14 ft) high in areas with clear, sunny afternoons (e.g., southwestern United States) to permit maximum exposure to the relatively cool northern sky, which acts as a radiation sink. In areas with cloudy afternoons (e.g., eastern United States), shades 2.1 to 2.7 m (7 to 9 ft) in height are more effective, as they limit the diffuse sky radiation received by animals beneath the shades. The amount of shade needed for young cattle is .7 to 1.2 m^2 (7.5 to 13 ft^2) per animal, and larger cattle need 1.8 to 2.5 m^2 (19.4 to 27 ft^2) per animal. Shades are strongly recommended for sick cattle or for animals in hospital pens. Under conditions of heat stress, water requirements of cattle are increased dramatically, and increased access to water should be considered.

Cold housing (see Chapter 4) can be provided for beef cattle. One or more sides are typically open (usually the south or east, depending on prevailing winter winds in the locale). Such structures are ventilated by natural airflow, and the resultant winter temperatures are typically 2 to 5°C above outdoor conditions as a result of body heat. Totally enclosed housing requires ventilation to maintain the air temperature at acceptable levels and to minimize the accumulation in the air of water vapor, noxious gases, other odorous compounds, and dust. Ventilation systems may be either natural or mechanical.

Type of pen surface affects dustiness during hot dry weather and muck build-up during wet periods. Good drainage in outside pens is imperative, and dirt pens should be maintained to minimize accumulation of water. Mounds should be provided in dirt pens for cattle to lie on during inclement weather (Table 5-1). A hard surface apron in front of the feed bunks and around water troughs and shelters should be considered in dirt pens.

For hard-surfaced pens, materials should be durable, slip-resistant, impervious to water and urine, easily cleaned, and resistant to chemicals and corrosion from animal feed and waste. Concrete floors should be scored or grooved during construction to improve animal footing (Chapter 4). Properly designed slotted floors are self-cleaning. Fences, pen dividers, walls, gates, and other surfaces must be strong enough to withstand the impact of direct animal contact. Configuration and treatment of contact surfaces must minimize or eliminate protrusions, changes in elevation, and sharp corners to minimize bruising and injuries and to improve the efficiency of cattle handling.

Proper lighting permits inspection of animals in feedlots and other cattle housing systems and provides safer working conditions for animal care personnel. Maintenance of facilities (e.g., repair of fences and equipment) should be timely and ongoing.

Floor or Ground Area

Area recommendations for open lots and barns are listed in Table 5-1. Every animal should have sufficient space to move about at will, adequate access to feed and water and a dry resting site, and the opportunity to remain reasonably clean. Recommended area alone does not ensure that these conditions are met; conversely, in some cases these conditions can be met with less than the recommended area. The amount of area required is affected by type and slope of floor or soil surface, amount of rainfall, amount of sunshine, season, group size, and method of feeding.

Open feedlot pens need to be sloped to promote drainage away from feedbunks, waterers, pen dividers, and resting areas. Space allocations are related directly to slope. In temperate midwestern climates, the following relationships have been found to be workable (MWPS, 1987): 2% slope, 37 to 74 m^2 per animal (400 to 800 ft^2 per animal); 2 to 4% slope, 23 to 37 m^2 (250 to 400 ft^2); and 4% or greater slope, 14 to 23 m^2 (150 to 250 ft^2). Space allocations can be less in drier parts of the country. In the Southwest, at 0% slope, typical allocations are 14 to 23 m^2 per animal (150 to 250 ft^2 per animal). In other regions, space allocations may need to be increased above midwestern norms in consideration of such factors as soil type and rainfall distribution.

The area requirements for cattle are greatly influenced by group size. One animal housed separately in a pen requires the greatest amount of floor area on a per animal basis. As group size increases, the amount of area required per individual decreases. When an animal is housed individually, the minimum pen width and length should be at least equal to the length of the animal from nose tip to tailhead when the animal is standing in a normal erect posture.

Acceptable indoor pen floor surfaces for beef cattle include unfinished concrete, grooved concrete, concrete slats, expanded metal, plastic-covered metal flooring, and rubberized mat. The floor surface in stanchions and metab-

Table 5-1. Floor or Ground Area and Feeder Space Recommendations for Beef Cattle Used in Agricultural Research and Teaching.[a,b,c]

Area or space	Calves, 180 to 380 kg (400 to 800 lb)		Finishing cattle, 360 to 545 kg (800 to 1200 lb)		Bred heifers, 360 kg (800 lb)	
	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)
Floor or ground area						
Open lots (no barn)						
Unpaved lots with mound (includes mound space)	14.0 to 28.0	(150 to 300)	23.2 to 46.5	(250 to 500)	23.2 to 46.5	(250 to 500)
Mound space, 25% slope	1.9 to 2.3	(20 to 25)	2.8 to 3.3	(30 to 35)	2.8 to 3.3	(30 to 35)
Unpaved lot, 4-8% slope, no mound	28.0 to 55.8	(300 to 600)	37.2 to 74.4	(400 to 800)	37.2 to 74.4	(400 to 800)
Paved lot, 2-4% slope	3.7 to 4.7	(40 to 50)	4.7 to 5.6	(50 to 60)	4.7 to 5.6	(50 to 60)
Barns (unheated cold housing)						
Open front with lot	1.4 to 1.9	(15 to 20)	1.9 to 2.3	(20 to 25)	1.9 to 2.3	(20 to 25)
Enclosed, bedded pack	1.9 to 2.3	(20 to 25)	2.8 to 3.3	(30 to 35)	2.8 to 3.3	(30 to 35)
Enclosed, slotted floor	1.1 to 1.7	(12 to 18)	1.7 to 2.3	(18 to 25)	1.7 to 2.3	(18 to 25)
	(cm)	(in)	(cm)	(in)	(cm)	(in)
Feeder space when fed						
Once daily	45.7 to 55.9	(18 to 22)	55.9 to 66.0	(22 to 26)	55.9 to 66.0	(22 to 26)
Twice daily	22.9 to 27.9	(9 to 11)	27.9 to 33.0	(11 to 13)	27.9 to 33.0	(11 to 13)
Free choice grain	7.6 to 10.2	(3 to 4)	10.2 to 15.2	(4 to 6)	10.2 to 15.2	(4 to 6)
Self-fed roughage	22.9 to 25.4	(9 to 10)	25.4 to 27.9	(10 to 11)	27.9 to 30.5	(11 to 12)
	Cows, 455 kg (1000 lb)		Cows, 590 kg (1300 lb)		Bulls, 680 kg (1500 lb)	
	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)
Floor or ground area						
Open lots (no barn)						
Unpaved lots with mound (includes mound space)	18.6 to 46.5	(200 to 500)	28.0 to 46.5	(300 to 500)	46.5	(500)
Mound space, 25% slope	3.7 to 4.2	(40 to 45)	3.7 to 4.2	(40 to 45)	4.7 to 5.6	(50 to 60)
Unpaved lot, 4-8% slope, no mound	32.5 to 74.3	(350 to 800)	32.5 to 74.3	(350 to 800)	74.3	(800)
Paved lot, 2-4% slope	5.6 to 7.0	(60 to 75)	5.6 to 7.0	(60 to 75)	9.3 to 11.6	(100 to 125)
Barns, (unheated cold housing)						
Open front with lot	1.9 to 2.3	(20 to 25)	2.3 to 2.8	(25 to 30)	3.7	(40)
Enclosed, bedded pack	3.3 to 3.7	(35 to 40)	3.7 to 4.7	(40 to 50)	4.2 to 4.7	(45 to 50)
Enclosed, slotted floor	1.9 to 2.3	(20 to 25)	2.0 to 2.6	(22 to 28)	2.8	(30)
	(cm)	(in)	(cm)	(in)	(cm)	(in)
Feeder space when fed						
Once daily, limited feed access	61.0 to 76.2	(24 to 30)	66.0 to 76.2	(26 to 30)	76.2 to 91.4	(30 to 36)
Twice daily, limited feed access	30.5 to 38.1	(12 to 15)	30.5 to 38.1	(12 to 15)	. . .	. . .
High concentrate diet, ad libitum	12.7 to 15.2	(5 to 6)	12.7 to 15.2	(5 to 6)	. . .	. . .
High forage diet, ad libitum	30.5 to 33.0	(12 to 13)	33.0 to 35.6	(13 to 14)	. . .	. . .

[a]Primarily based on MWPS (1987).
[b]Values are on a per animal basis in a pen environment.
[c]In favorable (e.g. dry) climates, area accommodations may be less than indicated in this table.

olism stalls may be concrete, expanded metal, wood, rubberized mat, or a combination of these materials.

Intensive Laboratory Environments

Some agricultural research and teaching situations require that beef cattle be housed under intensive laboratory conditions. Cattle may be kept in metabolism stalls, stanchions, respiration chambers, or environmental chambers. Housing cattle in such facilities should be avoided unless required by the experimental protocol (e.g., complete urine or fecal collection, frequent sampling, or environmental control) and then should be for the minimum amount of time necessary. The physical facility must meet local environmental standards for emissions of air pollutants and effluent disposal systems for liquid and solid waste.

Cattle used in space-intensive conditions should have calm dispositions and be adapted to frequent contact with animal care personnel. In some cases, it may be advantageous to train such animals to a halter. Time spent preparing cattle for use in a laboratory improves the quality of research and the safety of both the animals and the humans. Cattle should not be housed in isolation unless approved by the ACUC for specific experimental requirements. Whenever possible, cattle should be able to maintain visual contact with others.

Because of the operating costs associated with single-pass ventilation systems in controlled environmental facilities, partial recirculation (up to 80%) of exhaust air from animal rooms is common. In facilities designed to recirculate even a small part of the exhausted air, treatment is necessary to remove odorous compounds, gases, and particulate matter.

Unless the experimental protocol has special requirements for lighting, illumination in all animal rooms should be uniform to minimize the physiological effects of variation in light intensity. During light periods, the minimum light intensity for intensively housed cattle is 70 lux (Manser, 1994). A diurnal light-dark cycle should be used, and a standardized daily schedule enhances environmental predictability for the animals (Wiepkema, 1985). Longer photoperiods (16 hr) seem to result in increased milk production and may enhance immune responsiveness of cattle; it is recommended that the light period be at least 12 hr.

Excreta should be removed from enclosed laboratories at least once daily. Pens or stalls should be washed thoroughly at the outset of every trial and as needed thereafter. The method of collection of feces and urine from cattle in metabolism stalls, stanchions, and chambers depends on the design and construction of the unit. Additional scrutiny may be needed to keep animals clean when they are housed in stalls or stanchions. Cattle may need to be washed and curried regularly to maintain cleanliness and to avoid fly infestations. Pens, stalls, and stanchions should be large enough to allow cattle to stand up or lie down without difficulty and should be long enough to allow cattle to maintain a normal standing position.

Cattle maintained in some laboratory environments have their activity restricted more than that of their counterparts in production settings. The length of time that cattle may remain in stanchions, metabolism stalls, or environmental chambers before removal to a pen or outside lot for additional exercise should be based on professional judgment and experience. Opportunities for regular exercise should be considered if they do not disrupt the experimental protocol. Studies requiring housing of animals in such laboratory environments should be carefully evaluated by the ACUC; particular attention should be given to the length of time that animals are to be kept in restricted environments. If cattle are to be housed in such environments for an extended period (more than 3 wk), the ACUC may ask to monitor the animals. Health and disposition of individuals should be monitored closely during such studies, and particular attention should be given to alertness of the animal, appetite, fecal and urinary outputs, and condition of the feet, legs, and hock joints. Rubber mats or suitable alternatives should be used to increase the comfort of cattle maintained for lengthy periods on hard surfaces.

FEED AND WATER

Diets for beef cattle should be formulated according to the recommendations of the NRC (1996). Formulation of diets should consider factors such as environmental conditions, breed or biological type, gender, and production demands for growth, gestation, or lactation.

Feed and water should be offered to cattle in ways that minimize contamination by urine, feces, and other materials. Feed bunks should be monitored daily, and contaminants or spoiled feed should be removed. In most situations, feed should be available at all times. However, restricted feeding of high energy diets may be practiced to meet maintenance requirements or targeted levels of production. Whenever restricted feeding is practiced, feed must be uniformly distributed in the bunk to allow all cattle to have simultaneous access to the diet. When high energy diets are fed, increased attentiveness should be given to possible occurrence of diet-related health problems such as grain overload, lactic acidosis, and bloat. Abrupt changes in diets should be avoided. Feed deprivation for more than 24 hr should be avoided, and feed deprivation for any length of time must be justified in the animal use protocol.

Cattle can vary considerably in body weight and condition during the course of grazing and reproductive cycles. Feeding programs should allow animals to regain the body weight that is lost during the normal periods of negative energy balance. Cattle should have continuous free access to a source of water, except perhaps before scheduled surgery or weighing. When continuous access to water is not possible, water should be available for 30 min at least twice daily, or more frequently, depending on weather conditions and amount of feed consumed.

SOCIAL ENVIRONMENT

Cattle are social animals. Each individual in the group should have sufficient access to the resources necessary for comfort, adequate well-being, and optimal performance. Mixing, crowding, group composition, and competition for limited resources are part of the social environment and in some circumstances, may be social stressors for certain cattle. Generally, cows from similar environments but from different social groups can be mixed with little or no long-term adverse effect on performance (Mench et al., 1990), but, because introduced cows may be the recipients of aggression, the number of mixing episodes should be minimized. Mixing of older cattle, especially bulls, results in more fighting than occurs when younger cattle are mixed (Tennessen et al., 1985). Fighting and mounting can be a problem associated with keeping bulls in social groups and can present a significant welfare problem if not managed carefully (Fraser and Broom, 1990). Attempts should be made to keep bulls in stable social groups and to minimize mixing.

When feed, water, or other resources critical for comfort or survival are limited, or when large differences exist among cattle in size or other traits related to position in the social order, some animals may be able to prevent others from gaining access to resources. In properly designed facilities, all individuals have unlimited access to feed, water, and resting sites to improve well-being and to decrease the correlation between position in the social order and productive performance (Hafez, 1975; Stricklin and Kautz-Scanavy, 1984; Fraser and Broom, 1990).

Proper animal care includes observation of groups and of individuals within groups to ensure that each individual has adequate access to the resources necessary for optimal comfort, welfare, and performance.

HUSBANDRY

For beef cattle, several procedures may be performed by properly trained, nonprofessional personnel. These include, but are not limited to, vaccinating, dehorning, and castrating young cattle, horn-tipping, ear-tagging, branding, weighing, implanting, used of hydraulic and manual chutes for restraint, roping, hoof-trimming, routine calving assistance, ultrasound pregnancy checking, feeding, and watering.

Other husbandry and health practices used in beef cattle research and teaching, but that require special technical training and advanced skill levels, include artificial insemination, electroejaculation, pregnancy palpation, embryo flushing and transfer, nonroutine calving assistance and dystocia treatment, emergency Cesarean section, retained placenta treatment, and dehorning and castration of older cattle.

Dystocia Management

Proper care and assistance at calving can decrease deaths of both calves and cows from dystocia. Matings should be planned to lessen the genetic probability of dystocia.

Parturition without complication is common in beef cows. Therefore, before administering assistance to a cow experiencing difficulty with calving, personnel should be familiar with the stages associated with approaching parturition and the signs of normal delivery. Cows that have complications must be assisted immediately, however. Facilities should be provided that are designed for restraint of cows and heifers experiencing dystocia. Because many animals, especially heifers, lie down during the obstetrical procedure, sufficient space should be provided to permit adequate freedom of movement. It is important that the obstetrical restraint facility be fitted with side gates, both of which are hinged at the head end, so that the animal can become fully recumbent and the obstetrical procedure can be performed with safety and efficiency.

Fetal extractors are useful to assist in the delivery of some calves, but personnel who use a fetal extractor should either be trained and experienced or else be directly supervised by someone who is.

STANDARD AGRICULTURAL PRACTICES

Castration

Castration of male beef cattle is performed to reduce animal aggressiveness, prevent physical danger to other animals in the herd and to handlers, enhance reproductive control, manage genetic selection, and satisfy consumer preferences regarding taste and tenderness of meat. Accordingly, castration of young bulls is a recommended practice. Castration of male beef cattle is least stressful when performed on calves at birth, before 2 to 3 months of age, or before the animals reach a body weight of 230 kg (see Farm Animal Welfare Council, 1981). Two studies conducted 10 yr apart (Prigge, 1976; Worrell et al., 1987) indicated that optimal performance and carcass quality were not affected when bulls were castrated before 230 kg. Bands without special applicators (e.g., elastrators) should not be used for castration of calves older than 1 wk of age.

It is strongly recommended that calves be castrated at the earliest age possible. Calves heavier than 230 kg should be locally anesthetized when surgical methods of castration are used or when the spermatic cords are crushed. There are several methods for castrating cattle, including surgical removal of the testicles using a knife or scalpel and cutting or crushing the spermatic cords with an emasculatome or emasculator. Bloodless castration procedures utilizing specialized application instruments are acceptable for older animals; no advantage to use of anesthesia is apparent when such bloodless castration is practiced (Chase et al., 1995). Whatever the method of castration, the procedures should be conducted by or under the supervision of a qualified, experienced person and carried out according to manufacturer recommendations and accepted husbandry practices (Battaglia and Mayrose, 1981; Ensminger, 1983).

For seedstock cattle raised for possible use as replacement breeding stock, castration of low performance bulls that have been culled from the pool of those intended for use in breeding is recommended around the time of weaning. Castration of older, heavier bulls should be performed only by skilled individuals. When it is necessary to castrate these heavier bulls, anesthesia and techniques and procedures to control bleeding must be used.

The possibility of infection should be given additional consideration. Equipment should be sterilized, and facilities should be clean and sanitized. Infection following castration can be minimized by keeping the animals in a clean area until the wound is healed. If tetanus is a common disease associated with the premises, the herd health veterinarian should schedule a prophylactic immunization program.

Dehorning

Horns on cattle can cause bruises and other injury to other animals, especially during transport and handling. Horns on adult cattle also can be a hazard to humans. Hornless cattle require less space in the feedlot and at the feed bunk. Polled breeds should be used whenever possible.

When horned breeds of cattle are selected, dehorning (removal of horns) should be performed while the cattle are young and under the supervision of experienced persons using proper techniques (Ensminger, 1970; Battaglia and Mayrose, 1981). The horn buds can be removed at birth or within the first month after birth by several means, including hot cauterizing irons, cauterizing chemicals, a sharp knife, or commercially available mechanical devices.

When it is necessary to remove horns from older cattle, methods that minimize pain and bleeding and prevent infection should be employed. Dehorning should be performed by a person knowledgeable and experienced in the appropriate procedures. Appropriate restraint and local anesthesia to control pain should be used when cattle older than 1 mo of age are dehorned. Cattle should be monitored for hemorrhage and infection following dehorning. Adult cattle should be dehorned only if the individuals are aggressive toward herdmates or humans. Dehorning may temporarily depress the growth of cattle (Loxton et al., 1982).

Tipping of horns (removing the tip only) can be done with little impact on the well-being of individual animals. However, Ramsay et al. (1976) reported that, after transport, carcass bruises were as common among tipped cattle as among horned ones.

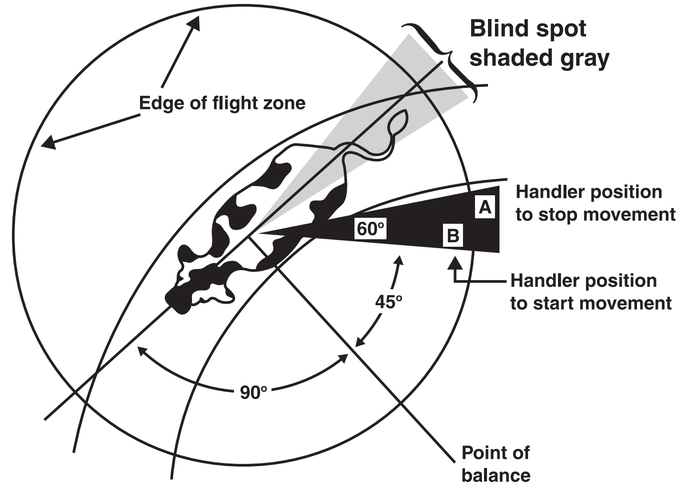

Fig. 5-1. Flight zone diagram showing the most effective handler positions for moving an animal forward. (From Grandin, 1993a).

HANDLING AND TRANSPORTATION

Well-designed cattle handling facilities make the task of handling cattle safe and efficient. Cattle behavior, hearing, vision, and genetics are among the many factors that are considered to be important for effective design of the facilities and for the quiet handling of cattle.

Knowledge and use of the flight zone (Figure 5-1) of cattle are important to proper handling. The flight zone varies, depending on whether cattle have been extensively or intensively raised. Extensively raised cattle may have flight zones up to 50 m, but flight zones of intensively raised cattle (e.g., feedlot) may be only 2 to 8 m (Grandin, 1989, 1993a, 1994). The size of an enclosure can shorten flight zones. An approximation of the flight zone can be made by approaching the animal and noting at what distance the animal moves away. When the handler is outside of the flight zone, cattle will turn and face the handler. Flight zones can be exploited by handlers to move cattle efficiently and quietly. For example, handlers should be positioned at the edge of the flight zone and behind the point of balance (located at the shoulder) in order to move cattle forward. To cause cattle to stop or back up, handlers should be positioned ahead of the point of balance. Too deep a penetration of the flight zone may cause cattle to bolt or run away. Personnel working with cattle should be trained to use flight zones correctly under intensive and extensive conditions.

Cattle are sensitive to intermittent loud noises, high frequency, and hissing sounds. Sensitivity is highest at frequencies of 8000 Hz (Grandin, 1989, 1993a). Machinery or other items emitting high frequency noise, hissing sounds, or intermittent loud noise in cattle handling areas should be silenced or removed. Cattle possess panoramic vision (Figure 5-1), but they perceive depth poorly, especially when moving with their heads raised. Consequently, items that create sharp contrasts of light (e.g., shadows) cause balking (Grandin, 1989, 1993a, 1994). Also, cattle tend to move from a dark to a light area more easily. It is generally recommended that cattle handling facilities, such as crowding pens, chutes, races, ramps, and crowding gates, have solid walls to decrease balking. Loading ramps should have an angle of 20% or less and should provide adequate traction to prevent slipping and falling.

Cattle have a natural tendency to circle around handlers while being moved. Numerous facility designs exist that take advantage of this tendency. When used properly, circular, single-file chute systems are generally more efficient for moving cattle. To be effective, handlers should be positioned along the inner radius of the system. Nonslip flooring is necessary to prevent cattle from slipping and falling while being moved. Holding gates within a single-file chute should allow cattle to see through them to avoid the appearance of a dead end. Solid holding gates are preferred for handling wild or very excitable cattle. Drain grates should not be positioned inside areas where cattle are being moved or held (Grandin, 1993b, 1994).

There are many different designs of restraining (squeeze) chutes. They may be hydraulic or manual models. Settings of pressure relief valves for hydraulic restraint chutes should be adjusted to prevent excessive pressure from being applied (Grandin, 1989, 1993a,b, 1994). Pressure should be applied slowly to avoid exciting the animal. Excessive pressure can cause injury and incite cattle to fight the restraint. Cattle should be able to breathe normally during restraint. Ideally, cattle should enter the restraining chute at a walk or be made to slow down before entering the head gate. The head gate can be self-catching or manually operated. Self-catching head gates are generally not recommended for use with horned cattle unless they are appropriately modified.

Electric prods, canes, or blunt objects must be used sparingly and must not be misused. Electric prods must never be applied to the head, nose, eyes, ears, genitals, udders, or anus of the cattle and must never be used on sick or injured cattle or very young calves. Proper handling techniques can greatly decrease or eliminate the need for such devices. A stick with plastic streamers or a garbage bag tied to the end is an effective device for moving cattle and changing their direction (Grandin, 1991, 1993b, 1994). Cattle temperaments vary among individuals and among breeds (Ewbank, 1993; Grandin, 1993a, 1994). Handling should be adjusted for genetic and phenotypic differences. Excitable types of cattle balk, become frightened, and run away more readily. Attempts should be made to reduce abrupt loud noises, to keep working areas free of hanging objects or obstructions, and to move the cattle quietly.

Downed or nonambulatory cattle must not be dragged. Specialized slide boards, carts, and sleds can be used to transport injured cattle to treatment areas. Downed cattle that are seriously ill or injured should be euthanatized immediately using an approved method of euthanasia. Emphasis must be placed on the prevention of downed cattle. Proper management and good facility upkeep and design, such as nonslip flooring, hoof care, trained calving assistance, gentle handling, and the marketing of cattle before they become debilitated, infirm, and weak can greatly decrease the incidence of downed cattle.

Personnel working with cattle must be knowledgeable about cattle behavior and trained in safe and proper handling techniques. Supervisors of animal care facilities must develop and expect adherence to proper animal handling policy. Equally important is the good design and maintenance of handling facilities. Cattle handling facilities maintained in good operating condition and free of clutter and manure build-up provide a safe and effective working environment for cattle and animal care personnel. Gates for human entrance and egress should be provided in pens and fences for handler ease and safety.

EUTHANASIA

The AVMA Panel on Euthanasia (AVMA, 1993) lists several methods of euthanasia that are appropriate for ruminants. Intravenous administration of barbiturates is an acceptable means of euthanasia in nearly all cases. Other conditionally acceptable methods include use of a penetrating captive bolt, gunshot to the head, electrocution, and administration of chloral hydrate. In all cases, euthanasia should only be performed by trained individuals who are skilled in the method used.

Agents that result in tissue residues cannot be used for the euthanasia of ruminants intended for human or animal food, unless those agents are approved by the FDA. Carbon dioxide is the only chemical currently used in euthanasia of food animals (primarily swine) that does not lead to tissue residues. Use of carbon dioxide is generally not recommended for euthanasia of larger animals. The carcasses of animals euthanatized by barbiturates may contain potentially harmful residues, and such carcasses should be disposed of in a manner that prevents them from being consumed by human beings or animals.

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Chapter 6: Guidelines for Dairy Cattle Husbandry

Dairy cattle include replacement heifer calves and yearlings, dry cows, lactating cows, and breeding bulls used for research and teaching purposes related to milk production. The basic requirements for safeguarding the welfare of dairy cattle are an appropriate husbandry system that meets all essential needs of the animals and high standards of handling (Agriculture Canada, 1990).

FACILITIES AND ENVIRONMENT

Physical accommodations for dairy cattle should provide a relatively dry area for the animals to lie down in and be comfortable (Jarrett, 1995) and should be conducive to cows lying for as many hours of the day as the cows desire. Recent work indicates that blood flow to the udder, which is related to the level of milk production, is substantially higher (28%) when a cow is lying than when a cow is standing (Metcalf et al., 1992; Jarrett, 1995).

Criteria for a satisfactory environment for dairy cattle include thermal comfort (effective environmental temperature), physical comfort (injury-free space and contact surfaces), disease control (good ventilation and clean surroundings), and freedom from fear. Cattle can thrive in almost any region of the world, if they are given ample shelter from excessive wind, solar radiation, and precipitation (Webster, 1983). Milk production declines as air temperature exceeds 24°C (75°F) or falls below -12°C (10°F) for Holstein and Brown Swiss cows or below -1°C (30°F) for Jerseys (Yeck and Stewart, 1959).

Heat stress affects the comfort of cattle more than cold stress does. Milk production can be increased during hot weather by the use of sunshades, sprinklers, and other methods of cooling (Roman-Ponce et al., 1977; Bucklin et al., 1991; Armstrong, 1994; Armstrong and Welchert, 1994) as well as by dietary alterations. Temperatures that are consistently higher than body temperature can cause heat prostration of lactating cows, but additional energy intake (+1%/°C) and higher heat production by the cow can compensate for lower temperatures, even extremely low ones. Consideration also needs to be given to humidity levels and wind chill factors in determining effective environmental temperatures. Adaptation to cold results in a thicker haircoat and more subcutaneous fat, which also reduces cold stress (Curtis, 1983; Holmes and Graves, 1994).

The newborn dairy calf has a lower critical temperature of 8 to 10°C (50°F) (Webster et al., 1978). The intake of high energy colostrum permits rapid adaptation to environmental temperatures as low as -23°C (-9°F) and as high as 35°C (95°F) in dry, individual shelters with pens (Erb et al., 1951) or in hutches (Jorgensen et al., 1970).

Calves may be housed individually in outdoor hutches or inside buildings in bedded pens or elevated stalls. If calves are exposed to low temperatures, they should be provided with dry bedding and should be protected from drafts. Proper ventilation is critical in closed buildings with multiple animals. Hutches should be sanitized by cleaning, followed by moving the hutch to a different location or leaving the hutch vacant between calves (Bickert et al., 1994). In hot climates or during hot summer weather, calf hutches need to be environmentally modified to ensure that the calf does not experience severe heat stress.

Housing and handling systems vary widely, depending on the particular use of the cattle in research and teaching (Albright, 1983, 1987). Recommended facilities for dairy cattle range from fenced pastures, corrals, and exercise yards with shelters to insulated and ventilated barns with special equipment to restrain, isolate, and treat the cattle. Generally, headlocks (one per cow), corrals, and sunshades are used in warm semi-arid regions. Pastures and shelters are common in warm humid areas, naturally ventilated barns with free stalls are used widely in cool humid climatic regions, and insulated and ventilated barns with tie stalls are common in colder climates.

Early research showed an economic advantage in providing housing for dairy cows during the winter instead of leaving them outside (Plumb, 1893). During good weather, to enrich the environment and to improve overall health and well-being, cows should be moved if possible from indoor stalls into the barnyard, where they can groom (Wood, 1977) themselves and one another, stretch, sun themselves, exhibit estrous behavior, and exercise (Albright, 1993b). Exercise decreases the incidence of leg problems, mastitis, bloat, and calving-related disorders (Gustafson, 1993).

Keeping cows out of mud increases their productivity and reduces endoparasitic and foot infections. Current trends and recommendations favor keeping dairy cows on unpaved dirt lots in the Southwest and on concrete in the North throughout their productive lifetimes. Concrete floors should be grooved to provide good footing and to reduce injury (Albright, 1994, 1995a; Jarrett, 1995). The concrete surface should be rough but not abrasive, and the microsurface should be smooth enough to avoid abrading the feet of cattle.

Data are limited on the long-term effects of intensive production systems; however, concern has been expressed about the comfort, well-being, behavior, reproduction, and udder, foot, and leg health of cows kept continuously on concrete. As a safeguard, cows should be moved from concrete to dirt lots or pasture, at least during the dry period. Also, rate of detection and duration of estrus are higher for cows on recommended dirt lots or pastures than for cows on concrete (Britt et al., 1986).

Exercise during the dry period does not adversely affect milk production, but does result in cows that are fit. Forced exercise after parturition reduces energy intake and milk production; therefore, forced exercise is not recommended (Lamb et al., 1979).

For recommendations for housing cattle in intensive laboratory environments (e.g., lighting, excreta collection, and metabolism or environmental chambers), refer to Chapter 5.

Area

Between and within breeds, ages, and body conditions, critical dimensions of dairy cattle vary less with weight than with age. Body length and hip width are relatively uniform (± 5%) across breeds at weights between 180 and 450 kg (400 and 1000 lb) (ASAE, 1987). More than 94% of the dairy cattle in the US are Holsteins, and area recommendations for female calves and heifers are usually related to age groupings for Holsteins (Woelfel and Gibson, 1978; Graves and Heinrichs, 1984; Heinrichs et al., 1994; MWPS, 1995). Average normal growth curves relate heart girth and live weight to age (Woelfel and Gibson, 1978; Graves and Heinrichs, 1984; Heinrichs et al., 1994; MWPS, 1995).

The length of individual stalls should be the length of the animal (Goodman, 1926), defined as the distance between

TABLE 6-1. Recommended Options and Sizes[a] for Pens and Stalls for Dairy Cattle Used in Agricultural Research and Teaching.

Components	Options	Sizes	
Individual calves	Hutches and yard or tether	1.5 to 3 m^2/head	(6 to 12 ft^2/head)
Until 2 mo [to 91 kg (to 200 lb)]	Bedded pen	2.2 to 3 m^2/head	(24 to 32 ft^2/head)
Until 7 mo [to 182 kg (to 400 lb)]	Stall[b]	.6 to .8 × 1.5 to 1.8 m^2/head	(10 to 15 ft^2/head)
Groups[c] of weaned calves			
[182 kg (<400 lb; 3 to 12/group)]	Movable shed (super calf hutch) plus yard	2 m^2/head	(21 ft^2/head)
	Inside pen	2.3 to 2.8 m^2/head	(25 to 30 ft^2/head)
	Bedded pack	3.1 × 4.9 to 6.1 m	(10 × 16 to 20 ft)
	Scraped alley	3.1 × 2.4 to 3.1 m	(10 × 8 to 10 ft)
Groups[c] of heifers in pens, 6 to 20/group	With free stalls	(see Table 6-2)	
181 to 454 kg (400 to 1000 lb)	With bedded pack	8 to 12 m^2/tonne	(4 to 6 ft^2/cwt)
34 to 136 kg (75 to 300 lb)		1.5 to 5.6 m^2/head	(16 to 60 ft^2/head)
		5. to 8 m^2/tonne	(2.5 to 4 ft^2/cwt)
	With slotted floor[d]	1.5 to 2.3 m^2/head	(16 to 25 ft^2/head
	With counterslope		
	Floors and	6 to 8 m^2/tonne	(3 to 4 ft^2/cwt)
	litter alley	1.5 to 3 m^2/head	(16 to 30 ft^2/head)
Dry cows and heifers [454 kg (>1000 lb)]	Bedded pack and	8 to 12 m^2/tonne	(4 to 6 ft^2/cwt)
	paved alley	4 to 9 m^2/head	(40 to 96 ft^2/head)
Maternity or isolation pens (5% of cows)[e]	With bedded nonslip floors	9.3 to 14.9 m^2/head	(100 to 160 ft^2/head)
		3.1 × 3.1 to 3.7 × 4.3 m	(10 × 10 to 12 × 14 ft)
Individual mature bulls	Rugged pens	13 to 22.3 m^2/head	(140 to 240 ft^2/head)
		3.1 × 4.3 m	(10 × 14 ft or larger)
	Tie stalls	1.4 × 2.5 to 2.6 m to 1.8 × 360 m	(54 × 97 to 102 in to 72 × 188 in)
Milking cows	Free stalls	(see Table 6-2)	
	Tie stalls	(see Table 6-2)	
	Paved lots	9 m^2/head	(100 ft^2/head)
	Unpaved corrals	46 m^2/head	(500 ft^2/head)

[a]Sizes exclude access for feeding and cleaning.
[b]Research protocol may require the use of individual stalls for calves.
[c]Different sources use different age groups. Weight variation increases with age.
[d]Space decreases with age. Spacing between slats is 3.18 cm at 169 kg, 3.82 cm at 170 kg, and 4.45 cm at 250 to 500 kg (1.25 in at 374 lb, 1.5 in at 375 lb, and 1.75 in at 550 to 1100 lb) (Woelfel and Gibson, 1978).
[e]In addition to maternity pens, treatment and handling facilities are recommended (Anderson, 1983; Anderson and Bates, 1983; Bates and Anderson, 1983; Graves, 1983; Veenhuizen and Graves, 1994; MWPS, 1995).

the pin bones and the front of the shoulders (ASAE, 1987) or between the pin bones and the brisket (Irish and Merrill, 1986). For stanchions and tie stalls, stall width to length ratio should be at least .8 (Goodman, 1926) to .7 (MWPS, 1985). The width of free stalls should be twice the hip width (Irish and Merrill, 1986). These dimensions have been taken into account for the recommendations for Holsteins shown in Tables 6-1 and 6-2.

Dairy cows prefer larger, more comfortable stalls and use free stalls 9 to 14 hr daily (Schmisseur et al., 1966; Irish and Martin, 1983). Free-stall systems may be adapted for feeding trials utilizing electronic gates. Free stalls are recommended for dairy cattle used in teaching, extension, and research programs throughout much of the United States. The range of effective dimensions of stalls for mature Holstein cows (Graves, 1977; MWPS, 1995) is presented in Tables 6-1 and 6-2.

Bedding

Resting dairy cattle should have a dry bed. Stalls ordinarily should have bedding to allow for cow comfort and to insulate the udder against cold temperatures. When handled properly, many fibrous and granular bedding materials may be used (MWPS, 1995), including long or chopped straw, poor quality hay, sand, sawdust, shavings, and rice hulls. Inorganic bedding materials (sand or ground limestone) provide an environment that is less conducive to the growth of mastitis pathogens. Sand bedding may also keep cows cooler than straw or sawdust. Regional climatic differences and diversity of bedding options should be considered when bedding materials are being selected. Bedding should be absorbent, free of toxic chemicals or residues that could injure animals or humans, and of a type not readily eaten by the animals. Bedding rate should be sufficient to keep the animals dry between additions or changes. Any permanent stall surfaces, including rubber mats, should be cushioned with dry bedding (Albright, 1983). Bedding material added on top of the base absorbs moisture and collects manure tracked into the stall, adds resiliency, makes the stall more comfortable, and reduces the potential for injuries (MWPS, 1995).

Bedding mattresses over hard stall bases such as concrete or well-compacted earth can provide a satisfactory cushion. A bedding mattress consists of bedding material compacted to 8 to 10 cm (3 to 4 in) and enclosed in a fabric (heavy weight polypropylene or other similar material). Shredded rubber may be used and is recommended as a mattress filler (Underwood et al., 1995). Small amounts of bedding (chopped straw) on top of the mattress keep the surface dry and the cows clean (MWPS, 1995).

Tie Stalls and Stanchions

To avoid contamination of the teat and reproductive tract orifices, waste removal must be more regular and thorough when cows are housed in tie stalls than when cows are housed in free stalls, corrals, or pasture situations. Cow trainers and gutter grates are recommended for cleaner stalls and cows.

Free Stalls

One free stall is recommended for each lactating cow. The stall base and bedding provide a resilient bed for cow comfort and a clean, dry surface to reduce the incidence of mastitis. Because cows prefer to stand uphill, the stall base should be sloped forward 4% [1.4 cm/m (.5 in/ft) rise] from rear to front. Commonly used materials for the base include concrete, clay, sand, and stone dust. Hardwood planks tend to rot. Rubber tires, if not firmly imbedded, tend to come loose (MWPS, 1995). In an ideal free stall, the stall bed and partition should define the lying position of the cow and accommodate natural lying and rising behavior (McFarland and Gamroth, 1994; MWPS, 1995).

Key features of most free-stall accommodations are a leveled dirt base, clean bedding, and regular and effective cleaning of alleys. When dangerous pathogens or toxic or noxious substances are identified in the environment, they should be removed; the area should be cleaned and disinfected; and new, uncontaminated material should then be supplied. Good management procedures include the removal and replacement of contaminated bedding or soil and the disinfection of such areas with agents that are effective against the specific pathogen or pathogens present.

Special Needs Areas

Cows with special needs are associated with greater risk and thus require special consideration with respect to facilities:

- Preparturition. Cows that are near the time of calving (2 to 3 wk prepartum) benefit from a clean, dry environment and access to an appropriate dirt lot for exercise. Feeding facilities should be provided to prepare cows for the high energy ration they will receive upon entering the milking herd. Free-stall housing situated for frequent observation and proximity to the maternity area is a desirable option.
- Maternity. In preparation for calving, cows should be moved to individual pens that are separate from other animals, especially younger calves. The environment should be well ventilated, and the pens should be maintained to be clean, dry, and well bedded. Recommended pen size is 3.7 m × 3.7 m or 3 m × 4.3 m (12 ft × 12 ft or 10 ft × 14 ft). One maternity pen should be provided for every 20 cows. The maternity pen should have a stanchion on one side for cow restraint. A concrete curb between each stall aids sanitation. Deep bedding should be used on concrete floors to prevent cows from slipping. Grooved concrete (e.g., diamond pattern) is also recommended (Albright, 1994, 1995a). Provisions should exist for lifting downer cows. Devices to aid and promote standing include hip lifters (hip clamps), slings (wide belt and hoist),

inflatable bags, and warm water flotation systems. Pen location should permit access by a tractor or loader to allow removal of downed cows. Each pen should be provided with adequate feeding space and fresh, clean water. Depending on local conditions, a calving pen may not be necessary. Cows can calve in a pasture area with lighting situated for observation. A calving pasture should be well sodded and drained, should be large enough to allow cows to move away from others in the group before calving, and should contain an adequate sheltered area. Use of a pasture pen can eliminate footing and bedding problems associated with calving pens.

- Removing calf. Dairy calves are normally removed from their dams as soon as possible following birth. The cow and calf are more difficult to separate after 3 d (Albright, 1987). Therefore, early removal (before 72 hr) is recommended (Hopster et al., 1995).
- Postcalving. A cow that has recently calved (from 0 to 7 d postpartum) should be placed in a special area for frequent observation before rejoining the milking herd. Individual feed intake and milk production should be monitored to determine whether the cow is progressing normally. Milk must be withheld from shipment as required by regulations. Free stalls or large, well-bedded pens may be used in this special area. For a larger herd, a special hospital and maternity barn, possibly equipped with a pipeline or portable milker, could house cows in this management category as well as cows that are calving or that have other special needs.
- Treatment. A treatment area in the barn for confining cows for artificial insemination, pregnancy diagnosis, postpartum examination, sick cow examination, surgery, and for holding sick or injured animals until recovery is recommended.
- Dry-off. Cows recently dried off should be separated from the milking herd for feeding purposes. Recommended medical treatments should be performed, and cows should be observed frequently to ensure normal progress.

Table 6-2. Recommended Sizes[a] of Free Stalls as Related to Weights of Female Dairy Cattle Used in Agricultural Research and Teaching.

Target weight	Approximate age[b]	Free stall[c]	Tie stall[c]
	(mo)		
118 kg (260 lb)	4	61 × 122 cm (24 × 48 in)[d]	NI[e]
182 kg (400 lb)	6	69 × 122 cm (27 × 48 in)	NI
236 kg (520 lb)	8	76 × 137 to 152 cm (30 × 54 to 60 in)	NI
327 kg (720 lb)	12	86 to 91 × 152 to 168 cm (34 to 36 × 60 to 66 in)	NI
377 kg (830 lb)	16	91 to 107 × 168 to 198 cm (36 to 42 × 66 to 78 in)	NI
454 kg (1000 lb)	20	99 × 183 cm (39 × 72 in)	122 × 152 to 175 cm (48 × 60 to 69 in)
500 kg (1100 lb)	24	107 × 198 to 213 cm (42 × 78 to 84 in)	122 × 160 to 175 cm (48 × 63 to 69 in)
545 kg (1200 lb)	26	114 × 208 to 213 cm (45 × 82 to 84 in)	122 × 168 to 175 cm (48 × 66 to 69 in)
636 kg (1400 lb)	48	122 × 213 to 218 cm (48 × 84 to 86 in)	137 × 183 cm (54 × 72 in)
727 kg (1600 lb)	60	122 × 229 cm (48 × 90 in)	152 × 183 to 198 cm (60 × 72 to 78 in)

[a]Sizes are generally higher from midwestern sources than northeastern sources.
[b]Age of Holstein or Brown Swiss for target weights.
[c]Measurements are given as stall width times stall length. Length of stall is for the side-lunge free stall. For forward-lunge free stalls, add 30 to 45 cm (12 to 18 in) (MWPS, 1995). Where brisket boards are in use, the stall bed from curb to brisket board should be 168 cm (66 in).
[d]Free stalls are not recommended for calves less than 4 mo (Graves and Heinrichs, 1984) or 5 mo of age (Woelfel and Gibson, 1978; MWPS, 1995).
[e]NI = Not included in recommendations for dairy heifers (Woelfel and Gibson, 1978; Graves and Heinrichs, 1984; MWPS, 1985; Heinrichs and Hargrove, 1987).

Corrals

Corrals should be scraped as needed, and concrete alleys should be scraped or flushed regularly to clean them effectively. Feedbunk areas should be scraped regularly, and any leftover feed should be removed. Shades and corrals should be designed to minimize areas of moisture and mud.

Pasture

Pasture management and watering facilities have been implicated in a number of significant bovine diseases and zoonoses. Pasture should be managed to avoid disease transmission. Stocking rates should be managed to maximize production per head unless forage supplementation is provided or unless production per unit of pasture area is to be studied. This strategy minimizes the stress that may result from overgrazing and also minimizes ingestion of plants from areas immediately surrounding those areas contaminated with excreta, thereby reducing the challenge of potential pathogens and helminth parasites. Some pathogenic microbes may survive more than 6 mo in fecal deposits. Shade should be provided during hot weather.

Lighting

Lighting recommendations for dairy cattle housed in indoor environments are the same as those for beef cattle in intensive environments (see Chapter 5).

FEED AND WATER

Except as necessary for a particular research or teaching protocol, dairy cattle should be fed diets that have been formulated to meet their needs for maintenance, growth, production, and reproduction (see Chapter 2). Feed ingredients and finished feeds should be wholesome, carefully mixed, and stored and delivered to the cattle to minimize contamination or spoilage of feeds. To ensure freshness, feeds that are not consumed should be removed daily from feeders and mangers, especially high moisture feeds such as silage. Feed should be far enough from waterers to minimize contamination.

Space should be adequate for feed and water. Feeders or mangers should be designed with smooth surfaces for easy cleaning and increased feed consumption. The recommended linear space per cow at the feed bunk is 61 to 90 cm (2 to 2.5 ft), which should allow every animal uninterrupted feeding (Malloy and Olson, 1994). Feeder design should permit a natural head down grazing posture to promote intake, improve digestive function, and decrease feed-wasting behavior (Albright, 1993a). At least one water space or 61 cm (2 ft) of tank perimeter should be provided for every 15 to 20 cows in a group. At least two watering locations should be provided for each group of cows. Each cow in tie stalls and stanchions should have its own water bowl or drinking cup (Andersson, 1985; MWPS, 1995).

All calves should consume colostrum in amounts of 8 to 10% of body weight (or 2 to 3 L) within 4 to 5 hr after birth and another 2 to 3 L within 24 hr of birth for a 36- to 45-kg (80- to 100-lb) calf (Stott et al., 1979; Stott and Fellah, 1983; Hunt, 1990; Pritchett et al., 1991; Mechor et al., 1992). Colostrum should be monitored with a colostrometer for quality (protein and antibody content). Mixed high quality colostrum pooled from several cows can be better than low quality colostrum from a particular dam. Until calves can consume dry feed at an adequate rate, they should be fed liquid feed in amounts sufficient to provide needed nutrients at 10% of body weight at birth per day until weaned. Water should be given at times other than when milk or milk replacer is fed to avoid possible interference with curd formation. Calves being raised as replacement heifers or for beef should be fed enough dry feed with sufficient fiber preweaning to stimulate normal rumen development (McGavin and Morrill, 1976). Calf research guidelines have been reported that permit uniformity in measuring and reporting experimental data (Larson et al., 1977).

Water intake affects consumption of dry matter (Kertz et al., 1984; Milam et al., 1986) and is itself influenced by individual behavior, breed, production rate, type and amount of feed consumed, water temperature, environmental temperature, atmospheric vapor pressure, water quality, and physical facility arrangement (Atkeson and Warren, 1934; Murphy et al., 1983; Andersson, 1985; Lanham et al., 1986). Nonlactating cows consume 3 to 15 kg of water/kg of dry matter consumed, depending on environmental temperature. Lactating cows consume 2 to 3 kg of water/kg of milk produced plus that required for maintenance (Little and Shaw, 1978).

Water should be available at all times (NRC, 1989) and should be checked daily for cleanliness and also monitored regularly to ensure that it is free of contaminants that could potentially put zoonotic agents into the human food chain (Johnston et al., 1986). Water sources should be readily accessible to all stock. Underfoot surroundings in watering areas should be dry and firm. Cattle should not be able to wade in drinking water.

SOCIAL ENVIRONMENT

Dairy cattle are social animals that operate within a herd structure and follow a leader (e.g., to and from the pasture or milking parlor). Cows exhibit wide differences in temperament, and their behavior is determined by inheritance, physiology, prior experience, and training. Cattle under duress may bellow, butt, or kick. Cows are normally quiet and thrive on gentle treatment by handlers. Cows learn to discriminate between people and react positively to pleasant handling. Cows have higher milk yields if handlers touch, talk to, and interact with them frequently (Albright and Grandin, 1993; Seabrook, 1994). Cows should have visual contact with one another and with animal care personnel. Handling procedures are more stressful for isolated cattle; therefore, attempts should be made to have several cows together during medical treatment, artificial insemination, or when cows are being moved from one group to another (Whittlestone et al., 1970; Arave et al., 1974).

Dairy cattle have traditionally been kept in groups of 40 to 100 cows (Albright, 1978), although specific research protocols may require smaller or larger group sizes. Variation in group size—small (50 to 99), medium (100 to 199), and large (200 or more)—does not cause a problem per se. Large herd size, however, can affect management decisions because overcrowding with insufficient number of headlocks or inadequate manger space per cow, irregular or infrequent feeding, and excessive walking distance to and from the milking parlor have a greater impact on behavior and well-being than does group size (Albright, 1995b).

HUSBANDRY

Vaccination schedules that are appropriate for the locality and the individual herd should be established with the advice of the attending veterinarian.

Certain dairy cattle behaviors (e.g., aggression and kicking) put at risk the health and well-being of herdmates as well as the humans handling the cattle. These behaviors can be reduced or modified by several devices and procedures, including stanchions, head gates, squeeze chutes, halters, and rope and tail hold. Nose tongs, hobbles, and electrical prods should be used sparingly, if at all.

Information about calving management is given by Albright and Grandin (1993). First-calf heifers should be bred to bulls with a reputation for siring easily delivered calves. Calf pullers should be used cautiously and only when necessary to prevent injury. If injury occurs during calving, the cow should be lifted into a standing position for rehabilitation. An apparatus with a wide belt and hoist may be used to lift a cow gently to her feet. Warm water flotation systems are also useful in rehabilitating cows.

Calves require special handling and care from the time they are born. Navels should be dipped in 7% iodine as soon as possible after birth. The newborn calf should be fed colostrum within the first 5 hr after birth. A calf should be given 8 to 10% of its body weight daily in fresh colostrum by bottle, bucket, or tube feeder. Colostrum is rich in nutrients and provides the calf with vital immunoglobulins. Good nutrition along with proper handling starts a calf on its way toward a healthy life.

STANDARD AGRICULTURAL PRACTICES

All animals should be individually identified (see Chapter 2). Heifer calves should have supernumerary teats removed at an early age (Moeller, 1981). Milking procedures should follow NMC guidelines.

Castration may be performed on male calves (see Chapter 5) except those being raised as veal calves (see Chapter 11) or kept as dairy bulls. Dehorning (disbudding) should be performed as described in Chapter 5.

Older calves and heifers close to calving should have supernumerary teats removed under local anesthesia by a qualified person. The removal of these extra teats is necessary because they can later disrupt the milking process and become infected. Removal may be performed in the first 3 mo of life with a scalpel or sharp scissors.

Tail-Docking

Docking of tails is a controversial, yet common practice performed on cows that are milked from the rear or that have filthy switches (Albright, 1972; Wilson, 1972; Ewbank, 1988; Jaquish, 1991; Ladewig and Matthews, 1992; Hemsworth et al., 1995; Phipps et al., 1995). Tail-docking has been prohibited in the United Kingdom (Ewbank, 1988) and some other European countries. Under conditions of high fly numbers, tail-docked heifers tail-flick more often and are forced to use alternative behaviors such as rear leg stomps and head turning to try to rid themselves of flies (Ladewig and Mathews, 1992; Phipps et al., 1995). More flies settle on tail-docked cows than on intact cows; the proportion of flies settling on the rear of the cow increases as tail length decreases (Matthews et al., 1995). Grazing and rumination are disturbed when fly attacks are intense (Ladewig and Matthews, 1992), and substantial losses to the United States cattle industry have been attributed to flies causing interference with grazing (Byford et al., 1992). Excellent fly control is therefore especially important for tail-docked cattle. A study of tail-docking in New Zealand (Matthews et al., 1995) found no difference in cortisol concentrations between docked and intact cows, but there were also no differences in milk yields, body weights, somatic cell counts, frequency of mastitis, or milker comfort among the treatments studied (intact tails, trimmed tails, and docked tails). Trimming switches with clippers or fastening the switch out of the way are preferred as alternatives to tail-docking in research or teaching herds. Further research is needed on the short- and long-term consequences of tail-docking in the United States herds.

Foot Care

Foot lameness is probably the single greatest insult to the welfare of the modern dairy cow. In a case-control study on lameness in dairy herds, the two factors found to be most influential in preventing lameness were maintenance of farm tracks (walkways) and patient handling of cows (Chesterton et al., 1989). Diet (acidosis) is also involved in the cause and control of lameness, especially lameness that is due to laminitis. Lameness may be controlled by foot bathing and foot trimming (Webster, 1993). A cow with properly trimmed hooves and healthy feet and legs will stand quietly and occasionally shift her weight. Cows with feet and leg problems are more restless, crampy, and uncomfortable; they appear to walk in place (Albright and Grandin, 1993). In situations in which the potential exists for outbreak of infectious necrobacillosis of the hoof, hairy warts, or other foot infections, antiseptic footbaths or topical sprays are recommended (Blood et al., 1983). Properly designed and maintained footbaths should be placed in areas of heavy traffic flow (e.g., at exits from the milking area, but not at entrances). Predisposing causes of foot problems (e.g., sharp rocks or moist or muddy ground) should be removed. Topical spray application to the feet of individual cows is recommended (Shearer et al., 1995a,b).

HANDLING AND TRANSPORTATION

Loading and Shipping

Knowledge and utilization of the flight zone (see Chapter 5) are important during the moving of dairy cattle. See Chapter 2 for further information about handling cattle. Adequate space should be available for handling when dairy cattle are being loaded for shipping. Cattle need ample room to turn; the leaders will then move into the chute, and other cattle will follow.

Stair steps are recommended for loading ramps. Each step should be 10 cm (4 in) high with a 30-cm (12-in) tread width. Loading ramps for young stock and animals that are not completely tame should have solid sides.

Cows that become emaciated or too weak to stand must not be transported. If rehabilitation does not occur within a reasonable time, the animal should be euthanatized on the farm (LCI, 1992a).

Young dairy cattle or lactating cows should always be handled gently and allowed time to investigate their new environment and ease into it without outside distractions. Cows should be moved at a slow walk, particularly if the weather is hot and humid or if the flooring is slippery.

Attempts should be made to ship dairy cattle only under favorable weather conditions. In regions where temperature extremes are likely, consideration should be given to minimizing exposure of animals to such extremes during transport (Grandin, 1988, 1992, 1993; LCI, 1992a,b; Albright, 1993b; Malloy and Olson, 1994).

If young calves are to be marketed, individual care and colostrum should be provided for 2 to 3 d after birth. Calves should always have a dry haircoat, have a dry navel cord, and walk easily before being transported. A day-old calf can stand, but is unsteady and wobbly and is not ready for market. Calves should not be brought to a livestock market until they are strong enough to walk without assistance. To reach adequate strength and vigor, calves need to be a minimum of 5 d old (Grandin, 1990). In transit, calves must be handled carefully and receive protection from the sun and heat stress in the summer and from the cold and wind chill in winter.

Nonambulatory or downed animals must not be dragged (see Chapter 5). Recommendations by the LCI (1992a) address prevention, preparation, and prompt action. Nonambulatory cattle in research and teaching facilities must always be euthanatized using approved procedures.

EUTHANASIA

When necessary, euthanasia should be performed by trained personnel using acceptable methods established by the AVMA (1993). The approved methods for ruminants include barbiturates, penetrative captive bolt, gunshot, electrocution, and chloral hydrate (see Chapter 3).

SPECIAL CONSIDERATIONS

Milking Machine and Udder Sanitation

The milking facility should have a program for regular maintenance of milking machines and follow the comprehensive mastitis prevention and milking management program of the NMC. Because dairy cows may be studied and maintained in a variety of environments, various strategies for disinfection and sanitation are required. Appropriate equipment and competent personnel should be available for milking. Animal care facilities should be designed and operated to standards meeting or exceeding those of Grade A dairies (Pasteurized Milk Ordinance, 1993). The milking facility, whether stanchions or milking parlor, must have clean floors with good traction and proper illumination to be hygienic and safe.

Cows may be milked with portable milking equipment that is maintained to Grade A standards of efficiency and sanitation. Particular care should be taken not to undermilk or overmilk cows and to be attentive to a milking schedule (usually twice daily and regular intervals). Personnel who are trained or experienced in the husbandry and milking of dairy cows should be employed for this task. Written operating procedures should be established to control potential contamination of milk with antibiotics or other pharmaceutical agents.

Milking machine and udder sanitation are vital to an effective preventive program against mastitis. Water used to wash cows before milking should be of a high quality when manure and organic matter are present, because microbes in wash water have been implicated in mastitis outbreaks (Malmo et al., 1972). Care should be used to minimize the excessive use of water prior to and during udder preparation. Emphasis should be placed on ensuring that cows enter the milking parlor with clean, dry teats. Udders, especially teat ends, should be clean and dry when teat cups are applied for milking. Teat sanitation, predipping, and wiping immediately prior to machine attachment reduces udder infection caused by environmental pathogens (Bushnell, 1984; Pankey et al., 1987; Galton et al., 1988; Pankey, 1992; Malloy and Olson, 1994; Reneau et al., 1994). Another approach is to use a low water premilking preparation with recommended germicides (NMC) followed by wiping the teats and udder with a clean, dry towel. Postmilking disinfection of teats is an essential management practice that greatly reduces the incidence of mastitis (Neave et al., 1969; Philpot et al, 1978a,b; Philpot and Pankey, 1978; Pankey, 1992). Milkers handling cows should pay meticulous attention to their own personal hygiene and wash their hands thoroughly before milking and frequently during milking or wear clean rubber or latex gloves during milking to prevent contamination of the udder. Cows with contagious mastitis should be milked last to reduce the spread of mastitis throughout the herd. Udder hair removal is recommended as a means to improve milking hygiene and udder health.

Effective cleaning programs for milking machines include use of hot water; use of disinfectant solutions and other chemical agents effective for removing mineral, milk fat, and protein deposits from equipment between milkings; disinfection of teat cups between cows; and flushing of teat cups with warm water, cold water, boiling water, or chemical disinfectant solution.

Noise and Music

Changes observed in cows exposed to noise were well within the range of activity variation expected in a group of cows (Casaday and Lehmann, 1967; Head et al., 1993). However, disturbances by veterinarians and other visitors can reduce milk yield (King, 1976). Experimental results suggest that music can contribute to consistency in the environment of cows and can become part of a cluster of stimuli that condition the milk-ejection reflex (Whittlestone, 1960; Albright, 1981; Evans, 1984, 1990; Fox, 1984; Hart, 1985; Albright et al., 1992).

Stray Voltage

Numerous research studies have quantified the physiological and behavioral responses of dairy cattle to electric currents (Lefcourt, 1991; Aneshansley et al., 1992). The electrical currents required for perception, behavioral change, or physiological effects to occur are widely variable. Furthermore, symptoms associated with problems of stray voltage or electrical current are not unique, and many factors other than stray voltage and electrical current can cause similar problems in behavior, health, or production (Gorewit et al., 1992).

The sources of relatively small amounts of electrical currents passing through animals are often very difficult to locate. Stray voltage or electrical currents may arise because of poor electrical connections, corrosion of switches, frayed insulation, faulty equipment, or heavily loaded power lines.

Periodic evaluation of facilities for stray voltage is suggested. Solutions include voltage reduction, control of sources of voltage leakage, gradient control by use of equipotential planes and transition zones, and isolation of a portion of the grounding or grounded neutral system from the animals. Proper installation of electrical equipment and complete grounding of stalls and milking center equipment should help prevent stray voltage problems. Although stray voltages and electrical currents cannot be totally eliminated, they can be reduced (Albright et al., 1991; Lefcourt, 1991; Gorewit et al., 1992).

Bulls

The feeding and watering of growing and mature bulls should meet requirements of the NRC (1989). Bulls should be housed in clean, well-lit, and ventilated buildings or outside in facilities that protect them from inclement conditions. Young bulls kept in groups should be observed carefully as they mature to make certain that one or more individuals are not injured. Aggression increases with age. Smaller subordinate bulls should be removed from the group. Visual and vocal social interactions with other bulls may be stressful because free-ranging bulls do not live in groups (Hall, 1989). Space requirements for bulls are listed in Table 6-1.

The safety of humans and animals is the chief concern underlying management practices. By virtue of their size and disposition, bulls may be considered as one of the most dangerous domestic animals. Management procedures should be designed to protect human safety and to provide for bull welfare. Electroejaculation of bulls is sometimes necessary. It should be performed by a qualified person, preferably using the finger-electrode massage method (Ball, 1974; Weidler, 1978).

A program of annual self-regulation should be followed for (1) semen identification and sire health auditing service and (2) minimum requirements for health of bulls producing semen for artificial insemination (Certified Semen Services, 1992; Mitchell, 1992).

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Chapter 7: Guidelines for Horse Husbandry

Guidelines in this chapter apply generally to all domestic and feral equids. Accommodation dimensions and area recommendations should be downsized appropriately for ponies.

FACILITIES AND ENVIRONMENT

Indoor Environment

Dimensions of indoor occupancy should be sufficient for a horse to make normal postural adjustments at will. A reasonable area allowance for a single horse is twice the square of its height at the withers (Zeeb, 1981), which permits essential movements, including lying down in sternal or lateral recumbency. Although horses can engage in slow wave sleep while standing, rapid eye movement sleep occurs only when the horse is recumbent (Dallaire and Ruckebusch, 1974; Ruckebusch, 1975).

Box stalls should be large enough to permit the horse to lie down, get up, turn around, and not lie in, stand on, or eat from areas contaminated with its own feces or urine (Table 7-1). The recommended minimum area, including dimensions, for straight or tie stalls (including space for the manger) is shown in Table 7-1. A 3.7-m × 3.7-m (12-ft × 12-ft) stall should accommodate any size horse.

General guidelines for metabolism stalls are in Chapter 2. If possible, horses should be removed from the stalls daily for short periods of exercise to minimize edema of the lower limbs.

Stall doors may be sliding, hinged, or divided (Dutch). Divided doors allow the horse to have, in effect, a larger stall when it puts its head out, yet permit visual isolation of the horse when so desired. Care must be taken when Dutch doors are used so that the horse cannot reach light switches, electrical cords, or outlets. Stall doors should either be solid or made of material in which the horse cannot become entangled. Doors should be wide enough (1.1 to 1.2 m or 3.5 to 4 ft) to permit the horse to enter and leave its stall comfortably, but should not block adjacent alleys when open. Hinged or divided doors should open into the alley, not into the stall.

Suitable flooring materials for indoor stalls include rubber mat, artificial turf, packed clay, gravel, stone dust, asphalt, concrete, sand, and wood. Floor material should be selected for ease of cleaning and for sanitation, comfort, and safety of the horse. Slippery floors can lead to injuries, and hard surfaces can cause lameness. The harder floorings require deeper bedding, especially for larger horses. Concrete floors with a rough broom float surface that slope to a floor drain or exterior door are suggested for wash areas, alleys, and feed and equipment storage areas.

Solid walls are suggested for foaling stalls to prevent aggression by the postpartum mare toward horses in adjacent stalls (aggression that may be redirected toward her own foal).

An opening 2.5 cm (1 in) wide and 75 cm (30 in) above the floor in walls and partitions aids stall ventilation and can be closed with a removable filler strip. Open guards 1.4 to 1.5 m (4.5 to 5 ft) above the floor between box stalls may be made of 1.3-cm (.5-in) steel rods, 1.9-cm (.75-in) pipe spaced not over 10 cm (4 in) apart on centers, No. 4 gauge welded-steel fencing, flattened expanded 9-gauge metal, No. 9 chain-link fencing, vertical hardwood slats, or comparable material.

Ceilings, when present, should be made of a moisture-proof material, preferably one that is smooth with a minimum of exposed pipes and fixtures. Minimum ceiling height should be at least .3 m (1 ft) higher than the horse's ears when the head is held at its highest level. Commonly used ceiling heights are 2.4 to 3.1 m (8 to 10 ft) for stall areas and 4.3 to 4.9 m (14 to 16 ft) for riding areas.

Windows or unglazed openings are recommended but are not essential if adequate lighting and ventilation are supplied by other means. Full-size doors with expanded metal screens may be used as windows in exterior stall walls. A tip-in or removable 61-cm × 61-cm (2-ft × 2-ft) window in each box stall aids lighting and natural (non-mechanical) ventilation in warm weather. The bottom of breakable barn windows should be 1.5 m (5 ft) or more above the floor, and windows should be protected to prevent breakage. Plexiglass windows that can be opened are preferable to fixed translucent panels installed as part of the wall sheathing because such panels are difficult to maintain. Skylights or translucent panels in the roof are useful to let more light into stalls.

Tropical and subtropical climates require stall arrangements that are very open to the outside. Commonly used are shed row barns in which the stalls open to the outside under an overhanging roof. Added ventilation is encouraged by stall doors with openings to the floor and slatted or nonsolid stall walls. If barns without these features are used in these environments, those barns should be large and constructed with thick concrete block or well-insulated walls, very high ceilings, and extensive roof venting, unless complete climate control (air-conditioning) is planned.

An alley should be provided between rows of stalls to allow room for horses to pass, for feed and bedding to be

TABLE 7-1. Recommended Dimensions of Housing and Transportation Accommodations for Horses and Ponies Used in Agricultural Research and Teaching.

Indoor facilities	(m)	(ft)
Box stall	3.7 × 3.7	(12 × 12)
1.8 m^2/100 kg of BW[a]		
(9 ft^2/100 lb of BW)		
Straight or tie stall, including manger	1.5 × 2.7[b]	(5 × 9)
.82 m^2/100 kg of BW		
(4 ft^2/100 lb of BW)		
Alleys, width		
Between rows of stalls	2.4–3.1	(8–10)
Behind rows of stalls	1.8	(6)
In front of single row of stalls	1.2	(4)
Outdoor facilities		
Fencing height for		
Horses	1.4–1.8	(4.5–6.0)
Ponies	1.1–1.5	(3.5–5.0)
Outdoor pen	3.7 × 3.7	(12 × 12)
Pasture	≥.4 ha	(≥1 acre)
Trailers		
Ceiling for horse height		
Up to 1.5 m (15 hands)[c]	1.7–2.0	(5.6–6.5)
1.5-1.6 m (15 to 16 hands)	2.0–2.2	(6.5–7.0)
Width		
Single of tandem	1.2	(4)
Two horses abreast	1.7-2 × 1.8-3.1	(5.6-6.6 × 5.9-10.2)

[a]Body weight.

[b]Lengths up to 3.7 m (12 ft) are used; length is measured from the manger front to the rear of the stall.

[c]One hand is about 10 cm (4 in).

handled, and for manure to be loaded; an alley located behind a single row of stalls and in front of a row of stalls allows for feeding and moving horses and allows for people to pass. Alleys in horse barns should be wide enough for the horse to turn around (2.4 m or 8 ft), or, if narrower, should have exits to the outside at both ends. Alley doors to the outside may be overhead, swinging, or sliding and should be sized appropriately to the alleyway. A wider alley is suggested where Dutch doors permit horses to have their heads in the alley.

Bedding. The type of bedding should be consistent with the comfort of the horse and with proper sanitation. Acceptable beddings include wheat, oat, or rye straw, grass hay, dried pasture clippings, wood shavings, peat moss, sawdust, paper, shredded cardboard, and sand. Horses fed a complete pelleted diet should not have sand bedding because they tend to ingest the sand and suffer from intestinal impaction. Bedding should be free of toxic chemicals or other substances that would injure horses or people. Black walnut shavings (Ralston and Rich, 1983), fresh cedar shavings, cocoa husks, and wood that has been pressure-treated have caused illness. Cocoa and cedar can also result in abnormal blood and urine profiles. Rubber mats alone may be used when the experimental or instructional protocol does not permit traditional bedding or for horses that are hyperallergic or suffering from chronic obstructive lung disease. Otherwise, rubber mats should be used only with bedding.

Temperature and Ventilation. The horse can acclimatize to subzero air temperatures, but needs wind protection such as a windbreak or a run-in stall. Newborn foals need more protection because of their relatively high lower critical temperature. Relative humidity in horse quarters should be 50 to 80%.

Ventilation air changes must be related to environmental temperature, outside humidity, atmospheric vapor pressure, total weight of horses, and heat and water vapor production (from animals, equipment, and bedding) in the barn. Ventilation rate capacity should be at least .7 to 2.8 m^3/min per 450 kg (25 to 100 ft^3/min per 1000 lb) of horse; the lower rate is for outdoor temperatures –18 to –7°C (0 to 20°F), and the higher rate is for outdoor temperatures –1 to 10°C (30 to 50°F) (MWPS, 1987). Additional ventilation capacity, plus air circulation, is needed for hot weather. Supplemental heat may be needed with cold weather ventilation, and insulation is recommended for warm housing. Flat ceilings aid air distribution and reduce heating needs for mechanical ventilation in warm barns. Relative humidity should be below 80%, and ammonia concentration should be below 10 ppm.

Lighting. Lighting should permit inspection of the horses and condition of bedding. Illumination of at least 200 lux is recommended for alleys, handling, and feeding areas (Currence and McFate, 1984). One 100-W incandescent lamp (approximately 1600 lumens) per 8 m^2 (90 ft^2) of floor or for each box stall is adequate to produce 200-lux illumination intensity (MWPS, 1987). There is some evidence that total darkness in a horse barn should be avoided (Houpt and Houpt, 1988); it is recommended that windows or another light source be present at night to avoid injury. Luminaires and lamps, or tubes, as well as all electrical wiring and switches, should be recessed or otherwise protected against damage by or to the horses.

Sanitation and Waste Disposal. Stalls should be cleaned as needed, usually daily, to keep horses clean and dry and the air suitably free of dust and odors, especially ammonia. Gutters, drains in the alley, or some other means for drainage of urine and spilled water should be provided. Gases emitted during storage, handling, and treatment of manure should be assessed. A 450-kg (1000-lb) horse produces about 20 kg (45 lb) of manure daily, plus spilled water, bedding, and other waste. Although manure as deposited is composed of about 80% water, it is relatively dry to handle (MWPS, 1987).

Horses should not have access to manure storage areas because of the danger that they might acquire gastrointestinal parasites. Manure should be either spread and incorporated into cropland or composted before being spread directly on pasture to be grazed by horses. Refuse should be disposed of appropriately.

Outdoor Environment

Pastures, Paddocks, and Corrals. In general, horse pastures, paddocks, and corrals should provide a reasonably comfortable environment, including sunshade, windbreak, and firm soil upon which to rest; sufficient area for normal postural adjustments and an appropriate resting place; and an enclosure that confines the horses safely and is free of trash, holes, and other dangerous objects, but that avoids unnecessary physical restraint. These outdoor accommodations should also provide for the biological needs of the animal (e.g., feed and water, exercise, reproduction if appropriate, and freedom to avoid contact with excreta).

The requirement of the horse for space in paddock and corral areas may vary considerably, depending on environmental situations (e.g., soil type, climate, forage availability, and drainage), size and type of animals (ponies, light horses, or draft horses), and, in certain cases, temperament of the individuals in a group. The minimum area for an individual in an outdoor pen is 3.7 m × 3.7 m (12 ft × 12 ft), but a larger area is suggested so that the horse can exercise, roll, and avoid groupmates. More horses may be accommodated in a larger enclosure. In wet, muddy conditions, area allowance should be increased to minimize churning, and elevated areas should be provided for the animals to lie down. Tight spaces and sharp corners or projections should be avoided in the pens to reduce injury and the chance of dominant animals trapping subordinates. The pens should be cleaned as needed to ensure proper sanitation and pest control. Continuous long-term maintenance of horses in the minimal area should be discouraged because it does not allow for sufficient exercise, especially for young horses.

In temperate climates, horses may often be confined to paddocks or pastures without shelter other than that provided by terrain, trees, wind fences, or sunshades. Shelters should be provided in very hot, very cold, or wet environments. A separate feed and creep area should be provided for foals (see Feed). Depending on age, weight, feeding level, acclimatization status, and husbandry system, no additional shelter may be necessary. Still, in certain cases, bedding may be required to enable the horse to keep warm and dry. Insulated sunshades or access to a ventilated stable should be provided in areas where summer temperatures reach 29°C (85°F) or higher if adequate natural shade is not available.

Three-sided or run-in sheds are suitable shelters (see Table 7-1). The minimum shelter area per horse is two to three times the minimum straight stall dimension. Drainage systems should direct water away from areas of heavy use (e.g., near feeders, watering troughs, run-in sheds, and shades).

Fencing and Gates. Guides to fencing dimensions and materials are available from the MWPS (1986), Ensminger (1969), and other sources. Fencing may be made of various materials, including wooden posts and rails, solid boards, wire (including high tensile wire), metal pipe, plastic, rubber, and V-mesh or chain-link fencing. It is not necessary to paint or seal fences, except when the protocol requires it. Barbed wire fencing should be avoided. Fences should be constructed to avoid features injurious to horses, such as sharp, protruding objects (e.g., nails, wires, bolts, and latches), and, if possible, narrow corners (e.g., less than a 45° angle) in which a horse can be trapped by a groupmate and kicked, bitten, or otherwise injured.

Fence heights for horses are given in Table 7-1. The bottom of fences and gates should be at least 25 cm (10 in) above the ground or extend to the ground to prevent the horse from catching a leg under the fence or gate, especially when rolling.

Electric fencing may be used for horses under certain conditions. Electric fence controllers should have been approved by Underwriters Laboratories or other accepted testing organizations. A single wire used for fencing should be set .8 to 1 m (30 to 40 in) above the ground, depending on the size of the animal (Ensminger, 1969). Strips of white or colored textile material or metal should be attached to the single strand of wire to improve visibility. An alternative to electric wire is highly visible, conductive plastic tape.

Gates may be constructed of several different materials, including wooden boards, pipe, sheet metal, and wire. The height of gates should be similar to that of adjoining fences to discourage animals from attempting to jump over the lower point. The width of gates should not leave a space in which an animal may become caught and injured. The bottom of gates, like the bottom of fences, should either extend to the ground or be 25 cm (10 in) or more above the ground.

FEED AND WATER

Feed

Horses housed inside or where they cannot graze should be fed and watered at least twice a day. For horses confined inside or in areas where they cannot graze, roughage in the form of hay or other fibrous feedstuffs should be provided to reduce the incidence of colic and stable problems (e.g., cribbing, wood-chewing, tail-chewing, or ingestion of bedding) and to approximate the natural diet more closely.

Horses should be fed so that they are neither underweight nor overweight (see Carroll and Huntington, 1988 for body condition scoring). To maintain normal body condition and health, a horse should be fed to meet the current NRC (1989) requirements for its class using feeds that are suitable for horses. Nutrient requirements of horses on pasture may be provided from forages available in the pasture or by a combination of pasture forage plus supplemental feeding of roughage and grain. During certain periods of the year, growth of forages may be greatly reduced, or the forage may become less palatable and digestible, thus necessitating supplemental feeding. Also, it is important to consider the effect of the environment on energy requirements, which increase significantly during periods of cold, wet weather (NRC, 1989). At other times, depending on stocking rate, little if any supplemental feeding may be required. Salt must always be available on pasture. When horses are feeding only on pasture, the trace minerals known to be deficient locally should be added to the salt source.

If horses are expected to meet their nutrient needs solely from pasture, care must be taken to ensure that the pasture can indeed support their requirements. Pasture stocking density varies from .4 to 4 ha (1 to 10 acres) or even more per horse, depending on the type, concentration, and growth stage of the forage and the season (Hintz, 1983). Good pasture management is required to optimize utilization of improved pastures. Care should include regular fertilization and clipping (mowing) of excess growth to increase the nutrient value and palatability and the control of parasites through manure removal or pasture dragging to break up the manure piles.

If supplemental feeding is required in pasture situations, fence line mangers, buckets, or boxes may be used to allow feeding from the adjoining road. Multiple sites (buckets or boxes) are preferable to a single site to decrease the risk of injury during aggressive competition for feed.

Feed Containers. Feed containers may be constructed of metal, plastic, rubber, concrete, wood, or any other material that is safe, sturdy, and cleanable. Hay may be fed from mangers, bags, nets, and racks or on the floor. Horses appear to prefer eating from the floor (Sweeting et al., 1985), and, in a properly cleaned stall, relatively little danger exists of parasite transmission. Ingestion of sand from a sand floor, however, can lead to sand colic.

Hay racks should be free of sharp edges and corners. The usual distance between the ground and bottom of the rack is .9 to 1.2 m (3 to 4 ft) when outdoors. Grain may be fed in buckets, in the lower part of many hay racks, or from separate troughs or boxes. Feed containers should permit the horse to insert its muzzle easily. A 30-cm (12-in) diameter is commonly used. Examples of acceptable dimensions of hay mangers and boxes have been published (MWPS, 1986), but these do not represent minimum dimensions. It is important to monitor feed containers daily to be sure that they are clean, free of moldy or wet feed, and not broken or damaged. Pastures should be inspected routinely for growth of unusual or poisonous plants (Kingsbury, 1964; Oehme, 1986), especially when pastures are overgrazed.

Freestanding hay racks may also be used for groups of horses. These racks may be placed away from the fence or adjacent and perpendicular to the fence, thus allowing them to be filled from the other side of the fence. Drainage away from the feeder should be provided to minimize mud during rainy weather. Alternatively, feeders can be placed on rubber or cement aprons. When horses in paddocks or corrals are fed from the ground, the potential for parasite transmission is greatly increased because of fecal contamination of the feed, and hay wastage is high. Feeding hay at ground level is desirable, however, because it provides for a more normal eating posture and respiratory drainage; hay can be placed in a 1-m (3-ft) deep container about 1 m (3 ft) wide positioned on the ground or in a rubber truck tire. The container should be cleaned out regularly.

Creep feeders may be used for foals. These feeders may consist of an enclosure located in the pasture (usually near the hay manger) with openings too small for adult horses to enter, but large enough for foals to enter. Creep feeders, like other feeders, should be clean, free of sharp protrusions, and in good repair, and the feed should be kept fresh.

Feeding space for horses has not been well defined and may vary considerably depending on the size, number, and temperament of the individuals that must eat from the same feeder simultaneously. Sufficient bunk space or feeding points should be provided to preclude excessive competition for feed. An extra feeding point (one more than the number of horses) reduces aggression toward, and stress upon, the lower ranking of horses in the dominance hierarchy. This extra feeding point is particularly important if the feed ration is restricted. Hay racks that provide 1 m (3 ft) of eating space per animal and a continuous opportunity for consumption should be placed down the center or long side of the pen. The feeding of grain should be avoided in large groups, unless the horses are separated into individual feeding slips with head dividers or stalls to reduce competition by dominant horses (Holmes et al., 1987). There should be at least 5 to 6 m (16 to 20 ft) between individual grain feeders for group-fed horses.

Water

If a natural water source is used, care must be taken to ensure that flow rate is sufficient in dry weather, that water is not frozen in cold weather, and that supplementary water sources are provided if necessary. Watering devices used in pastures or corrals should be durable and require little maintenance. The water source should be clean and safe; NRC (1974) recommendations for livestock water quality may be used as a guide in determining suitability for use.

Water should be continuously available or made available at least twice daily. The requirement for water depends on several factors, such as environmental temperature, animal function, and diet composition. In general, however, a horse needs 2 to 4 L (2 to 4 qt) of water/kg (2.2 lb) of dry matter intake (NRC, 1989). A horse fed to maintenance in a thermoneutral environment may need 15 to 35 L (4 to 8 gal) daily, but a horse that is working and sweating or a lactating mare may need 50 to 80 L (12 to 18 gal) daily. Signs of dehydration are sunken eyes, skin that tents (remains compressed when pinched), and increased capillary refill time at the gums.

Water Containers. Several widely spaced waterers or a large water trough should be provided in each pen. Waterers may vary from simple buckets to troughs or automatic drinking devices. Waterers should be free of sharp edges. Automatic waterers must be functional, clean, and able to be operated by the horses. Waterers that operate by a pressure plate pressed by the horse require several days for most horses to learn to operate them. Foals and horses with very small muzzles may not be able to operate these devices and may instead drink dry the water from the reservoir under the pressure plate without pressing it. Also, the noise of some waterers as they refill frightens some horses initially. It is wise to provide a water bucket under the waterer until the horses learn. Waterers should be inspected daily (more often in hot weather) to be certain that they are operating properly and are free of foreign material. Water troughs should be cleaned as needed to prevent algae or dirt from accumulating. Water should be heated to prevent freezing in cold weather and be inspected daily to ensure that it is free of ice. Provision of warm water increases intake in cold weather (Kristula and McDonnell, 1994). Proper installation of heating devices is necessary to prevent electrical shock. A float or stick may be placed in a trough to allow birds and other animals that fall into the trough to escape. Waterers should be positioned in a manner to prevent horses from injuring one another, and preferably not against the fence line.

SOCIAL ENVIRONMENT

Horses are herd animals. The average feral herd contains five to seven adult mares, a stallion, foals, and juvenile offspring (Waring, 1983; Berger, 1986). When possible, horses should be kept in groups (which may be considerably larger than the feral norm) to reduce the incidence of behavior problems and to eliminate injuries incurred when an isolated horse tries to join others. Total isolation of individual horses who have previously lived in a group, even for a few hours, causes immune changes (Mal et al., 1991). Although horses in most groups are compatible with one another if sufficient space is provided, observation is necessary to detect situations in which one or more horses are being injured or deprived of feed or shelter because of aggressive behavior. Mares and geldings may be housed together, but some geldings—despite complete castration—continue to behave like stallions (Line et al., 1985) and may fight with other geldings or injure foals during the breeding season. No more than one stallion should be kept with a group of mares.

Care should be taken to prevent horses from becoming injured when they are first introduced to one another or when they are crowded. Introduction should take place in daylight, when the horses can see the fences and when the caretaker can observe the horses. A horse is most likely to be injured when it cannot escape from an aggressor.

HUSBANDRY

Horses should be treated with an anthelmintic as often as needed to reduce environmental contamination with parasitic ova. The type of antihelmintic administered should be rotated to prevent antihelmintic resistance from developing. Horses should also be protected from external parasites when necessary (*Horse Industry Handbook,* 1993). All horses should be vaccinated for tetanus. Vaccinations for other diseases such as rabies and equine encephalitis are appropriate in areas where these diseases occur. Teeth should be examined annually and floated if necessary.

Management. Horses groom themselves by rubbing against stationary objects and engaging in mutual grooming with another horse. Horses confined to tie or metabolism stalls, where they cannot perform those behaviors, should be groomed by animal care personnel at least once a week or more frequently if shedding. Hooves should be cleaned weekly and trimmed every 6 to 8 wk as necessary to prevent lameness and infection.

With proper husbandry, horses may be kept in an indoor stall for several months at a time if necessary, but those standing for prolonged periods in either box or tie stalls may develop edema of the lower limbs (stocking up) or abdomen, especially if pregnant. Healthy horses in box stalls should receive a minimum of 30 min of free time (turn out) or 15 min of controlled exercise per day. More time for exercise should be provided if the horses are confined to tie stalls. Stall walking, weaving, and cribbing are all more likely to occur in confined horses.

Noise

Horses are sometimes disturbed by sudden noises, and background white noise or music is often used to mask or habituate the horses to unexpected sounds that might otherwise startle them. Noise control should be considered in facility design for the benefit of the horses and personnel. Some horses seem to perceive ultrasound, so devices producing these high frequency sounds should be avoided.

STANDARD AGRICULTURAL PRACTICES

Castration may be performed on horses at any age from a few weeks to many years of age. Surgical castration is performed, and anesthesia must be used at all ages.

HANDLING AND TRANSPORTATION

Handling and Restraint

General guidelines for the restraint of animals are presented in Chapter 2. Horses may be minimally restrained with halters and bridles, and extra control may be gained by the chain of a lead shank over the horse's nose. A horse may be restrained by hobbling, that is, by strapping the foreleg in a flexion. As a form of restraint, a twitch may be used on the horse's upper lip. Horses also may be restrained by crossties attached to the halter, but these should have safety releases, especially if the procedure to be performed is painful or if the horse is unaccustomed to restraint. Slip knot lassos should not be used to restrain horses.

Horses may also be restrained in stocks and chutes. A stock may be as simple as a single L-shaped pole, or it may have solid doors in front and back. Chutes should have either solid sides or sides that end 25 cm (10 in) above the ground. The chute should be able to be opened from either side in case the horse falls or injures itself.

Chemical restraint is effective when it is administered by a qualified person, but care should be taken because, when some drugs are used, an apparently sedated horse may react suddenly and forcefully to painful stimuli (Tobin, 1981). General or local anesthesia should be administered by a qualified person, preferably a veterinarian, for castration and other painful procedures.

Transportation

The typical vehicle used to transport horses accommodates from one to several horses that may or may not be tied. During transportation, attempts should be made to minimize trauma and anxiety of the horses. Considerations include loading, manner of driving, interior space, footing, ventilation, and possible interior padding.

Horses are sometimes transported in groups in trucks. It is preferable that horses not be transported in mixed-sex or mixed-size groups. They should not be placed in double-decker conveyances designed for cattle because these trucks do not meet the height requirement.

Trailers. Trailers deteriorate with use and exposure. Floorboards should have a framework of sufficient strength to bear twice the weight of any horse to be transported. Floor planking and metal floor braces and door latches should be inspected before every trip.

The required dimensions of a trailer depend on the size of the horses being hauled (Table 7-1). Stock trailers with or without enclosed fronts or roofs may be used. Stall-type horse trailers should have a butt chain or bar. The rear doors may either be hinged (horse steps up into trailer) or have loading ramp doors, or both, with a strong fastening bar on the door to prevent rear doors from opening during transit. If a partition is used, it should be 1.25 to 1.5 m (4 to 5 ft) high and should extend to within .5 m (1.5 ft) of the floor. However, in two-horse trailers that are narrower than 1.7 m (5.6 ft), only a partial partition less than 0.3 m (1 ft) wide or a bar should be used. The horse should be able to spread its legs enough to achieve proper balance. If a partial partition is used, legs should be protected with wraps or bandages. Flooring should not be slippery. Sand, bedding, or a nonslippery mat should be used to provide better footing and thus reduce anxiety and injury.

Horses should be tied using a quick-release knot in transit in one- or two-horse trailers to prevent turning and to stabilize them in case of accident. To prevent accidents when horses traveling as a group shift during transit, they should not be tied. Horses travel with less injury and possibly less anxiety when hauled in slant load or rear-facing trailers (Cregier, 1982a,b; Clark et al., 1993; Smith et al., 1994).

Regulation of air movement through the trailer is essential to avoid thermal stress or excess exposure to exhaust fumes. Adequate ventilation is especially crucial during extremely hot or cold weather. In hot weather, horses should not be left in parked trailers because heat stroke is likely; in cold weather, horses in moving trailers may need to be provided with blankets, especially if the air flow through the trailer cannot be controlled well (as in stock type trailers that are not fully loaded). A horse that is moving around excessively in the trailer is probably in trouble and should be checked.

Lighting in the trailer facilitates animal handling at night. Care must be taken to avoid injuring horses when transporting mixed sexes or sizes.

Horses may need to be fed and watered during a trip. They should not be expected to travel more than 18 hr at one time without leaving the trailer, and feeding and watering are recommended every 12 hr (Cregier, 1982a,b). Removal of horses after this period to allow them to move about helps to prevent colic, founder, and lower leg edema. Many of the respiratory problems that occur during shipping stress can be avoided by ensuring that the head is not elevated above the point of shoulder and by feeding hay below chest level during transit or by taking breaks that allow the horse to lower its head at least ever 6 to 8 hr (Racklyeft and Love, 1990). Leg wraps, tail wraps, bell boots, or tranquilizers are not necessarily required, but they may be beneficial for some horses during transit.

EUTHANASIA

Euthanasia should be performed using intravenous sodium pentobarbital. In emergency situations, gunshot to the brain may be used by trained personnel; precautions should be taken for human safety. Paralytic agents such as succinyl choline must not be used for euthanasia.

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Chapter 8: Guidelines for Poultry Husbandry

The husbandry guidelines in this chapter are for the three major poultry species in the United States: chickens (both egg-type and meat-type), turkeys, and ducks.

FACILITIES AND ENVIRONMENT

The physical environment afforded by a poultry facility should not put birds at undue risk of injury or expose them to conditions that would be likely to cause unnecessary distress or disease (Davis and Dean, 1968; Berg and Halverson, 1985; Tauson, 1985; North and Bell, 1990). The facility should prevent bird escape and entrapment, maintain air quality by ventilation, allow the birds to keep themselves clean, minimize extremes of environmental temperature consistent with the housing system (less control is possible with open-type houses), avoid unnecessary accumulation of waste, and protect birds from unusual deleterious environmental factors (e.g., predators).

Design of the housing system should facilitate cleaning and inspection of birds on all decks without handling them, yet the birds should be easily accessible. Adequate lighting should be available for examination of all birds, and a mechanical platform or other system should be provided for examination of higher level decks, if those cannot be readily seen by attendants standing on the floor. Feeding and watering equipment also should be accessible for easy maintenance.

Chickens, turkeys, and ducks are likely to panic when sudden changes occur in their environment (e.g., a wild bird flying through the house or loud noises to which the birds are not habituated). When kept in group housing, they may trample each other and pile up against barriers or in corners with resulting injury and mortality. Therefore, such sudden changes should be prevented to the extent possible. Alternatively, young birds, which are less susceptible to such stimuli, can be habituated to conditions that are likely to be encountered and cause hysterical responses later in life.

FEED AND WATER

General recommendations for feeding and watering are covered in Chapter 2. Requirements for feeder and watering space are outlined in the text and tables in the section on Husbandry.

Feeding Programs Throughout Life

Because meat-type chickens have been bred for rapid growth to market age, obesity of breeder stocks is a problem unless energy intake is controlled beginning early in life. Feed should be allocated to maintain a recommended body weight for the particular stock and age. Rations may be either a fixed amount of feed allotted either daily or under various alternate-day feeding schemes. Procedures that require restricted feeding should have enough feeder space so that all birds can eat concurrently.

Ducks experience difficulty consuming mash because, as it becomes moist, the mash tends to cake on their mouth parts. Therefore, it is recommended that all feeds for ducks be provided in pelleted form. Pellets no larger than .40 cm (5/32 in) in diameter and approximately .80 cm (5/16 in) in length should be fed to ducklings under 2 wk of age. Pellets .48 cm (3/16 in) in diameter are suitable for ducks over 2 wk of age.

Water

Newly hatched birds may have difficulty obtaining water unless they can find waterers easily. Similar difficulties may occur when older birds are moved to strange surroundings, especially if the type of watering device differs from that used previously by the birds.

Watering cups that require birds to press a lever or other releasing mechanism involve operant conditioning. Because individuals may fail to operate the releasing mechanism by spontaneous trial and error, shaping of the behavior may be required. Thus, watering cups may need to be filled manually for several days (or weeks in some cases) until the birds have learned the process. Water pressure must be regulated carefully with some automatic devices and watering cups. In such cases, pressure regulators and pressure meters should be located close to the levels at which water is being delivered. Manufacturer recommendations should be used initially and adjusted if necessary to obtain optimal results. Automatic watering devices may require frequent inspection to avoid malfunctions that can result in flooding or stoppage. Recommendations for watering devices are given in Table 8-1.

Poultry ordinarily should have continuous access to clean drinking water. However, with some restricted feeding programs, overconsumption of water may occur, leading to production of overly wet droppings. This situation can be controlled by restricting excessive water intake, usually by limiting water availability to certain times of the day, in accordance with accepted management programs that consider the amount of time that feed is available and also environmental temperature conditions. Water may also be shut off temporarily in preparation for the administration of vaccines or medications in the water. Recommendations

TABLE 8-1. Minimum Watering Space Recommendations for Poultry in Multiple-bird Pens and Cages Recommended for Use in Agricultural Research and Teaching.

Bird type and age	Linear space[a,b]						Cups or nipples[a]	
	Females				Males		Females	Males
	(cm)	(in)			(cm)	(in)	(maximum no. birds/device)	
Chickens (all types, floor or cage)								
wk 1 (provide one 3.78-L [1-gal] or four .95-L [1-qt] chick waterers/100 chicks								
Layer-type[c] (floor or cage)								
0 to 6 wk	1.5	(.6)			2.0	(.8)	20	15
6 to 18 wk	2.0	(.8)			2.5	(1.0)	15	11
>18 wk	2.5	(1.0)			3.3	(1.3)	12	9
Breeder flocks (mixed sex, floor)								
Broiler-type[d,e]								
Turkeys[f] (floor)								
Females (three-stage rearing)								
0 to 5.5 wk	1.3	(.5)						
5.5 to 11.0 wk	1.3	(.5)						
11 to 16.5 wk	1.3	(.5)						
Males (five-stage rearing)								
0 to 4 wk					1.3	(.5)		
4 to 8 wk					1.3	(.5)		
8 to 12 wk					1.9	(.75)		
12 to 16 wk					1.9	(.75)		
16 to 20 wk					2.5	(1.0)		
Breeder females[g]								
8 to 16 wk	1.9	(.75)						
16 to 30 wk	1.9	(.75)						
>30 wk (breeder pen)	1.9	(.75 ad libitum)						
Breeder males	2.5	(1.00 restricted)						
8 to 16 wk			1.9	(.75)				
16 to 25 wk			1.9	(.75)				
>25 wk (breeder pen)			1.9	(.75 ad libitum)				
			2.5	(1.00 restricted)				
Ducks			(cm)	(in)			Cups[h]	Nipples
Brooding or growing							(no./100 birds)[h]	
0 to 7 wk			1.9	(.75)			10	15
Developing breeders								
7 to 28 wk			2.5	(1.00)			12	18
Laying breeders								
28 wk			2.5	(1.00)			12	18

[a]Assumes moderate temperatures and that males require approximately 30% more space than females.

[b]Perimeter space for round waterers is obtained by multiplying linear trough space by .8.

[c]Recommended values are for Leghorn-type chickens. To obtain values for Mini-Leghorns, multiply by .9 before 6 wk and by .75 after 6 wk; for medium weight breeds, multiply by 1.1 before 6 wk and by 1.15 after 6 wk.

[d]Because various watering systems are available, investigators should follow the manufacturer's recommendations as to the maximum numbers of birds placed per waterer.

[e]If breeder growing flocks are being restricted in water time, they must be provided full access to water for at least 3 hr in the morning, starting just before their normal feeding time. Laying flocks should be given a minimum of 8 hr of access to water, also starting just before their normal feeding time. All flocks must have continuous access to water when environmental temperature exceeds 90°F.

[f]Modified from Berg and Halvorson (1985).

[g]Space during earlier ages is the same as for market turkeys.

[h]Cups approximately 7.6 cm (3 in) in diameter and 2.5 cm (1 in) deep of the "Swish" type.

for watering space vary widely, depending on species, type, bird density, and whether water intake is restricted (Table 8-1). Waterers should be examined frequently to ensure their proper operation.

Ducks. Most conventional poultry drinkers may be used for ducks, except for cup drinkers that are smaller in diameter than the width of the duck's bill. Nipple drinkers support slightly poorer duck performance during hot weather than do trough waterers.

Ducks can grow, feather, and reproduce normally without access to water for swimming or wading, but weight gain may be improved slightly during summer months if such water is provided (Dean, 1967). If ducks are provided water for swimming or some other wet environment, they should also have access to a clean and dry place; otherwise, they are unable to preen their feathers and down properly, and the protection normally provided by this waterproof, insulated layer is lost.

SOCIAL ENVIRONMENT

Certain common social environments are particularly stressful to poultry and should be avoided as indicated in this section.

Chickens. Excessive fighting and sexual abuse of individuals showing extremely submissive behavior may occur in groups of mature males residing in floor pens. If such abuse is likely to be encountered, as when aggressive stocks are used, late adolescent or mature males should be placed in environments where those behaviors are not possible or are less troublesome: in individual cages, in multiple-bird cages with moderate density (Craig and Polley, 1977), or in heterosexual flocks with appropriate sex ratios. The proportion of mature males in sexually mature flocks should be low enough to avoid injury to females from excessive mounting. The optimal ratio in most breeder flocks is 1 male to 12 to 15 females for egg-type strains and 1 male to 9 to 11 females for meat-type chickens.

There is sufficient evidence to recommend that the number of hens per cage should not exceed 8. When group size increases to 12 or more in relatively high density hen cages, adult hen hysteria may occur in some stocks; moreover, productivity declines, and feather loss may be excessive (Hansen, 1976; Craig and Adams, 1984; Craig and Muir, 1996). Also, fearfulness and feather loss are greater in 8-hen cages than in 4-hen cages when comparisons are made at the same densities (Craig and Milliken, 1989). Significant differences in productivity and mortality with group sizes greater than 4 to 8 (density held constant) may (Al-Rawi et al., 1976) or may not be detected (North Carolina State University, 1992; Carey et al., 1995).

Repeated movement of individuals from one socially organized flock to another tends to induce stress in those individuals that are moved (Gross and Siegel, 1985). Human interactions with chickens can also contribute, either favorably or unfavorably, to the social environment of the animal (Gross and Siegel, 1982; Jones, 1994).

Turkeys. Tom turkeys are prone to excessive aggression as they become older. Early beak-trimming reduces the likelihood of injuries from fighting among toms.

Ducks. For sexually mature breeder ducks, injury to females resulting from excessive mounting by drakes may be exacerbated in the presence of other stressful conditions, such as lameness associated with foot pad trauma caused by improper flooring (discussed later in this chapter). For Pekin breeders, the ratio of males to females should not exceed 1:5 and may require periodic adjustment throughout the breeding cycle because of higher mortality rates for females than for males.

HUSBANDRY

Area and Feeder Recommendations

Use of floor area by individual birds within groups follows a diurnal pattern and is influenced by the dimensions and other aspects of the accommodation. Birds may huddle together for shared warmth or spread out for heat dissipation. They generally use less area during resting and grooming than during more active periods. When competition for feed is substantial because of limited feeder space, inhibition of feeding in subordinate birds is likely (Cunningham and van Tienhoven, 1984).

Recommendations for minimum floor area and feeder space for multiple-bird pens and cages are presented for layer-type chickens, broiler-type chickens, turkeys, and ducks in Tables 8-2, 8-3, 8-4, and 8-5, respectively. Allowances for layer-type chickens are based on extensive research. In a survey of experiments involving density effects (mostly with White Leghorn hens), Adams and Craig (1985) made multiple comparisons within specific categories for several production traits and for livability. Their survey indicated that livability and hen-housed egg production were reduced significantly when areas of 387 and 310 cm^2 were compared with 516 cm^2, amounting to reductions of 2.8 and 5.3% in livability and 7.8 and 15.8 eggs per hen housed, respectively.

Decreases in livability and other measures of well-being were also associated with high density in subsequent studies. Thus, Craig et al. (1986a,b) found that livability and egg mass were significantly lower with 310 cm^2 than with 464 cm^2; Okpokho et al. (1987) and Craig and Milliken (1989) found livability was lower at 348 cm^2 than at 464 and 580 cm^2; and Craig and Milliken (1989) found lower hen-day rate of lay and egg mass per hen at the highest density. In the same studies, however, no differences in survival and egg production measures were detected between the two lower densities. From data on plasma corticosteroid concentrations, Mashaly et al. (1984) concluded that more than 387 cm^2 of space per hen should be provided; Craig et al. (1986a,b) found that plasma corticosteroid concentrations were higher at 310 than at 464 cm^2. Similarly, feather condition was worse (Craig et al., 1986a,b), and fearfulness was greater when estimated at 40 wk of age

Table 8-2. Minimum Floor Area and Feeder Space for Layer-type Chickens in Multiple-bird Pens and Cages Recommended for Use in Agricultural Research and Teaching.

Age	Kind of house	Floor[a]	Floor area per bird[b]				Feeder space per bird[b,c]			
			Female		Male		Female		Male	
(wk)			(cm²)	(in²)	(cm²)	(in²)	(cm)	(in)	(cm)	(in)
0–6	Pen	Litter	464	(72)	606	(94)	2.5	(1.0)	3.3	(1.3)
6–18		Litter	929	(144)	1206	(187)	5.1	(2.0)	6.6	(2.6)
>18		Litter	1625	(252)	2116	(328)	10.2	(4.0)	13.2	(5.2)
		S&L, W&L	1393	(216)	1812	(281)	10.2	(4.0)	13.2	(5.2)
		All-S, All-W	1161	(180)	1509	(234)	10.2	(4.0)	13.2	(5.2)
0–3	Caged	Wire	97	(15)	129	(20)	1.0	(.4)	1.3	(.5)
3–6		Wire	155	(24)	200	(31)	2.0	(8)	2.5	(1.0)
6–12		Wire	232	(36)	303	(47)	3.0	(1.2)	4.1	(1.6)
12–18		Wire	310	(48)	400	(62)	5.1	(2.0)	6.6	(2.6)
18–22		Wire	387	(60)	503	(78)	7.6	(3.0)	9.9	(3.9)
>22		Wire	464	(72)	606	(94)	10.2	(4.0)	13.2	(5.2)
			Breeder flocks							
				(cm²)	(in²)			(cm)	(in)	
Mature	Pen	Litter		1858	(288)			10.7	(4.2)	
		S&L, W&L		1625	(252)			10.7	(4.2)	

[a]Kind of flooring: S&L, W&L = >50% slats (S) or wire (W) and <50% litter (L); All-S, All-W = all slats or all wire.

[b]Recommended values are for Leghorn-type chickens. To obtain values for Mini-Leghorns, multiply by .9 before 6 wk and by .75 after 6 wk; for medium weight breeds, multiply by 1.1 before 6 wk and by 1.15 after 6 wk.

[c]Perimeter space for round feeders is obtained by multiplying linear trough space by .8.

[d]Cages should allow birds to stand erect.

Note: During the first week, supplementary feed should be placed on some type of temporary feeders (such as egg flats) on the floor.

or older (Okpokho et al., 1987; Craig and Milliken, 1989). Using data on egg production, mortality, and serum corticosterone concentrations, Roush et al. (1989) concluded that 3 hens, rather than 4, should be kept in cages of 1549 cm² area; that is, within the goals and constraints employed, hens should have 516 rather than 387 cm² area.

Because of a relative absence of research on well-being indicators for broiler chickens, turkeys, and ducks, recommendations are based on professional judgment, experience, and the opinions of recognized authorities. Generally, area allowances are assumed to be adequate when productivity of the individual birds is optimal and conditions that are likely to produce injury and disease are minimal.

For cage housing, unless otherwise stated, it is assumed that the cages have wire, plastic-coated wire, or plastic floors, which allow the waste produced to drop through the cage. Recommended floor space excludes the space that is taken up by feeders and waterers if those are located within the cage and take up floor space. Waterers should be readily available to all birds in each cage.

Caged hens may cease egg production temporarily or birds may even undergo a molt (suggesting that they are stressed) if removed from the cages to which they have become accustomed, for example, for cage cleaning. To minimize such stress, hens and roosters may be kept in their cages for 18 mo or longer, as long as air cleanliness is maintained and excreta are disposed of regularly from under the cages. However, the incidence of ostopenia and weak bones is higher in hens caged for prolonged periods than in hens housed in systems where greater freedom of movement is possible (Knowles and Broom, 1990).

Singly caged birds are frequently used in agricultural research and teaching to establish or demonstrate fundamental principles and techniques. Because within-cage competition for feed and water is absent, feeding and watering spaces are not critical; however, individually caged birds must have ready access to sources of feed and water. Table 8-6 presents recommended floor area allowances for adult chickens, turkeys, and ducks that are kept in single cages. The recommended minimum dimensions given allow birds to turn around within their cages.

Minimum watering space recommendations for use in multiple-bird cages and pens are presented in Table 8-1. These recommendations assume moderate ambient temperatures.

Flooring

Poultry may be kept equally well on either solid floors with litter or in cages or pens with raised wire floors of appropriate gauge and mesh dimension. When poultry reside on solid floors, litter provides a cushion during motor activity and resting and absorbs water from droppings. The ideal litter can absorb large quantities of water and also release it quickly to promote rapid drying. The poultry

TABLE 8-3. Minimum Floor Area and Feeder Space for Broiler-type Chickens in Multiple-bird Pens and Cages Recommended for Use in Agricultural Research and Teaching.

Average weight range		Approximate age	Type of housing and floor	Foor area/bird		Feeder space/bird[a]	
			Broiler breeders				
(g)	(lb)	(d)		(cm²)	(in²)	(cm)	(in)[a]
		Hatch to 23 wk of age (females or mixed ratio, 1:10, of males to females)					
<300	(<.7)	0–21	Litter	320	(50)	3.8	(1.5)
300–600	(.7–1.3)	22–42	Litter	690	(107)	5.1	(2.0)
600–900	(1.3–2.0)	43–63	Litter	870	(135)	6.4	(2.5)
900–1200	(2.0–2.6)	64–84	Litter	1058	(164)	7.6	(3.0)
1200–1500	(2.6–3.3)	85–105	Litter	1238	(192)	8.9	(3.5)
1500–1800	(3.3–4.0)	106–126	Litter	1426	(221)	10.2	(4.0)
1800–2100	(4.0–4.6)	127–140	Litter	1612	(250)	11.4	(4.5)
2100–2400	(4.6–5.3)	141–150	Litter	1740	(270)	12.7	(5.0)
2400–2700	(5.3–6.0)	151–160	Litter	1860	(288)	12.7	(5.0)
		Hatch to 23 wk of age (males only)					
<300	(<.7)	0–14	Litter	320	(50)	3.8	(1.5)
300–600	<.7–1.3)	15–28	Litter	690	(107)	5.1	(2.0)
600–900	(1.3–2.0)	29–43	Litter	870	(135)	6.4	(2.5)
900–1200	(2.0–2.6)	44–61	Litter	1058	(164)	7.6	(3.0)
1200–1500	(2.6–3.3)	62–77	Litter	1238	(192)	8.9	(3.5)
1500–1800	(3.3–4.0)	78–92	Litter	1426	(221)	10.2	(4.0)
1800–2100	(4.0–4.6)	93–104	Litter	1612	(250)	11.4	(4.5)
2100–2400	(4.6–5.3)	105–120	Litter	1740	(270)	12.7	(5.0)
2400–2700	(5.3–6.0)	121–138	Litter	1860	(288)	14.0	(5.5)
2700–3000	(6.0–7.2)	139–149	Litter	1974	(306)	15.3	(6.0)
3000–3300	(6.1–7.2)	150–161	Litter	2090	(324)	16.5	(6.5)
>3300	(>7.2)	>162	Litter	2195	(340)	17.9	(7.0)
		Lay period (>20 wk of age, males and females)					
Males and females or females only							
>2100	(>4.6)	>140	2/3 slat, 1/3 litter	1860	(288)	12.7	(5.0)
>2100	(>4.6)	>140	Litter	2787	(432)	12.7	(5.0)
>2100	(>4.6)	>140	Multiple-bird mating cages[b]	1860	(288)	12.7	(5.0)
Females only							
>2100	(>4.6)	>140	Single cages[c]	1160	(180)		
Males only							
>2400	(>5.3)	>120	Single cages[d]	1390	(216)		
			Commercial broilers				
		Hatch to final market weight					
<300	(<.7)		Litter or cages[e]	248	(38)	3.8	(1.5)
300–600	(.7–1.3)		Litter or cages	342	(53)	3.8	(1.5)
600–900	(1.3–2.0)		Litter or cages	432	(67)	3.8	(1.5)
900–1200	(2.0–2.6)		Litter or cages	516	(80)	3.8	(1.5)
1200–1500	(2.6–3.3)		Litter or cages	606	(94)	3.8	(1.5)
1500–1800	(3.3–4.0)		Litter or cages	703	(109)	5.0	(2.0)
1800–2100	(4.0–4.0)		Litter or cages	780	(121)	5.0	(2.0)
2100–2400	(4.6–5.3)		Litter or cages	871	(135)	5.0	(2.0)
2400–2700	(5.3–6.0)		Litter or cages	948	(147)	5.0	(2.0)
2700–3300	(6.0–7.2)		Litter or cages	1019	(158)	5.0	(2.0)
>3300	(>7.2)		Litter or cages	1097	(170)	6.4	(2.5)

[a]Feeder space for broiler breeders is greater than for commercial broilers because they are feed restricted. Therefore, broiler breeders must be given enough feeder space so that all of the birds can consume their feed at the same time.

[b]Cages must have a minimum of 103 cm (16 in) of head height.

[c]Cages must be a minimum of 25 cm (10 in) wide with a head height of at least 48 cm (18-19 in).

[d] Cages must be a minimum of 30 cm (12 in) wide with a head height of at least 48 cm (18-19 in).

[e]The limiting factors for broilers in cages are generally the feeder capacity, water capacity, and cage height. All birds must be able to stand erect without hitting their heads on the top of the cage. Enough feeder capacity should be available for once a day feeding.

TABLE 8-4. Minimum Floor Area and Feeder Space for Turkeys in Multiple-bird Pens and Cages Recommended for Use in Agricultural Research and Teaching.

	Weight		Type of housing and floor	Floor area/bird		Feeder space/bird	
	(kg)	(lb)		(cm^2)	(in^2)	(cm)	(in)
Growing turkeys	<.3	(<.7)	Litter or wire	257	(40)	3.8	(1.5[a])
	.3–2	(.7–4.4)	Litter or wire	580	(90)	3.8	(1.5)
	2–3	(4.4–6.6)	Litter or wire	807	(125)	3.8	(1.5)
	3–6	(6.6–13.2)	Litter	1419	(220)	5.1	(2.0)
	6–8	(13.2–17.6)	Litter	1871	(290)	5.1	(2.0)
	8–12	(17.6–26.5)	Litter	2741	(425)	5.1	(2.0)
	12–16	(26.5–35.3)	Litter	3548	(550)	5.1	(2.0)
Breeder turkeys				(cm^2)	(in^2)		
Hens	<8	(<17.6)	Floor pen[b]	2786	(3)		
	8–12	(17.6–26.5)		3715	(4)		
	>12	(>26.5)		4644	(5)		
Toms	<12	(<26.5)		3715	(4)		
	12–17	(26.5–37.5)		4644	(5)		
	>17	(>37.5)		5573	(6)		
Hens	<12	(<26.5)	Cage[c]	2694	(2.9[d])		
Toms	<20	(<44.1)		4644	(5[d])		
	>20	(>44.1)		8359	(9[d])		

[a]Supplemental feeder lids should be used for starting.

[b]Does not include space for nests or broody pens.

[c]Cage design must allow the birds to stand erect.

[d]Minimum dimensions 46 cm (18 in) for hens <12 kg (26.5 lb), 61 cm (24 in) for toms <20 kg (44.l lb), and 91 cm (36 in) for toms >20 kg (44.1 lb).

[e]Floors should be litter.

house should be ventilated to maintain litter in a slightly moist condition.

Some of the materials used for litter, depending on local availability, include rice hulls, straw, wood sawdust or shavings, and cane bagasse. Because litter materials differ in their ability to absorb and release water, husbandry practices should be varied to maintain proper litter conditions. Litter being stored for future use should be kept dry to retard mold growth.

When poultry are kept in cages or on raised floors, accumulated droppings should not be permitted to reach the birds. Droppings should be removed at intervals reflecting industry practice, and the basis for frequency of removal of droppings should be justified in the protocol or husbandry written operating procedures.

Ducks. Particular attention should be paid to the type of floor provided in pens or cages for the common duck because the epidermis of the relatively smooth skin on the feet and legs of this species is less cornified than that of domesticated land fowl (Koch, 1973) and therefore is more susceptible to injury. Properly designed, nonirritating floor surfaces minimize or prevent injury to the foot pad and hock and subsequent joint infection.

Dry litter floors are least irritating to the feet and hock joints of ducks and should be used whenever possible, particularly if ducks are going to be kept for extended periods. Litter floors that are not kept dry present a serious threat to the health of the flock.

Wire floors and cage bottoms of proper design may be used without serious adverse effect if the ducks are not kept on wire for more than 2 or 3 mo. Younger ducks and smaller egg-type breeds (e.g., Khaki Campbell) are less susceptible to irritation from wire than are older and larger meat-type breeds (e.g., Pekin). Properly constructed wire floors and cage bottoms should provide a smooth, rigid surface that is free of sags and abrasive spots. The 2.5-cm (1-in) mesh, 12-gauge welded wire is usually satisfactory for ducks of all ages over 3 wk. Mesh size should be reduced to 1.9 cm (3/4 in) for ducklings under 3 wk of age. Vinyl-coated wire is preferable, but stainless steel or smooth, galvanized wire is satisfactory. Slats are not recommended for ducks because leg abnormalities have developed in many ducks kept in research pens with slatted floors.

Irritation to the feet and legs of ducks is reduced greatly if hard flooring such as wire occupies only a portion of the total floor area of a pen. In large floor pens, one-third wire and two-thirds litter is a satisfactory combination, provided that drinking devices are located on the wire-covered section of the pen, which greatly reduces the transport of water from the drinking area to the litter.

Maintenance of litter in a satisfactorily dry condition is considerably more difficult in housing for ducks than in that for chickens and turkeys. Ducklings drink approximately 20% more water than they need for normal growth (Veltmann and Sharlin, 1981), and, as a result, the moisture content of their droppings is relatively high—approxi-

TABLE 8-5. Minimum Floor Area and Feeder Space for Ducks[a] in Multiple-bird Pens and Cages Recommended for Use in Agricultural Research and Teaching.

Type and developmental stage	Type of housing and floor	Per bird: Floor area/bird		Feeder space/bird[b]	
	Floor pen housing[c]				
Meat/egg type	Total and semi-confinement	(cm^2)	(in^2)	(cm)	(in)
Brooding/growing, wk					
1	Litter[d]	232	(36)	.9	(.35)
2	Litter	464	(72)	1.0	(.4)
3	Litter	839	(130)	1.3	(.5)
4	Litter	1116	(173)	1.5	(.6)
5	Litter	1393	(216)	1.7	(.65)
6	Litter	1671	(259)	1.8	(.7)
7	Litter	1858	(288)	1.9	(.75)
1	Wire	232	(36)	.9	(.35)
2	Wire	439	(68)	1.0	(.4)
3	Wire	651	(101)	1.3	(.5)
4	Wire	974	(151)	1.5	(.6)
5	Wire	1187	(184)	1.7	(.65)
6	Wire	1413	(219)	1.8	(.7)
7	Wire	1625	(252)	1.9	(.75)
Developing breeders, wk 7–28	Litter[e]	2322	(360)	10.2[f]	(4.0[f])
Laying breeders, all stages	Litter	3251	(504)	2	(.8)

[a]Space recommendations for ducks were determined with Pekin ducks. The allocations given should be adequate for all domesticated breeds, but they may be slightly excessive for some of the smaller breeds.

[b]Space on one side. When access is available from both sides, the amount of space available is doubled.

[c]If ducks are under semiconfinement, allow indoor space equal to the amount recommended for total confinement.

[d]Waterers located on wire-covered section with cement drain underneath.

[e]Developing breeders may be raised outdoors on well-drained soil (preferably sand) with open shelter. A minimum of 1290 cm^2 (200 in^2) of shelter area/bird should be provided.

[f]Additional space is allowed for restricted feeding.

TABLE 8-6. Minimum Floor Area and Dimensions for Single-bird Cages for Mature Chickens, Turkeys, and Ducks Recommended for Use in Agricultural Research and Teaching.[a]

Species and type	Floor	Floor area per bird: Female		Male		Minimum dimension: Female		Male	
		(cm^2)	(in^2)	(cm^2)	(in^2)	(cm)	(in)	(cm)	(in)
Chicken									
Layer-type[b]	Wire	826	(128)	929	(144)	20.3	(8)	20.3	(8)
Broiler-type	Wire	1161	(180)	1393	(216)	25.4	(10)	30.5	(12)
Turkey									
<12-kg (26.4-lb) hens	Wire	2696	(418)			45.7	(18)		
<20-kg (44.1-lb) toms	Solid[c]			4644	(720)			61.0	(24)
>20-kg toms	Solid[c]			8359	(1296)			91.4	(36)
Duck									
Pekin	Wire	1625	(252)	1625	(252)	30.5	(12)	30.5	(12)

[a]Cages for all species should allow birds to stand erect.

[b]Recommended values are for Leghorn-type chickens. To obtain values for Mini-Leghorns, multiply by .75; for medium weight breeds, multiply by 1.15.

[c]Litter.

mately 90% (Dean, 1984). To offset this extra water input in duck houses, extra litter and removal of excess water vapor by the ventilation system are essential. Supplemental heat is often necessary to aid in moisture control.

Brooding Temperatures and Ventilation

Because thermoregulatory mechanisms are poorly developed in young chicks, poults, and ducklings, higher environmental temperatures are required during the brooding period. Requirements of young birds may be met by a variety of brooding environments (e.g., floor pen housing with hovers or radiant heaters distributed in localized areas, battery brooders, and cage or pen units in heated rooms).

Ventilation is ordinarily gradually increased over the first few weeks of the brooding period. Whether ventilation is by a mechanical system or involves natural airflow, drafts should be avoided, and streams of air should be minimized that impinge upon portions of pens or groups of cages. In relatively open brooding facilities, as with houses having windows for ventilation and with chicks kept in floor pens, draft shields may prove beneficial during the 7 to 10 days after hatching.

Young birds may huddle together or cluster when sleeping but are likely to disperse when awake. Within limits, birds can maintain appropriate body temperatures by moving away from or toward sources of heat when that is possible and by seeking or avoiding contact with other individuals. Extreme huddling of young birds, especially during waking hours, usually indicates a need for more supplemental heat; dispersal, associated with panting, indicates that the environment is too warm.

With brooding systems that allow birds to move toward or away from heat sources, the temperature surrounding the brooding area should be at least 20 to 25°C during the first few weeks but not be so high as to cause the young birds to pant or show other signs of hyperthermy. When the entire room is heated and chicks are not free to move to cooler areas, the minimum temperatures that are recommended below may be too high. Thus, during the first week after hatching, a lower temperature, for example, a few degrees below 32°C (90°F), may reduce the lethargy and nonresponsiveness that is otherwise likely to be seen. As indicated in the preceding paragraph, chick behavior should be monitored to be sure that temperatures are within acceptable ranges.

Areas with minimum temperatures that are adequate for comfort and prevent chilling should be available to young birds. The following minimum temperatures and weekly decreases are suggested until supplementary heat is no longer needed:

- for chicks, a 32 to 35°C ambient temperature (90 to 95°F) initially, decreasing by 2.5°C (4.5°F) weekly to 20°C (68°F) [however, for some well-feathered strains, supplemental heat may be discontinued at 3 wk if room temperature is 22 to 24°C (72 to 75°F)];
- for poults, 35 to 38°C (95 to 100°F), decreasing by 3°C (5°F) weekly to 24°C (75°F);
- for ducklings, 26.5 to 29.5°C (80 to 85°F), decreasing by 3.3°C (6°F) weekly to 13°C (54°F). After the brooding period, ducklings are comfortable at environmental temperatures of 18 to 20°C (64 to 68°F).

Ducks. The recommended ventilation rates for chickens and turkeys have also given good results with ducks (Davis and Dean, 1968). Generally, however, lower relative humidity is desirable in duck houses to help offset the higher water content of duck droppings. Proper screening underneath watering equipment in houses with litter floors and the addition of generous amounts of litter are necessary features of the moisture control program. When outside temperature allows, supplemental heat may be used to help to control moisture build-up in duck houses.

STANDARD AGRICULTURAL PRACTICES

For handling birds and for all practices under this heading, experienced and skilled persons should carry out or train and supervise those who carry out these procedures.

Beak-Trimming

Egg-Strain Chickens. Although Eskeland (1981) and Struwe et al. (1992) reported that, in the absence of cannibalism, moderately beak-trimmed hens appeared to experience less stress than did those with intact beaks, the majority of evidence indicates that beak-trimming to control cannibalism causes pain and heightened beak sensitivity that persists for several weeks or even months (Breward and Gentle, 1985; Duncan et al., 1989; Craig and Lee, 1990; Gentle et al., 1990; Lee and Craig, 1990, 1991). Also, evidence exists that available stocks differ in their beak-trimming requirements (Craig and Lee, 1990) and that genetic selection is effective in reducing or even eliminating most feather-pecking and beak-inflicted injuries (Craig and Muir, 1993, 1996; Muir, 1996).

Therefore, when feasible, stocks should be used that require either minimal or no beak-trimming. Nevertheless, beak-trimming is justified in stocks that otherwise are likely to suffer extensive feather-pecking and cannibalistic losses. Management guides, available from most breeders, indicate appropriate ages, methods, and amount of beak to be removed to reduce these vices. In the absence of such information, other sources of information should be used (e.g., consultation with poultry faculty specialists; North and Bell, 1990). Beak-trimming should be carried out when birds are as young as possible to minimize pain (Hughes and Gentle, 1995).

Broiler-Type Chickens. Beak-trimming has long been an accepted practice to reduce feather-pecking and cannibalism in breeder stocks.

Turkeys. Beak-trimming of turkeys is a standard management practice. As with chickens, evidence exists that strains (Noble et al., 1994) and sexes (Denbow et al., 1984;

Cunningham et al., 1992) differ in their requirement for and response to beak-trimming. In strains of turkeys that exhibit a high incidence of beak-inflicted injuries, arc-type beak-trimming at hatching is effective in reducing such injuries (Noble et al., 1994). Severe arc-type beak trimming (1.0 mm anterior to the nostrils) increases mortality relative to hot-blade trimming of the upper beak at 11 days of age (Renner et al., 1989). There is no evidence that arc-type beak-trimming 1.5 mm from the nostrils at hatching or hot-blade trimming of the upper beak at 11 days of age increases mortality relative to leaving beaks intact (Renner et al., 1989; Noble et al., 1994). Arc-type beak trimming 1.5 mm anterior to the nostrils or hot-blade trimming of the upper beak at 11 days of age is recommended to prevent cannibalism in strains of turkeys that exhibit a high incidence of beak-inflicted injuries.

Ducks. Feather-pecking is a vice that sometimes occurs in ducks and may be controlled by either partial removal of the nail of the upper bill or inhibition of the growth of the nail by heat treatment (Dean, 1982). If not controlled, feather-pecking injures the feather follicles of the tail, wings, and back, and the protective feather and down covering breaks down.

Toe-Trimming

Because of the size and weight of the birds involved and the sharpness of their toenails, broiler breeder males and market turkeys generally have certain toes trimmed in order to prevent them from inflicting serious injuries to the hens during natural matings or to their penmates. Toe-trimming should be done at 1 day of age using an electrical device that removes and cauterizes the third phalanx of the toes involved.

Broiler Breeder Males. When meat-type males are to be used in natural matings, the practice of trimming certain toes at 1 day of age should be considered; toe-trimming of breeding males prevents scratching and mutilation of females during mating. However, there is also evidence that toe-trimming may impair the mating ability of males (Ouart, 1986). The removal of one nail does not appear to cause chronic pain (Gentle and Hunter, 1988).

Turkeys. Toe-trimming is a widespread management practice in turkey production. The number of toes trimmed per foot varies from 1 to 3 plus the dewclaw. Carcass grade of turkeys may or may not be improved by toe-trimming (Owings et al., 1972; Proudfoot et al., 1979; Moran, 1985), although rate of early mortality may be increased (Owings et al., 1972; Newberry, 1992). Toe-trimming may be justified when excessive injuries are likely to occur, but alternative methods should be developed to prevent bird injury.

Comb Removal (Dubbing)

Comb removal (dubbing) of chickens may be desirable if birds are to be kept in cages where combs rub or frequently get caught in wire openings after significant comb growth has occurred. Dubbing of cockerels is more likely to be needed because of greater comb growth by the male. To perform successful comb removal with minimal bleeding and excellent long-term results, cuticle or small surgical scissors should be used to remove the comb during the first few days after hatching.

Induced Molting

In birds, plumage is normally replaced before sexual maturity. This process, termed molting, also occurs after sexual maturity and is associated with a pause in egg production, which can be lengthy and take place out of synchrony with others in the flock if the birds are permitted to molt naturally. Inducing synchronized, rapid molt in order to extend the productive life of a flock has become a common procedure for commercial table-egg layers and sometimes for broiler breeders and turkey breeders.

There is a considerable amount of literature available on induced molting (Wolford, 1984). Procedures used include feed or feed and water restriction; manipulation of dietary ingredients such as calcium, iodine, sodium, or zinc; and administration of pharmaceutical compounds that influence the neuroendocrine system, sometimes coupled with a reduction in photoperiod. These procedures cause an abrupt cessation of egg production, coupled with body weight and feather loss. Restoration is accomplished by feeding a diet designed to meet the nutritional requirements for a non-ovulating feather-growing hen.

The most common procedure used to induce molt is feed withdrawal. Data do not suggest that water withdrawal is beneficial, and considerable field experience has shown it to be detrimental, especially during hot weather; thus, water should not be withdrawn during the molt. Unfortunately, there are few data on the well-being of hens during the withdrawal and postwithdrawal periods. However, feed deprivation in general is known to be a significant stressor for birds and results in both increased stress hormones and behavioral changes (Mench, 1992). Until more information is available, programs that minimize the length of the feed withdrawal period should be used whenever possible.

Mortality that occurs during the feed withdrawal period is generally associated with birds that were sick or emaciated going into the molt. It is, therefore, strongly suggested that such birds be removed and euthanatized before the start of feed withdrawal. It is further recommended that feed be abruptly removed at the beginning of the feed withdrawal period and immediately returned to ad libitum intake at the end. This procedure prevents small birds from having less than full access to the feed when it is available.

HANDLING

Human-Poultry Relationships

Socialization of poultry with humans can be carried out with relative ease by frequent exposure to kind, gentle care. Even brief periods of handling, beginning at the youngest possible age, confer advantages for ease of later handling of birds and increase feed efficiency, body weights, and antibody responses to red blood cell antigens (Gross and Siegel, 1993). In addition, Gross and Siegel (1982) found that positively socialized chickens had reduced responses to stressors and that resistance to most diseases tested was better than that of birds that had not been socialized. Therefore, gentle handling of birds should be done when feasible or unless the protocol or the use of large numbers dictates otherwise.

Routine Handling

In many experimental and teaching situations, newly hatched birds or relatively small numbers of older birds need to be handled. In those cases, individuals can be easily caught, manipulated, and moved about. Examples include wing- or leg-banding; immunization by intranasal or intraocular application of drops and wing-web puncture; and removing or placing birds in different groups, cages, and holding crates. Trained and experienced scientists and caretakers know that birds struggle less if they have been socialized, if the environment is relatively quiet, and if the body is fully supported in an upright position (Gross and Siegel, 1993). More complex procedures—for example, obtaining blood samples, intraperitoneal and venous puncture, and artificial insemination—often require at least two experienced persons. Skilled operators should adequately train personnel in such handling procedures so that stress to birds is minimal. Particular care should be exercised in handling caged layers to minimize the risk of bone fractures (Gregory and Wilkins, 1989a).

When large numbers of birds are to be moved or treated, handling methods need to be compatible with the housing systems involved (Nicol and Saville-Weeks, 1993). A source of major concern should be the manner in which individual birds are caught, carried, and placed in new quarters or crates. In many situations, birds are at risk of injury because they are caught and moved by grasping a single leg or wing with subsequent exertion of excessive force in moving the bird. Thus, Gregory and Wilkins (1989a) found that, when hens were caught by one leg and removed from cages at the end of lay, the incidence of broken bones was 12.7%; the incidence was only 4.6% when both legs were used in removing hens from the cages. Broilers carried even briefly in the inverted position by the legs show a larger corticosterone response than do birds carried in an upright position, and the response lasts for about 3 hr (Kannan and Mench, 1996). Therefore, birds should be carried upright whenever possible. Poultry harvesting machines are currently under development that appear to cause less stress in depopulating floor pens than does typical commercial manual catching (Nicol and Saville-Weeks, 1993). Recommendations regarding space, ventilation, and thermal control during transportation are discussed in Chapter 2.

EUTHANASIA

Appropriate methods of euthanasia and slaughter for poultry are covered in Chapter 3 and by the AVMA Panel on Euthanasia (1993). Briefly stated, acceptable euthanasia initially depresses the central nervous system to ensure insensitivity to pain. Anesthetic agents are generally acceptable, and most avian species can be quickly and humanely subjected to euthanasia by injection of an overdose of a barbiturate. Where relatively large numbers are involved, as in disposal of excess baby chicks, exposure to gas euthanasia agents such as carbon dioxide in enclosed containers may be used. Argon anoxia (less than 2% oxygen) or low concentrations of carbon dioxide (less than 35%) in argon with 2% residual oxygen have been found to be effective and to produce minimal distress (Mohan Raj, 1993) for market weight meat birds and laying hens. If the experimental protocol requires that poultry be killed using the commercial method of exsanguination, it is strongly recommended that birds first be stunned using a gas or electrical stunning method if possible. Although exsanguination does result in a relatively rapid loss of consciousness if both carotid arteries are completely severed (Gregory and Wotton, 1986, 1988), exsanguination may be incomplete if blood clots form (European Commission, 1997). Considerations involved in electrical stunning are discussed by Gregory and Wilkins (1989b) and Bilgili (1992). Cervical dislocation is also acceptable with birds small enough that the procedure may be carried out quickly and completely. Electrocution is acceptable if the current travels through the brain and through the heart. Embryonated eggs can be destroyed by chilling or freezing at a temperature of <4°C for 4 hr (European Commission, 1995). Decapitation or anesthetic overdose are also suitable methods for embryos that have been exposed for experimental purposes. Maceration in a purpose-designed macerator is also considered a humane method for killing embryos and surplus baby chicks (Bandow, 1987). Methods selected should take into account any special requirements of experimental protocols so that useful data are not lost.

SPECIAL CONSIDERATIONS

Alternative Housing Systems

European research into alternative housing systems to replace cage housing for egg-strain hens, such as strawyards, aviaries, and free-range systems, has been extensive in recent years (Appleby et al., 1992a). It appears that no housing or management system is likely to be optimal in all respects, and the concept of a welfare plateau (Duncan, 1978) is useful; that is, ethically acceptable levels of welfare can exist in a variety of housing systems. Welfare of the caretaker, in addition to bird well-being, deserves consideration in evaluation of alternative housing systems (Craig and Swanson, 1994). Evaluation of alternative housing systems may require temporary easing of the guidelines during the evaluation process.

Research during the last two decades indicates that modification of commercial cages from those currently in wide usage for chickens may improve the health and welfare of birds (Tauson, 1995). Thus, cage height of at least 40 cm (15.7 in) over 65% of the cage area and not less than 35 cm (13.8 in) at any point seems desirable (Harner and Wilson, 1985; Nicol, 1987). Taller cages may be necessary for larger breeds. Cage floors with a slope of no more than 9° in shallow, reversed cages may result in better foot health (Tauson, 1981). However, such low slopes may not be desirable in deeper cages, because difficulties are encountered in getting eggs to roll out efficiently (Elson and Overfield, 1976). Horizontal bars across the front of the cage appear to allow birds to feed easily and with reduced probability of entrapment (Tauson, 1985), and wide cage doors allow easier removal of birds. If existing or new cages are high enough, the addition of a perch results in extensive use by hens and has been shown to improve bone strength and foot health (Appleby et al., 1992b; Duncan et al., 1992). Perches may be either round or square depending on diameter, and birds readily use perches of either wood or wire mesh; smooth plastic perches are less preferred (Faure and Jones, 1982; Muiruri et al., 1990; Appleby et al., 1992b). Provision of an abrasive strip on the baffle plate of the feeder results in hens having claws that are not excessive in length (Tauson, 1986).

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Chapter 9: Guidelines for Sheep and Goat Husbandry

Sheep and goats are small ruminants that share many characteristics, but certain aspects of facility design and husbandry must take into account their differences in behavior and physiology. For optimal results, the people who care for these animals should be well-trained and have good observational skills.

FACILITIES AND ENVIRONMENT

Sheep and goats used in agricultural research and teaching may be maintained under a wide variety of conditions, ranging from pasture or range to intensive production systems. The management system employed should be appropriate for the research or teaching objectives while providing resources for the proper care of the animals.

Artificial shelter for sheep and goats is not always necessary because of their adaptability and the insulating value of dry wool and hair. For shelter from wind, sheep and goats naturally take advantage of surrounding terrain such as trees and ridges. Trees and shrubs also serve as shade. When barns or sheds are provided, adequate ventilation and clean, dry surroundings reduce bacterial and viral build-up and increase animal comfort. In many cases, local environmental standards for manure handling and disposal are in existence and must be met. Guidelines for facilities layout and housing can be found in the *Sheep Production Handbook* (Sheep Industry Development Program, 1992) and in the *Sheep Housing and Equipment Handbook* (MWPS, 1994). Shelter to provide warmth, shade, and protection from wind and precipitation is important for goats. Fiber-producing goats require special care after shearing.

In range, pasture, or outdoor drylot conditions, area requirements are determined by available feed and forage as well as prevailing weather conditions. Thus, area requirements vary considerably among locations, depending on conditions, husbandry, and management. Minimum area recommendations for confined sheep are listed in Table 9-1. (MWPS, 1994). These recommendations are based on freedom of movement, animal safety, and waste management. The amount of barn space actually required depends on the intent of the research and teaching, type and slope of pen surface, weather conditions and exposure, and group size. Acceptable floor surfaces include well-drained compacted soil, concrete, composition mats, wood, and expanded-metal flooring. When goats have access to outside lots or pastures, an adequate sheltered area is 0.5 m^2 (5.4 ft^2) per goat (Kilgour and Dalton, 1984). Stall feeding of dairy goats requires 1.5 m^2 (16 ft^2)/goat (Kilgour and Dalton, 1984). Sheep and goats are relatively intolerant of mud, so access to well-drained shelter is desirable. Paving of heavy traffic areas and outdoor pen areas may be desirable. Dust control in pens assists in the control of respiratory problems, health, and fleece quality.

Provision of additional feed and protection from wind and precipitation should be provided if the animals may experience hypothermy. In intensive production facilities, ventilation and structural design should prevent moisture condensation during cold weather and excessively high temperature during hot weather. Newborn lambs and kids and recently shorn sheep and goats are susceptible to hypothermy, hyperthermy, and sunburn, so frequency of observation should be increased and appropriate shelter should be provided if natural conditions do not offer sufficient protection. The water requirement of sheep and goats increases during hot and humid weather, and it is essential that animals have access to an adequate water supply to reduce the possibility of hyperthermia. Shade may be necessary in some situations. If exposure to stressful environmental conditions is prolonged in intensively managed facilities, animal density and ventilation rate within the facility should be adjusted. During hot weather handling or driving sheep or goats should be restricted to the early morning and evening, the cooler parts of the day.

Intensive Laboratory Environments

Some agricultural research and teaching situations require that sheep be housed under intensive laboratory conditions. Sheep that are subjected to intensive procedures requiring prolonged restraint, frequent sampling, complete collection of feces and urine, or other procedures experience less stress if they are trained and adapted to their intensively managed environments. Sheep may be kept in pens, metabolism stalls, stanchions, respiration chambers, or environmental chambers to facilitate these procedures. Sheep should not be housed alone in intensive environments and should be able to maintain visual contact with other animals.

Unless the experimental protocol has special light requirements, illumination in all animal rooms should be uniform to minimize the physiological effects of variation in light intensity. The diurnal cycle of light and darkness may also affect the performance of sheep, and, therefore, maintaining a photoperiod similar to that of natural daylight is recommended.

Sheep housed in intensive laboratory environments should be kept clean, and excreta should be removed at least once daily. Pens and stalls should be washed thoroughly at the outset of every trial and as needed thereafter. Collection vessels for feces and urine depend on the design and construction of the units. Cleanliness should be maintained, and fly infestations should be avoided. It is recommended that sheep be shorn prior to being maintained in these facilities to reduce fly and hygiene problems. Pens, stalls, and stanchions should be large enough to allow sheep to stand up and lie down without difficulty and to maintain normal standing and lying postures.

Sheep maintained in intensive laboratory environments have their activity restricted more than when managed under typical production settings; therefore, sheep in these facilities should be monitored more closely and should be observed more frequently. The length of time sheep may be maintained in these environments before removal to a pen for additional exercise should be based on professional judgment and experience. Studies that require housing sheep in such environments should be carefully evaluated by the ACUC; particular attention should be given to the length of time activity is restricted. Opportunities for regular exercise should be provided if exercise does not affect the experimental protocol. Sheep housed in these intensive environments for extensive periods (>3 wk) should be closely monitored, and particular attention should be given to appetite, fecal and urinary output, and soundness of feet and legs.

Fencing

Because there are many production situations and many sizes and ages of sheep and goats, the optimum fence construction varies (Miller, 1984). To contain most sheep and goat breeds, a 1.1-m (42-in) high board or wire fence is generally sufficient if adequate feed and water are provided and startle (caused by sporadic loud sound, flashing lights, dogs, and predators) is minimal. Boards, planks, high tensile wire, chain-link, and woven wire fence material with 2- to 5-m (6- to 16-ft) spacing of posts are typical for permanent pasture and yard fences. High tensile wire is stronger and stiffer than woven wire, and it breaks sooner when repeatedly bent. Plastic net or wood-slat snow fence materials are useful for portable, temporary pens. A 1.12-m (48-in) high fence is needed for goats. Goats are more agile than sheep; goats climb and jump more, jump higher, and habitually dig and crawl under fence wire. A four-wire electric fence is effective, but the goats should be given time to recognize and respect the electric wire before they are herded in the vicinity of the fence (Selders, 1981). Barbed wires, spaced 15 to 20 cm (6 to 8 in) apart and tightly strung on 2-m (6-ft) high posts, can contain mature goats on good pasture (Miller, 1984). Sheep and, especially, horned goats can get their heads and legs trapped in an inappropriate

TABLE 9-1. Minimum Floor Area and Feeder Space Recommendations for Confined Sheep Used in Agricultural Research and Teaching.[a,b]

Facility	Floor type	Rams (65–90 kg, 180–300 lb)		Dry ewes (65–90 kg, 150–200 lb)		Ewes and lambs (additional creep area required)		Lamb creep area (12–14 kg, 5–30 lb)		Feeder lambs (14–50 kg, 30–110 lb)	
		(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)	(m^2)	(ft^2)
Building floor area	Solid	1.86–2.79	(20–30)	1.12–1.49	(12–16)	1.39–1.86	(15–20[c])	.14–.19	(1.5–2.0)	.74–.93	(8–10)
	Slotted	1.30–1.86	(14–20)	.74–.93	(8–10)	.93–1.12	(10–12[c])	.14–.19	(1.5–2.0)	.37–.46	(4–5)
Lot area	Dirt	2.32–3.72	(25–40)	2.32–3.72	(25–40)	2.79–4.65	(30–50)	. . .	. . .	1.86–2.79	(20–30)
	Paved	1.49	(16)	1.49	(16)	1.86	(20)	. . .	. . .	.93	(10)
Feeder space		(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)
Limit-fed		30.48	(12)	40.64–50.80	(16–20)	40.64–50.80	(16–20)	22.86–30.48	(9–12)	22.86–30.48	(9–12)
Self-fed		15.24	(6)	10.16–15.24	(4–6)	15.24–20.30	(6–8)	2.54–5.08	(1–2)	2.54–5.08	(1–2)

[a]Adapted from MWPS (1994).

[b]Space requirements should be increased for fully fleeced or horned sheep and during hot weather.

[c]Increase space if lambing rate is ≥ 170%.

fence. A goat fence of woven or net wires should have vertical wires spaced 30 cm (12 in) apart and horizontal wires spaced more than 15 cm (6 in) apart to allow the animals space to withdraw their heads. During the breeding season, it is difficult to keep bucks in pens separated from does that are coming into estrus. An electric wire around the inside of a net wire can provide an effective buck pen.

Lighting

Sheep or goats confined in a barn should experience diurnal cycles of light and dark. Photoperiod and light intensity should be adequate for inspection, maintenance of activity patterns, and physiological control of reproductive functions in breeding animals (Ortavant, 1977). An illumination of 220 lux is recommended (MWPS, 1994). A window area of .5 m^2 (5.4 ft^2) per goat can provide adequate light and ventilation (Colby, 1972). Although natural daylight ordinarily is sufficient for sheep in most situations, supplemental light of 170 lux is recommended for ease of observation during lambing or kidding. In outdoor pens, lighting deters predators. Either natural or artificial light may be used to control reproduction by manipulating the photoperiod to which ewes are exposed.

FEED AND WATER

Sheep and goats should be fed and watered according to established nutrient requirements to provide for proper growth in young animals and long-term maintenance of body weight, body condition, and reproduction of adults (NRC, 1981, 1985). The body condition of sheep and goats may vary considerably during different parts of the grazing and reproductive cycles (Engle, 1994). Feeding programs should make it possible for animals to regain body weight following the normal periods of weight loss.

A wide variety of feedstuffs may be fed to sheep and goats, but changes in the roughage and concentrate composition of the diet should be made gradually. The animals should be managed during the transition period to avoid development of digestive disorders such as acidosis, enterotoxemia, and polio encephalomalacia. When nontraditional feedstuffs are fed, composition of the feeds should be evaluated, and attention should be paid to correcting potential nutrient toxicities or deficiencies.

Feeding and watering equipment should be constructed and located to be available for ready access, to prevent injury to animals, and to prevent contamination of feed with excreta. Feedbunks and water sources should be monitored regularly and contaminants should be removed.

SOCIAL ENVIRONMENT

Because sheep and goats are highly social animals, they should, when possible, be maintained in groups to avoid unnecessary stress (Kilgour and de Langen, 1970). Individuals that are isolated from the flock or that have recently been separated from close social companions (e.g., at weaning) should be monitored frequently to reduce the possibility of injury following separation.

New individuals may be introduced into sheep flocks with relatively little social strife. However, unacquainted rams or bucks may severely injure each other. Care should be taken to prevent excessive fighting among males when they are newly mixed. Goats have a strong social hierarchy, and the addition of several goats to an established group is generally less stressful and more successful than the addition of an individual. Although horned and polled animals may be penned together, care should be taken to protect the polled animals. Sufficient space and multiple feeders should be provided to prevent individuals from dominating feed and water supplies.

In intensive production conditions, survival of the newborn lambs or kids can be enhanced by dividing larger flocks or herds into smaller groups, modifying facility design, increasing the frequency of observation, and using lambing pens or jugs. These procedures facilitate the development of the bond between dam and offspring.

HUSBANDRY

Managers and animal handlers should be trained and skilled in performing a variety of routine management procedures on sheep and goats. Ear-notching, ear-tattooing, tail web-tattooing, ear-tagging, shearing, and hoof-trimming are among the routine husbandry procedures that may be performed on sheep and goats at any age. Correction of entropia should be performed as soon as possible. Immunization should be provided against pertinent diseases (e.g., enterotoxemia). Colostrum should be provided as a source of antibodies soon after birth to avoid disease during the perinatal period. Further information on management procedures of sheep and lambs are described in detail in the *Sheep Production Handbook* (Sheep Industry Development Program, 1992) and the *Sheep Care Guide* (Sheep Industry Development Program, 1995).

Parasite Control

Parasite control is extremely important, especially when sheep and goats are on pasture. Frequent observation is necessary during periods of high risk from fly strike. Parasite control programs should be devised for each particular facility with the recognition that programs that work for sheep may not be effective for goats at the same facility.

Shearing

Because sheep do not shed wool naturally, shearing is necessary for their physical well-being. Shearing lambs during hot weather improves performance and stimulates feed intake. Shearing ewes prior to the lambing season provides a more favorable environment for newborn lambs and makes it easier for lambs to suckle. Crutching, the practice of shearing the wool from around the dock and udder, is an acceptable alternative when ewes are not shorn.

The shearing facility should be clean and dry. To minimize the spread of infectious disease (e.g., caseous lymphadenitis) between flocks, shearing equipment should be disinfected after each flock. When infectious disease conditions are present, equipment should be disinfected between sheep. A good shearer is a skilled professional. A proper shearing technique restrains and positions the sheep correctly to ensure both control and comfort of the animal. Pregnant ewes may be shorn if handled properly. To facilitate the comfort of sheep during shearing, sheep should be held off feed and water for 6 to 12 hr before shearing. Sheep should be dry when shorn. Sheared sheep need shelter from severe cold, windy, or wet conditions. Raised or stubble combs, which leave some wool on the sheep, may be used if sheep are likely to be exposed to inclement winter weather conditions. In hot weather, shade is necessary for recently shorn sheep to prevent sunburn.

Other husbandry and health practices used in sheep and goat research and teaching that require special technical training and advanced skill levels include artificial insemination, electroejaculation, pregnancy detection, ultrasound evaluations, embryo flushing and transfer, and venipuncture.

STANDARD AGRICULTURAL PRACTICES

Tail-Docking

Tail-docking of lambs is performed to reduce the possibility of soiling the long tail with urine and feces and the subsequent development of fly strike, a potentially fatal condition. Kids have an erect tail that is not docked. Tail-docking of lambs is necessary unless the life span is limited to a season when fly infestations are unlikely and when the feed used does not result in a heavily contaminated fleece. Docking may be accomplished by several means including rubber rings, hot iron cautery, surgical removal, and surgical removal following the application of an emasculator (Battaglia and Mayrose, 1981; Smith et al., 1983; Ross, 1989). Very short docking is discouraged because it probably contributes to the occurrence of rectal and vaginal prolapses. Tail-docking should be done at as early an age as possible, preferably before 2 wk of age. Removal of the tail after 2 mo of age should be performed under local anesthesia with special care taken to prevent heavy blood loss.

Castration

Castration is performed to prevent indiscriminate breeding, thus exercising genetic control, and to regulate the lambing season. Castration also prevents the breeding of young female flockmates that may become pregnant but are not in adequate physical condition to undergo pregnancy and lactation as well as the development of aggressive behavior in maturing males and the resulting injuries that frequently accompany this behavior. Castration is usually performed by application of rubber rings, by crushing the spermatic cord with an emasculator (the Burdizzo method), or by surgical removal of the testicles. Tetanus antitoxin should be given at castration when there is risk of tetanus. When a surgical method of castration is used, lambs and kids should be less than 2 mo of age; anesthesia should be used and special care taken to minimize hemorrhage and infection. The most appropriate method of castration depends partly on prevailing conditions.

Recommendations as to when docking and castration should be carried out are somewhat contradictory (Shutt et al., 1988; Lester et al., 1991; Wood and Moloney, 1992). However, docking or castration performed on lambs less than 24 hr old may disrupt the critical bonding process and the normal suckling activity of the lamb that are so important in securing adequate colostrum. Performing these procedures as early in life as possible, considering weather, nutritional stress, environment, and the presence of complicating disease processes, promotes overall lamb well-being.

Dehorning

Disbudding of goats should be performed at less than 1 mo of age. Cautery should be used when possible. Removal of horns of an adult animal should be done under general anesthesia or sedation and local anesthesia.

HANDLING AND TRANSPORTATION

Sheep show strong flocking behavior in pens as well as on pasture. Breed, stocking rate, topography, vegetation, shelter, and distance to water may affect the strength of this behavior. Isolation of individual sheep usually brings about signs of anxiety. Separation from the flock is a primary factor causing sheep to try to escape. Sheep tend to follow one another even in such activities as grazing, bedding down, reacting to obstacles, and feeding (Hutson, 1993). When handling sheep, these characteristic behaviors should be considered and used advantageously.

Transportation of sheep and goats should take into consideration the climatic conditions and productive stage of the animals. Care should be exercised in the transport of animals, and special consideration should be given during conditions of temperature extremes and high humidity. Appropriate measures should be taken to reduce the risk of pregnancy toxemia and transport tetany when sheep and goats are transported by supplying an adequate supply of nutrients immediately prior to long distance transport. Transportation of ewes and does during late gestation should be avoided. When possible, animals should be gated off into smaller groups during transport to prevent pileups and death losses.

EUTHANASIA

Severely injured sheep or sheep that are ill and have a very low chance of survival should be euthanatized. The AVMA Panel on Euthanasia (1993) identifies several appropriate methods for sheep, including overdose of anesthetic or injection with a euthanasia solution, penetrating captive bolt and exsanguination, or careful gunshot to the head. Other methods recommended by the AVMA may be used if proper equipment and expertise are available.

The carcasses of animals euthanatized by barbiturates may contain potentially harmful residues, and such carcasses should be disposed of in a manner that prevents them from being consumed by human beings or animals. In all cases, euthanasia should be performed by trained individuals who are skilled in the method used.

SPECIAL CONSIDERATIONS

Predator Control

In certain geographic locations and during certain seasons, protection from predators (e.g., dogs and coyotes) is an important part of providing adequate care for sheep and goats. Nonlethal means of predator control (e.g., guard animals, lights, noise, and fencing) are preferable but may be inadequate. Special fencing may be used to exclude some predators from livestock pastures (Sheep Industry Development Program, 1992). Lethal means of control are appropriate when necessary to reduce injury and loss of sheep and goats. State and local ordinances must be followed.

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Chapter 10: Guidelines for Swine Husbandry

FACILITIES AND ENVIRONMENT

Swine may be kept and readily adapt to a variety of production systems (*Pork Industry Handbooks,* undated and 1978 to present; MWPS, 1983; Baxter, 1984; Whittemore, 1993). The level of management applied in each viable system determines how much comfort the swine experience. More stockmanship may be necessary to meet pigs' needs in certain systems. Specific attention should be paid to management of effective environmental temperature (Table 10-1), exposure to sun, ventilation, vapor pressure, floor condition, area per pig, manure management, and quantity and quality of feed and water.

A predictable daily management routine allows pigs to develop a routine of their own. Animal care personnel should plan for swine management under climatic extremes and emergency conditions; personnel should be able to provide appropriate husbandry to minimize environmental stressors and animal distress. Animal care staff should be familiar with the behavior of normal pigs and of pigs experiencing stress or reduced well-being in order to improve pig comfort effectively when needed.

Attention should be given to pig dunging and resting preferences during both the design phase and the daily operation of swine facilities. Movement of manure and urine between pens should be minimized. Similarly, animal care personnel should take necessary precautions to prevent transmission of pathogens between pens and between facilities, even at the same location. Buildings should be periodically sanitized and disinfected.

Lighting

The domestic pig is less sensitive to its photic environment than are some other species. In the wild, swine do not depend on vision as much as 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 light-dark cycle preference is not similar to any natural situation.

No particular daily photoperiod is necessary for growing pigs (Berger, 1980). Developing breeding animals may benefit from photoperiods with long days (e.g., 16 hr light:8 hr dark), although results are still largely inconclusive (Zimmerman et al., 1980; Wheelhouse and Hacker, 1982). Lactating sows respond positively to photoperiods of 16 hr light:8 hr dark, resulting in enhanced piglet performance, and these sows may return to estrus sooner (Mabry et al., 1982, 1983; Stevenson et al., 1983).

FEED AND WATER

Pigs should be observed, and their well-being should be assessed, at least twice each day. Feeders and waterers should be checked to be sure they are functional. Feeders and waterers should allow easy access by swine with minimal waste of feed. Feeders or feeding places should be free from manure, urine, and other contaminants. Pigs may be fed from the floor as long as the surface is dry and clean and individual feed consumption is not limited by social competition. A water medicator may be used for management of enteric infections. When feed is delivered to animal houses and to individual pens, care should be taken to minimize dust.

Pigs should be fed to meet or to exceed nutrient requirements as determined by the NRC (1988). Water should be available for ad libitum intake, and special care should be taken to ensure that water is accessible for each size of pig.

SOCIAL ENVIRONMENT

Pigs by nature are social animals. Young pigs show behavioral and physiological signs of stress when held in complete isolation from other pigs. The precise relationship between group size and pig performance is neither predictable nor clear (Livingston et al., 1969; Patterson, 1985). Growing pigs are commonly found in group sizes from 2 to 30 pigs per pen, but even in groups of hundreds per pen.

Adult sows are often found in groups in nature, except for before and after parturition, when they seek isolation. In agricultural settings, holding sows in social groups may result in domination of subordination and may lead to excessive stress or trauma to individual sows. Feral boars are usually solitary animals, except during the breeding season. Thus, in some cases, adult pigs housed individually may experience less stress than growing pigs would. Agricultural research that proposes to house growing pigs individually or in isolation from other swine should be approved by the ACUC. Routine, total isolation should be avoided, but individual housing with at least some social contact (olfactory, some tactile) is acceptable. Short periods of total isolation (e.g., during transportation) may be unavoidable.

Table 10-1. Recommended Thermal Conditions for Swine Used in Agricultural Research and Teaching.

Type and weight	Preferred range[a]	Lower extreme[b]	Upper extreme[c]
Lactating sow and litter	15 to 26°C (59 to 79°F) for sow; piglets have 32°C (90°F) minimum creep area	25°C (77°F) creep area 15°C (60°F) sow area	32°C (90°F) for sow; no practical upper limit for piglets
Prenursery, 3 to 15 kg (7 to 33 lb)	26 to 32°C (79 to 90°F)	15°C (59°F)	35°C (95°F)
Nursery, 15 to 35 kg (33 to 77 lb)	18 to 26°C (64 to 79°F)	5°C (41°F)	35°C (95°F)
Growing, 35 to 70 kg (77 to 154 lb)	15 to 25°C (59 to 77°F)	–5°C (23°F)	35°C (95°F)
Finishing, 70 to 100 kg (154 to 220 lb)	10 to 25°C (50 to 77°F)	–20°C (4°F)	35°C (95°F)
Sow or boar, >100 kg (>220 lb)	10 to 25°C (50 to 77°F)	–20°C (4°F)	32°C (90°F)

[a]Based on values given by NRC (1981), DeShazer and Overhults (1982), Curtis (1985), and Hahn (1985).

[b]Values represent lower extremes in air temperature when pigs are held in groups. Bedding is recommended when air temperature approaches the lower extreme.

[c]Except for brief periods, above these air temperatures, cooling should be provided by means such as evaporatively cooled air for growing pigs or a water drip for lactating sows.

HUSBANDRY

Biosecurity

Teaching and research facilities must often strike a compromise between public access and minimizing the entry of disease organisms. Establishing a barrier between pigs and visitors requires visitors to do some or all of the following: shower in, wear clean footwear, change to on-site clothes, and wear only on-site clothes.

A herd health program should be in place, and attention should be given to isolating (30 to 60 days) and retesting of new stock, vaccination, sanitation, and minimum exposure to pathogens. Appropriate vaccinations should be administered in accordance with manufacturer guidelines and government regulations. For preparturient sows, vaccines should be administered early enough in advance of parturition, and according to the label on the vaccine, to allow accumulation of specific antibodies in the colostrum. Growing pigs should be vaccinated based on herd health needs.

To reduce interbuilding transmission of pathogenic microorganisms, careful attention should be given to traffic patterns of interbuilding personnel and disease organisms in feeds and transport vehicles. Barriers to microorganism transmission should be considered for personnel who move between houses, including showering in, changing clothes, and the use of disinfectant footbaths as personnel move between houses. Animal care personnel in swine research and teaching facilities should not be in contact with swine elsewhere unless strict biosecurity precautions are followed.

Farrowing Systems

Sow Management. Some degree of confinement of the periparturient sow is both necessary and preferred by sows (Phillips et al., 1991). Even in extensive housing systems, sows should be provided with a small house or pen in which they can be detained and from which groupmates can be excluded. During farrowing, sows should be isolated from physical contact with other mature animals.

The presence of a caretaker during parturition is not mandatory; however, this component of the system should be included in the planning phase of the research or teaching operation. Floor space recommendations are in Table 10-2.

Indoor farrowing environments should be cleaned, disinfected, and dried before the preparturient sow is allowed to enter. Outdoor farrowing environments should be either treated as just described or subjected to several days of rest and sunshine between farrowing groups. Sows may be treated to eliminate internal and external parasites before being allowed to enter the farrowing area. Laxative additives or a specially formulated diet may be fed before and after parturition to minimize constipation.

During hot weather (daily maximum temperature above 32°C [90°F]), sows should be zone-cooled. This cooling may be accomplished by dripping water directly on the sow's shoulders, by providing directed currents of air (snout coolers), or, in extensive systems, by allowing sows to wet themselves with water or mud.

Litter Management. Piglets require special attention because they are born with low reserves of energy and immunoglobulin, thermoregulate poorly, and are vulnerable to being crushed. Until weaning, piglets should be provided with an area that is warm, dry, draft-free, and zone-heated, and piglets should be protected from being crushed or injured by the sow.

The lower critical temperature of the piglet is about 35°C (95°F) at birth. However, the entire space in the house should not be heated to an air temperature even approaching the lower critical temperature of the piglets because the sow will become heat-stressed. Zone-heating, zone-cooling, or both, should be provided to meet the disparate thermal needs of the sow and piglets.

Any of the following procedures may be performed on piglets within a few days after birth: navel disinfected (if farrowing attended); needle teeth trimmed with a disinfected sharp device; tail trimmed to no less than 2.5 cm (1 in) from the body with a disinfected device (if piglets are to be raised indoors); supplemental iron injected (if piglets are to be nursed indoors); and individual identification made (usually ear notches).

Farrowing Pens and Crates. Extensive farrowing environments are acceptable research and teaching models when they are managed to minimize discomfort to piglets and sows. Sows kept outdoors should be observed regularly; bedding should be provided unless the thermal environment is adequate; fences should be sturdy and well-constructed. Electrified wire may be used. Proper health care for sows and piglets should be provided, and feces and urine should be removed periodically from such systems as needs arise. Sows and litters kept outdoors should be rotated among pastures to avoid accumulation of pathogens and parasites.

A farrowing house or pen should be cleaned and disinfected before each use. If sows farrow outdoors, appropriate sanitation procedures (e.g., moving huts and burning bedding) should be followed to ensure a clean farrowing environment. When supplemental zone-heating is not provided, farrowing houses on pasture and pens in central farrowing houses should be bedded with a suitable material such as straw. Bedding should be kept reasonably dry by the addition of more bedding material and by partial removal of soiled bedding at regular intervals as needed.

A typical farrowing pen measures at least 1.5 × 2.1 m (5 × 7 ft), but often is 3 × 3 m (10 × 10 ft). A protected area should be provided for piglets (at least .8 m^2 [8 ft^2]). This area should have supplemental heat (e.g., a 250-W heat lamp). Care should be taken to prevent thermal burns from supplemental heat sources. Guard rails should be placed on the perimeter of indoor pens to prevent the sow from crushing piglets against the wall.

Certain farrowing pens may accommodate acceptable piglet survival, including outdoor pasture systems with English-style farrowing arcs (Thornton, 1988; Edwards, 1995; McGlone et al., 1995) and pens with sloped floors for indoor sows (Collins et al., McGlone and Morrow-Tesch, 1990).

To reduce piglet injury and protect animal care personnel from overly aggressive periparturient sows, indoor sows may be confined in farrowing crates or free stalls from day 109 of gestation until the piglets are weaned (Curtis et al., 1995). A farrowing sow unit typically measures 1.5 × 2.1 m (5 × 7 ft), but the sow resides in a crate within that area that typically measures .6 × 2.1 m (2 × 7 ft) (Curtis et al., 1989). To lie down, sows slide along the restraining walls, which reduces piglet deaths. In addition, each sow and litter in a crate or pen can receive individual attention.

With few exceptions, the floors under or to the rear of the sow zone in farrowing crates are slotted or perforated. In this way, sows and piglets are effectively and quickly separated from their excreta, and the environment dries quickly. Acceptable types of slotted floors include perforated metal, woven metal, plastic-coated metal, metal bars, fiberglass, concrete, and combinations of materials. The floor surface should be unabrasive, nonporous, and not slippery (Fritschen and Muehling, 1984). Slots between slats should be wider behind the sow (usually 2.5 cm [1 in]) to allow passage of excreta. These wider slot openings should be covered during parturition to enable piglets to walk easily. Narrower perforations or slots prevent piglets from getting their feet caught in the floor openings. Rubber mats may be provided in the creep area for the first few weeks. Floor materials should be free of exposed or projecting materials to avoid injury to the leg, foot, or hoof. Bedding should be provided for farrowing crates equipped with solid floors.

Nursery Systems

Nursery systems include those housing and management arrangements for newly weaned pigs. Typically, pigs reside in a nursery from weaning until 8 or 9 wk of age. This period in the life of the pigs is critical because diet and environment change markedly when the pigs move to the nursery. Weaning at night may be less stressful than weaning during the early morning (Ogunbameru et al., 1992).

Piglets may be weaned at any age, but the younger the piglets are at weaning, the greater is the need for specialized facilities, care, a high degree of sanitation, and high quality diets (Lecce, 1986; Owen et al., 1995). Segregated early weaning is an emerging technology to improve pig health and well-being in herds with chronic disease. In a segregated early weaning system, piglets are weaned at 10 to 20 days of age and then transported to a facility that is geographically separated from other swine facilities (Dewey, 1995). This technology reduces the transfer of disease microorganisms from sows to nursery pigs by removing piglets from the sow before passive immunity decreases. The effects of early weaning on behavior of sows and piglets have not been evaluated fully, but benefits of properly executed segregated early weaning procedures include increased weight gain, improved feed efficiency, decreased morbidity, decreased mortality, and lower overall use of medication. Early weaned sows have subsequent reproductive delays, and piglets may have suppressed immunity (Hennessy et al., 1987) and may show excessive navel sucking and belly rubbing. If a disease microorganism is present in a segregated early weaning system, piglet morbidity and mortality may be very high.

The lower critical temperature of a 4-wk-old piglet (once it is eating at the rate of approximately 3 to 3.5 times thermoneutral maintenance) is around 26°C (79°F) (Table 10-1); therefore, most nurseries should be equipped with supplemental heating equipment. Exceptions to this are when piglets continue suckling (and thus obtaining heat from) the sow beyond 3 wk of age or when deep bedding is used to create a microenvironment in the range of thermoneutrality. In addition to supplemental heat, nursery houses should be maintained at a higher degree of sanitation than is required for older pigs. Nurseries should be operated on an all-in, all-out basis, and the facility should be cleaned, disinfected, and dried thoroughly between groups of pigs.

Weaned pigs should be self-fed a nutritionally complete and balanced diet unless the experimental protocol dictates otherwise (NRC, 1988). Up to 4 pigs may share a single proper feeding space. Pigs should be provided ad libitum access to clean water. One watering device is needed per 10 to 20 pigs and at least two watering devices per pen located far enough apart that one pig cannot dominate both. Floor area recommendations are in Table 10-2.

Slotted floors are common in nurseries. Flooring material may be similar to that in farrowing crate units. Pens with solid floors should be bedded with straw or a material with similar thermal and absorbent properties. If partially slotted floors are used, the waterer should be located over the slots.

Growing and Finishing Systems

The growing-finishing stage refers to pigs from 8 or 9 wk of age to market weight age of about 20 to 25 wk, or 100 to 125 kg (220 to 275 lb). The management of growing and finishing pigs differs from weanling pigs in that a lower standard of sanitation is required, units may be run with a continuous flow of pigs, and older pigs can tolerate a much wider range of environmental temperature than younger pigs (Table 10-1). Although growing-finishing systems may use a continuous flow of pigs, an all-in, all-out system is preferred.

Typically, growing and finishing pens are rectangular and contain no more than 40 pigs. Up to 10 pigs may share a feeder space, and up to 20 pigs may share a waterer. Specialized feeding and watering equipment may accommodate different pig densities. Penning materials should be sturdier than those used in nurseries. Floor area recommendations are in Table 10-2. Although needs for floor space are less well-defined for heavy weight finishing pigs, more floor space per pig is needed as pigs get heavier (Brumm, 1996).

Solid floors should be sloped (e.g., 2%) to allow water and manure to flow to a drain or a pit. Slotted floors need not be sloped. Although many flooring materials are acceptable, concrete slats are recommended for slotted floors. Concrete slats should be 9 to 20 cm (3.5 to 8 in) wide with an approximately 2.5-cm (1-in) slot between adjacent slats. Edges of slats should be rounded to preclude foot-claw injuries, and sharp edges should be avoided. Partially slotted floors are acceptable. Open flush gutter systems are acceptable, but risk of contamination between pens is greater.

Restricting the number of times pigs are moved or mixed is desirable because mixing pigs generally results in aggression, increases health problems, and causes performance setbacks.

Breeding and Gestation Systems

Sows, if managed properly, may be housed individually or in groups. When sows are kept in groups, social interactions are facilitated. When the group is fed a limited daily ration, competition for feed is often intense. Without intervention from animal care personnel, aggressive sows overeat, and subordinates ingest inadequate amounts of feed. Aggressive behavior in swine is common, and, if swine are left unattended, serious injury often results.

Stall housing for sows allows the caretaker to control individual feed allowances precisely but restricts sow movement. An alternative is a group pen equipped with individual stalls used only at feeding time.

Efforts to define the well-being of sows in different gestation housing systems have led to contrasting results and

TABLE 10-2. Minimum Floor Area Recommendations for the Animal Zone for Swine Used in Agricultural Research and Teaching.

Stage of production	Individual pigs (per pig)		Groups of pigs (per pig)[a]	
	(m^2)	(ft^2)	(m^2)	(ft^2)
Litter and lactating sow, pen	3.15	(35)	. . .	. . .
Litter and lactating sow, sow portion of crate	1.26	(14)	. . .	. . .
Nursery, 3 to 27 kg (7 to 60 lb) of body weight	.54	(6)	.16–.37	(1.7–4.0)
Growing, 27 to 57 kg (60 to125 lb) of body weight	.90	(10)	.37–.56	(4.0–6.0)
Finishing, 57 to 104 kg (125 to 230 lb) of body weight	1.26	(14)	.56–.74	(6.0–8.0)
Late finishing, 105 to 125 kg (231 to 275 lb) of body weight	1.26	(14)	.74–.84	(8.0–9.0)
Mature adults[b]	1.26	(14)	1.49	(16.0)

[a]Group area allowances for growing pigs range from starting to ending body weight in each phase. The needed floor area per pig decreases as group size increases (McGlone and Newby, 1994). The data presented here are for typical group sizes from 5 to 20 pigs per pen. For small group sizes (2 to 4 pigs), the pens should be longer than the body length of the largest pig in the pen.

[b]Stall size minimum width should be 56 cm (22 in), and minimum length should be 2.2 m (7 ft). Young adult females may be housed in stalls of 2 m (6.5 ft) length.

inconclusive interpretations (Brouns and Edwards, 1992). At present there is no consensus among scientists in identifying those factors responsible for the lack of agreement among studies. It has been suggested that specific genetic strains of sows may differ in their ability to adapt to particular housing environments (Beilharz, 1982), but this hypothesis has not been fully investigated. Inputs from managers, proper habituation, and selection of appropriate genetic stock appear to be primary contributors to the well-being of sows, independent of most gestation systems used.

Keeping gestating gilts and sows in tethers is banned for new facilities in the European Community member countries as of 1997. The net scientific opinion among some scientists is that, even under controlled conditions, the tether system can be stressful to the gilt or sow (Janssens, 1994, 1995; McGlone et al., 1994). Housing gifts and sows in tethers increases the attention required by management to ensure their proper application. Recent summaries of reproductive data in the field identified an association between use of tethers, lower farrowing rates, and more nonproductive sow days (PIC USA, Inc., 1994). Because both field and controlled studies point to the likelihood of reduced reproductive success and endocrine signs of a chronic stress response to tethers, the tether system is not recommended for teaching and research facilities.

Both field and controlled studies (McGlone et al., 1994; PIC USA, Inc., 1994; McGlone, 1995) support the idea that the individual crate or stall promotes high reproductive success and does not induce a stress response, based on endocrine and immune data. However, extended periods in crates may lead to muscle or bone weakness (Marchant and Broom, 1996). A properly designed crate or group system is an acceptable model production system for teaching and research units. Newer systems, presently under development, require extensive evaluation (Baxter, 1995) before being introduced as standard housing systems.

Housing. Recommended areas for breeding sows and boars of different types and sizes are listed in Table 10-2. Sexual development of gilts that have been selected to enter the breeding herd is hastened when they are kept in groups (10 to 12 per pen recommended in intensive production systems) with the opportunity for contact with mature boars for at least 30 min/day.

Sows in group pens (e.g., 5 to 10 per pen) and on restricted feed rations should be of uniform size and temperament. In extensive production systems, larger group sizes can be managed because feeding space per sow can be increased to reduce competition for feed.

Recommended dimensions for gestation stalls are .56 × 1.98 m and 1.02 m high (1.8 × 6.5 ft and 3.3 ft high) for gilts and .61 × 2.13 m and 1.02 m high (2 × 7 ft and 3.3 ft high) for sows. Standing sows and gilts should not be forcibly in contact with the sides, ends, or top of the stall (Curtis et al., 1989).

Individual housing of mature boars is recommended to preclude interactions among boars. When mature boars that are unfamiliar with one another are penned together, intense fighting usually occurs. In systems in which boars reside in small groups, boars should be of similar size, and it is highly desirable that they be reared together from the time of puberty.

Recommended dimensions of stalls for boars are .71 × 2.13 m and 1.17 m high (2.3 × 7 ft and 3.8 ft), but even larger stalls or pens may be required for extremely large boars.

Mating Facilities. Specialized facilities or areas are needed for breeding. Breeding may be by natural service or artificial insemination. Boar breeding areas should be slip-resistant. Artificial insemination areas include boar semen collection and sow insemination areas. Boar semen collection areas should be designed to consider boar and worker safety as well as animal comfort and sanitation. Sow insemination areas may be the same as gestation facilities for sows.

Pen mating (placing a boar with sows unattended) and hand mating (personnel attending boar-sow matings) are mating options. With pen mating in pasture and drylot systems, primary considerations are to minimize extremes in environmental temperature, rest boars between mating sessions, and avoid putting young boars with old sows or old boars with gilts.

For pen mating in intensive production systems, area allowance and flooring are additional considerations. Pens should be at least 2.44 m (8 ft) wide and provide at least 1.86 m^2 (20 ft^2) per sow or 1.6 m^2 (17 ft^2) per gilt. One boar per pen is recommended. Slip-resistant, dry floors are required to prevent injury.

With hand mating, the sow usually is mated in a designated mating pen but may be mated in the pen of either the sow or the boar. In any case, that pen should be a minimum of 2.44 × 2.44 m (8 × 8 ft) and have a slip-resistant floor.

The flooring surface in mating pens should be considered during the planning and construction of the facility. In pens with an area of solid concrete, floors may be made slip-resistant by applying a wood float or broom finish or by placing grooves in the concrete. A 2.5-cm (1-in) diamond pattern has proved satisfactory (Levis et al., 1985). In pens used for hand mating but without good footing, absorbent substances or rubber mats may be placed on the floor.

Sows kept for several parities may require special attention. Animal caretakers should be aware of the possibility of shoulder sores, long hoof growth, and thin body condition. These and other health problems should be treated as soon as they are identified.

Metabolism Stalls. Metabolism stalls are used to pen individual pigs for certain investigations of nutrition and physiology, with the approval of the ACUC. The metabolism stall usually keeps pigs in a manner that precludes them from turning around and soiling feed or eating feces. If the flooring and penning materials are appropriate for the size of the pig to be used and if the space allowances for individual pigs are met (Table 10-2), then pigs may be penned for extended periods in metabolism stalls without problems.

The precise width of a metabolism stall may require adjustments to provide total urine and fecal collection while preventing the pigs from turning or flipping. Slightly smaller space allowances may therefore be needed to accomplish these objectives. In studies requiring the use of metabolism stalls, twice daily interaction between the animal care staff and the pigs is especially important. Visual and vocal interactions with other pigs also support the well-being of individually housed pigs. Pigs should be held in metabolism stalls no longer than required by the approved animal care protocol.

STANDARD AGRICULTURAL PRACTICES

Castration

Boar taint, defined as a specific objectionable odor and flavor in meat, often occurs when boars are slaughtered at 100 kg (220 lb) of body weight or heavier. In view of demand by United States packers for heavier market hogs, almost all male pigs are castrated before slaughter. If teaching and research pigs are to be marketed in commercial chains, castration is recommended. If the research intends to reflect commercial pork production, castrated males are appropriate model animals.

Castration causes clear signs of pain and discomfort for pigs castrated at any age evaluated (McGlone and Hellman, 1988; McGlone et al., 1993; White et al., 1995). Signs of pain and discomfort include reduced times spent nursing or feeding, increased vocalization (apart from that induced by handling) as pigs increase in age, inflammation and swelling at the castration site, and acute reduction in performance.

To minimize stress on the pig, castration should be performed as early as possible and preferably between 1 and 14 days of age. After day 14 of age, local or general anesthetic should be administered prior to castration under prescription from the attending veterinarian. For boars of any age, trained personnel should use disinfected instruments, and a precastration disinfectant should be applied to the incision site. To allow proper drainage, the incision should be in the ventral scrotum and should not be sutured.

Other Standard Practices

Several other standard agricultural practices that cause only brief pain or distress but that prevent more serious distress or injury later in the pig's life may also be performed. Thus, teeth of pigs may be clipped at a very young age to reduce damage to littermates and to the sow. No more than one half of the tooth should be trimmed. Ears may be notched to provide permanent individual identification. Tails may be docked to reduce the potential for tail-biting. Tusks of boars may be trimmed to prevent them from harming humans or other pigs. Sows and boars may have their hooves trimmed to allow them to walk with greater ease and to avoid injuries.

HANDLING AND TRANSPORTATION

Guidelines for the handling and transportation of pigs are adapted from the *Swine Care Handbook* of the NPPC (1996). Safety and comfort should be of primary concern when transporting pigs. Weak pigs should not be loaded or transported with healthy ones. Appropriate steps should be taken to segregate sick and injured pigs immediately and to care for their special needs.

When pigs are transported, ventilation should be adequate, and the floor should be slip-resistant. When possible, animals should be shipped in groups of uniform weight. Pigs of 22.7 kg (50 lb) should have a minimum of .14 m^2 (1.5 ft^2), and 182-kg (400-lb) pigs should have .55 m^2 (6 ft^2) (Grandin, 1988, 1989).

Injuries and bruises can result in animal suffering and carcass damage when pigs are improperly managed during handling and transport. Recommendations for facility design for loading and unloading trucks, restraining animals, and handling them in packing plants have been published (Grandin, 1983, 1988, 1991).

Transport and handling stresses can be aggravated by adverse weather and wide temperature fluctuations. Hot weather is a time for particular caution. The Livestock Weather Safety Index (Grandin, 1992) is used as the basis for deciding how to handle and ship swine. Swine should not be transported during extreme weather. During transit in warm weather, swine should be protected from heat stress by being shaded, wetted, and bedded with wet sand or shavings. Prompt unloading in hot weather is essential because heat builds up rapidly in a stationary vehicle.

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 (0°C), 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 hr. The ACUC should consider water needs during transport in hot weather.

Truck beds should ordinarily be clean and dry and equipped with a well-bedded, nonslip floor. Pigs should be loaded and unloaded promptly. The chutes used should be designed specifically for swine (Grandin, 1988). Injuries can be reduced when the pigs on a truck are held in several small groups and are handled and moved carefully.

Caretakers should seek to prevent animals from becoming nonambulatory by feeding nutritionally sound diets, maintaining sound health programs, providing good flooring surfaces, and selecting genetically sound breeding stock. Swine that are unable to walk or that are ill or severely injured and will not likely recover should be humanely euthanatized at the facility and not be transported through market channels.

EUTHANASIA

The AVMA Panel on Euthanasia (AVMA, 1993) lists several methods of euthanasia that may be appropriate for pigs. Certain euthanasia techniques are suggested here for very young and adult pigs in consideration of both worker safety and humane euthanasia.

Carbon dioxide is a suitable method for euthanatizing swine providing that residual oxygen is removed quickly from the CO_2 chamber. This method requires a special chamber to administer the gas, which might be found in a biomedical facility. Carbon monoxide is not recommended because it is a potential human health hazard.

An overdose of anesthetic or injection with a euthanasia solution is a humane method that may be practiced after careful training in a teaching or research unit. Barbiturates require special handling and licensing.

As recommended by the AVMA (1993), larger swine (over 23 kg) may be euthanatized by lethal injection or penetrating captive bolt and exsanguination. Other recommended methods may be used if proper equipment and expertise are available.

SPECIAL CONSIDERATIONS

Pigs with Small Mature Body Size

Some specific strains of *Sus scrofa* or *Sus vittatus* have or have been selected to have a small mature body size. These strains include, but are not limited to mini, micro, and pot-bellied pigs. These pigs may be used in commercial agricultural production, but are more often kept as pets or used as biomedical research models. However, the husbandry requirements of these pigs are generally similar to those of traditional domestic pigs, with some exceptions.

Thermal and nutrient requirements should be carefully considered. Pigs with small mature body size are more sensitive to cool temperatures than are larger pigs because of their sparse hair coat and small body size. Because they are smaller and eat less per day, their nutrient requirements per weight of feed may be higher, although they must be limit-fed to control body condition (avert obesity). The physical plant (e.g., flooring and penning materials) should be appropriate for their body size.

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Chapter 11: Guidelines for Veal Calf Husbandry

Special-fed veal production in the United States typically utilizes Holstein bull calves that are fed a diet of liquid milk replacer and grown to finishing weights of 160 to 200 kg (350 to 450 lb) at 15 to 20 wk of age. Meat from these calves is referred to as milk-fed veal. Bob veal refers to calves, usually less than 3 to 4 wk of age and less than 68 kg (150 lb), which are destined to be slaughtered. Grain-fed veal or veal calves that are not special-fed are reared on feeding programs including grain and hay and are marketed at weights between 68 to 181 kg (151 to 400 lb). Meat from these calves is referred to as red veal (USDA, 1991).

The AVMA (1995) recognizes that veal calf production systems are well established and can be humane. Veal calves should be handled with care, gentleness, and patience. Stress on calves usually results in suboptimal physiological functions or adverse behavioral reactions and should be minimized to ensure calf well-being and performance (Stott, 1981; Dantzer et al., 1983; Wilson et al., 1994b). Sick or injured calves should be segregated and treated promptly (AVMA, 1987).

FACILITIES AND HOUSING

Calves should be housed in settings that are conducive to optimal performance, health, and overall well-being. Several systems satisfy these objectives, but each has certain limitations (Webster et al., 1985a,b; Agriculture Canada, 1988; Le Neindre, 1993; Rushen, 1994; Stull and McDonough, 1994).

Internal surfaces of veal calf barns should be made of nontoxic materials that either can be cleaned and disinfected effectively or are disposable. Internal surfaces and fittings of houses, stalls, pens, and other equipment accessible to calves should have no sharp edges or projections. All floors, particularly slotted ones, should be designed, constructed, and maintained so as to avoid injury or distress to calves.

During daylight periods, natural or artificial indoor lighting intensity should be high enough that every calf can be seen clearly for inspection at any time. Light levels above 22 lux are recommended at the level of the floor (Andrews and Read, 1983) or the calves' eyes (Stull and McDonough, 1994).

Ventilation and air temperature are important considerations, especially for the newly arrived calf. The lower critical temperature for a calf under 1 wk of age is 10°C (50°F) (Webster et al., 1978), but the optimal temperature for young calves is 18 to 21°C (65 to 70°F) (Meyer, 1991). Relative humidity between 50 and 60% is recommended, but older calves can tolerate over 70% (Meyer, 1991). High temperatures create stress in calves that can reduce appetite and affect meat color. Two low cost cooling methods are recommended for hot weather of 27 to 38°C (80 to 100°F): large diameter paddle fans overhead and evaporative cooling (Meyer, 1991).

Veal calves may be raised in either group pens or individual stalls. Stalls provide an opportunity for the caretaker to feed and monitor calves individually (Parker, 1968; Heard et al., 1972; Linton et al., 1974; Roy, 1980; Andrews and Read, 1983; Wilson et al., 1994b). All enclosures should be constructed to allow for proper drainage of waste to ensure calf cleanliness. Arranging stalls in rows facilitates visual inspection of calves and allows for social, visual, and head-to-head contact between neighboring calves.

Size of Stalls

Individual calf stalls in the United States for calves weighing 160 kg (350 lb) commonly measure .56 to .60 m (22 to 24 in) wide and approximately 1.5 to 1.65 m (60 to 66 in) long (Colby et al., 1975; Schwartz, 1990; AVA, 1994; Stull and McDonough, 1994). In all new or renovated facilities, stall size should be a minimum of .65 m (26 in) wide and 1.65 m (66 in) long. The minimal length of the side wall partition is usually .61 m (24 in). Shortening the sides of the stall reduces problems with bruised flanks as calves increase in size (Kammel, 1991; AVA, 1994). To accommodate larger veal calves (>160 kg [350 lb]), an additional 2.5 cm (1 in) and 10 cm (4 in) in the width and length, respectively, should be allowed for each additional 11.4 kg (25 lb) increase in body weight.

The larger Dutch-style stalls of .75 m × 1.8 m (30 × 72 in) are recommended. Calves are tethered for the first 6 to 8 wk of age and then released. Calves so motivated can turn around, get up, lie down, and rest comfortably; barriers should prevent calves from defecating in their feed buckets (van Putten and Elshof, 1982; AVA, 1994).

Slotted Floors

Slotted floors for veal calves may be made of oak, expanded wire with plastic coating, or other suitable material that is maintained in good repair in order to minimize knee injuries and lameness (Steenkamer, 1982). Slats should be oriented perpendicularly to the dorsal axis of the calf to improve footing and reduce injury.

Tethers

Tethering is used in conjunction with individual stalls to allow normal daily care of the calves and to avoid undue transmission of disease. Tethers are utilized to prevent the calf from leaving its stall or turning around and possibly contaminating the feeding area with feces. Tethers should be long enough to permit the calves to stand, groom, eat, rest in a natural sternal posture, or with their head and neck turned to the side of their body, and allow movement forward and backward, yet be short enough to prevent strangulation or turning around. Tethering devices may be straps, chains, or ropes and must incorporate a swivel feature in the design. Tethered calves should be monitored at least twice daily; tether and collar lengths should be adjusted as needed. All calves should be carefully trained and conditioned to the tether (AVA, 1994). Research results have shown no difference in veal calf performance (average daily gain, feed efficiency, hemoglobin, or carcass quality) whether movement in pens or stalls was restricted by tethers or was unrestricted (Knesel et al., 1983, 1993).

Group Pens

When group pens are used, pen size should be determined by the number of calves, finished market weight of calves, flooring material, and waste management system. Calves in systems utilizing ad libitum intake should be grouped according to size to facilitate sufficient individual intake of milk replacer (Stephens, 1974). Larger groups may decrease the caretaker's ability to detect illness (van Putten, 1982). Veal calves in groups tend to exhibit more variation in growth rate than do calves housed individually (Roy, 1980; Webster and Saville, 1981; Steenkamer, 1982; Stull and McDonough, 1994). Even if they are destined to reside in groups eventually, calves may need to be kept in individual accommodations until at least 1 to 2 mo of age for health reasons (Wood et al., 1967; Roy, 1980; Stephens, 1982; van Putten and Elshof, 1982).

In multiple-pen rearing systems, calves may be kept on slotted floors or solid floors with bedding; under these conditions, straw may be offered for ad libitum intake from a feeder (Bogner, 1982; Steenkamer, 1982). When small groups of calves (e.g., 3 to 5) are kept together, 1.4 to 1.7 m^2 (15 to 18 ft^2) of floor area per calf should be provided. Large groups (usually no more than 20 to 30 calves) of calves fed using automated feeding machines with artificial teats should be placed in a single pen with 1.2 to 1.4 m^2 (13 to 15 ft^2) of available floor area per calf (Stull and McDonough, 1994).

SOCIAL ENVIRONMENT

Behavior of veal calves housed under various systems has been studied extensively (Stephens, 1974, 1982; van Putten and Elshof, 1982; de Wilt, 1985; Webster et al., 1985b, 1986; Le Neindre, 1993; Rushen, 1994; Stull and McDonough, 1994; other work cited elsewhere in this chapter). Recent research has confirmed that there are few major differences between postures and behavior of calves kept in stalls and those kept in group pens (Albright et al., 1991; Stull and McMartin, 1992). Total time spent in recumbency or the number of transitions from recumbency to standing was similar in a study comparing calves in stalls with calves penned in groups over 8 wk of age (Stull, 1992). Although some normal behaviors are better satisfied in group pens than in individual stalls, certain abnormal or detrimental behaviors (e.g., cross-sucking and genital sheath sucking, urine drinking, tongue playing, aggression, and competition for feed) may increase.

In view of the strong stimulatory effect that milk has on sucking behavior, the provision of a dry teat for calves to suck after feeding should be considered as a means of enriching their environment (de Passillé et al., 1992).

FEED AND WATER

Veal calves should be fed to meet or to exceed the established nutrient requirements for calves (NRC, 1989), except for iron (see Iron section). Calves are usually bucket-fed twice daily, and a supply of clean, fresh drinking water should be available (NRC, 1989) after about 2 wk (AVA, 1994). There is no evidence that offering water to young calves for ad libitum intake causes diarrhea (Kertz et al., 1984).

Grain-fed (red) veal calves are fed a variety of diets including milk replacers, grain, forages (hay, silage, or pasture), and processed feeds (NRC, 1989; AVA, 1994; Wilson et al., 1994b). Early performance and health of the young calf are highly dependent upon proper digestive function in the abomasum. This structure can effectively bring about coagulation of milk protein by the action of rennin and partial digestion by pepsin and hydrochloric acid. Development of strong curd formation results in greater retention time in the abomasum, enabling more complete enzymatic action on protein and fat fractions (Radostits and Bell, 1970; Ternouth et al., 1974, 1975; Cunningham and Knesel, 1982). However, modern technology for feed manufacturing appears to have eliminated the need for clotting of milk replacers (Longenbach and Heinrichs, 1998). Milk replacers for starting and growing veal calves contain 20 to 24% protein and 16 to 20% fat and should be fed for the first 6 to 8 wk. Finisher milk replacers should then be fed to provide 16 to 20% protein and 18 to 20% fat until slaughter weight is reached. Vitamins and minerals should be supplemented in milk replacers, and amino acids may also be added to the diets (Heinrichs, 1994, 1995).

The protein in milk replacers for veal calves is typically based on milk sources (Warner, 1970; Colby et al., 1975; Roy, 1980; Cunningham and Knesel, 1982; Stull and McDonough, 1994). Low quality milk protein or milk protein substitutes have insufficient curd-forming properties and may not support top performance in veal calves. Homogenization and addition of emulsifying agents for fats generally improve both dietary digestibility and performance (Cunningham and Knesel, 1982).

Iron

Hemoglobin concentration in blood varies considerably among calves at birth and between calves fed diets supplemented or unsupplemented with iron (Blaxter et al., 1957; Hibbs et al., 1961; Cunningham and Knesel, 1982). Veal calves fed only whole milk or milk replacers supplemented with iron experience declining blood hemoglobin concentration and changes in other blood traits over time (Niedermeier et al., 1959; Roy et al., 1964; Eeckhout et al., 1969; Warner, 1970; Bremner et al., 1976; Reece, 1980, 1984; Roy, 1980; McFarlane et al., 1988; Wilson et al., 1994a). These trends have not been shown consistently to influence the health, behavior, or performance of veal calves. The iron (inherent or added) that is available to veal calves in milk replacer, water, and supplementary sources should be adequate to maintain the health, performance, and overall well-being of the calves.

The supplementation of iron should be based on monitoring calves at 7 and 10 wk of age for hemoglobin concentration; targeted levels should be maintained between 7.5 and 8.5 g/dl (Wilson et al., 1994b). Iron content is highest in starter diets, and dietary concentrations then decline as calves reach market weight. This decline in dietary iron limits myoglobin content in the muscle, thus producing the preferred light-colored carcasses, but still allows for normal appetite and optimal growth (Bremner et al., 1976).

Research is needed (1) to confirm the optimal frequency for determining hemoglobin concentrations of calves and (2) to determine whether marginally anemic calves might be less able than normally fed calves to tolerate normal activity (Schwartz, 1990).

HUSBANDRY

Calves should ingest colostrum soon after birth. The risk of disease and mortality for veal calves may be related to individual immune status (Gay et al., 1965; Irwin, 1974; Postema and Mol, 1984; McDonough et al., 1994). However, good husbandry can minimize disease problems even when the calves arrive at the facility immunologically compromised and carrying infectious disease (Heard et al., 1972; Linton et al., 1974; Peters, 1986).

When calves arrive at the barn, the health of each calf should be assessed carefully, and any necessary treatment regimens should be started immediately. Health may be compromised by several conditions, including dehydration, navel infections, diarrhea, respiratory problems, or lice. If severe, these conditions may contribute to death. Signs of healthy calves are a dry navel, ability to walk unassisted, alert ears and clear eyes, no signs of diarrhea, and, upon arising, resumption of a normal standing posture after stretching.

A system of monitoring calves throughout the growing period should be established. Animal care personnel should be taught to recognize signs of illness and external parasites. Frequent observation is advisable during the first few weeks after arrival. Alert handlers should have the ability to perceive appropriate behavior and posture (Albright, 1993). Any sick or injured calves should be treated immediately. Daily records should be kept (e.g., calves treated and treatment).

Appropriate medication and vaccination programs should be used to reduce the incidence of disease and mortality, improve calf health and performance, and ensure that no violative residues occur in the carcass (Colby et al., 1975; Roy, 1980; Wilson and Dietrich, 1993). Treatment and vaccination schemes should be based on veterinary advice and experience.

STANDARD AGRICULTURAL PRACTICES

Because veal calves reach market at an early age, they are neither dehorned nor castrated. Calves should be identified by ear tags.

HANDLING AND TRANSPORTATION

Sand or barn grit to improve traction of calves coming into or exiting the barn is usually necessary, as is the prevention of any sharp turns or obstacles that may cause calf or human injury. Loading alleys and chutes should be wide enough to accommodate finished calves but not to allow the calves to turn around. Because there are fewer distractions, calves move better if the chute sides are solid rather than open. Portable panels to receive or ship calves are helpful. Electric goads (prods) should be used sparingly, if at all, and must not be used on very young calves. An alternative to these types of instruments is additional personnel or other techniques to help keep the calves moving.

The researcher or teacher should be the primary determinant of trucking practices and truckers used, even in a contractual feeding arrangement. Stress that occurs when the finished calves are moved from the barn and onto and off the truck at the packing plant can cause bruises and darkening of muscle color. Therefore, it is in the best interests of everyone concerned that the calves be handled with care and concern to prevent injury and stress (Grandin, 1982; AVA, 1994).

EUTHANASIA

When necessary, euthanasia should be performed by competent personnel using accepted methods established by the AVMA (1993). The approved method for young calves is barbiturates. Other techniques that may be used for calves are penetrative captive bolt, gunshot to the head, electrocution, and chloral hydrate (see Chapter 3).

SPECIAL CONSIDERATIONS

The all-in, all-out method of occupancy is recommended (Colby et al., 1975; Roy, 1980; Cunningham and Knesel, 1982) to minimize the transfer of pathogens from older to younger calves and to perform proper sanitation procedures. Facilities should be steam-cleaned and disinfected between successive groups of calves. All equipment used for feeding veal calves should be thoroughly cleaned immediately after each use and disinfected daily by heat or with dairy disinfectants approved under milk and dairy regulations. Equipment should be allowed to drain and dry thoroughly between feedings.

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Appendix 1

United States Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training

The development of knowledge necessary for the improvement of the health and well-being of humans as well as other animals requires in vivo experimentation with a wide variety of animal species. Whenever US Government agencies develop requirements for testing, research, or training procedures involving the use of vertebrate animals, the following principles shall be considered; and whenever these agencies actually perform or sponsor such procedures, the responsible institutional office shall ensure adherence to these principles:

I. The transportation, care, and use of animals should be in accordance with the Animal Welfare Act (7 U.S.C. 2131 et seq.) and other applicable federal laws, guidelines, and policies.

II. Procedures involving animals should be designed and performed with due consideration of their relevance to human or animal health, the advancement of knowledge, or the good of society.

III. The animals selected for a procedure should be of an appropriate species and quality and the minimum number required to obtain valid results. Methods such as mathematical models, computer simulation, and in vitro biological systems should be considered.

IV. Proper use of animals, including the avoidance or minimization of discomfort, distress, and pain when consistent with sound scientific practices, is imperative. Unless the contrary is established, investigators should consider that procedures that cause pain or distress in human beings may cause pain or distress in other animals.

V. Procedures with animals that may cause more than momentary or slight pain or distress should be performed with appropriate sedation, analgesia, or anesthesia. Surgical or other painful procedures should not be performed on unanesthetized animals paralyzed by chemical agents.

VI. Animals that would otherwise suffer severe or chronic pain or distress that cannot be relieved should be painlessly killed at the end of the procedure or, if appropriate, during the procedure.

VII. The living conditions of animals should be appropriate for their species and contribute to their health and comfort. Normally, the housing, feeding, and care of all animals used for biomedical purposes must be directed by a veterinarian or other scientist trained and experienced in the proper care, handling, and use of the species being maintained or studied. In any case, veterinary care shall be provided as indicated.

VIII. Investigators and other personnel shall be appropriately qualified and experienced for conducting procedures on living animals. Adequate arrangements shall be made for their in-service training, including the proper and humane care and use of laboratory animals.

IX. Where exceptions are required in relation to the provisions of these principles, the decisions should not rest with the investigators directly concerned but should be made, with due regard to Principle II, by an appropriate review group such as an institutional animal care and use committee. Such exceptions should not be made solely for the purposes of teaching or demonstration.

Appendix 2

TABLE A-1. Zoonotic Diseases of Agricultural Animals.[a]

Disease in humans	Causative agent	Common hosts	Means of spread
Anthrax	*Bacillus anthracis*	Livestock	Contact, inhalation, or ingestion
Brucellosis	*Brucella suis*	Swine	Contact and ingestion of milk, milk products, raw meat
	Brucella abortus	Cattle, sheep	
	Brucella melitensis	Sheep, goats	
	Brucella ovis	Sheep	Direct contact, particularly with semen, aborted fetuses, fetal membranes, amniotic fluid
Campylobacteriosis	*Campylobacter fetus*	Cattle, sheep, pigs	Ingestion of raw meat and raw milk
	Campylobacter jejuni	Poultry	
Chlamysiosis	*Chlamydia* spp.	Poultry	Inhalation
Colibacillosis	*Escherichia coli*	Livestock	Ingestion
Leptospirosis	*Leptospira* spp.	Cattle, sheep, swine, goats	Contact, urine-contaminated soil or water
Pseudotuberculosis	*Yersinia pseudotuberculosis*	Turkeys	Contact, contaminated food and water, ingestion
Salmonellosis	*Salmonella* spp.	Livestock and poultry	Ingestion, inhalation, contact
Tetanus	*Clostridium tetani*	Horses, sheep	Bite wounds, contaminated puncture wounds
Tuberculosis	*Mycobacterium tuberculosis*	Cattle	Contact, ingestion, inhalation
	Mycobacterium bovis	Cattle	
	Mycobacterium avium	Poultry, swine, sheep	
Q fever	*Coxiella burnetii*	Cattle, sheep, goats	Inhalation ingestion of contaminated raw milk, contact with amniotic fluid or placenta, blood-sucking arthropods
Eastern, Western, and Venezuelan equine encephalitis	Eastern equine encephalitis, Western equine encephalitis	Horses	Mosquito bites
Tularemia	*Francisella tularensis*	Sheep	Contact, bites of blood-sucking arthropods
Erysipeloid (pork finger)	*Erysipelothrix rhusiopathiae*	Swine, chickens, turkeys, sheep	Contact
Coccidioidomycosis	*Coccidioides immitis*	Cattle	Contamination of food
Ringworm, dermatomycosis	*Trichophyton* spp.	Farm animals	Direct contact; soil may be reservoir
	Microsporum spp.		
	Other dermatophytes		
Staphylococcal infections	*Staphylococcus* spp.	Livestock, especially dairy cattle	Contact, consumption of unpasteurized milk
Streptococcal infections	*Streptococcus* spp.	Livestock, especially dairy cattle	Contact, consumption of unpasteurized milk
Listeriosis	*Listeria monocytogenes*	Cattle, sheep, goats, chickens, turkeys	Possibly contact with mucous membranes, skin penetration, ingestion
Rabies	Rhabdovirus	Livestock	Bite wound, saliva in open wound
Milker's nodules (paravacinia)	Paravaccini virus	Cattle	Contact with teats and udders
Newcastle disease	Paramyxovirus	Chickens, turkeys	Direct or indirect contact
Animal pox	Pox virus	Livestock	Contact
Vesicular stomatitis	Rhabdovirus	Cattle, horses, swine	Contact
Psittacosis	*Chlamydia psittaci*	Poultry, waterfowl	Contact with birds or fecal material
Balantidiasis	*Balantidium coli*	Swine	Ingestion of feces
Nematodiasis	Roundworms	Swine, horses, cows	Ingestion, contact
Histoplasmosis	*Histoplama capsulatum*	Poultry	Inhalation of organism from material contaminated with feces
Cryptosporidium	*Cryptosporidium parvum*	Cattle	Fecal, oral
Orf	Parapox virus	Sheep, goats	Direct contact
Pasteurellosis	*Pasteurella multocida*	Ruminants	Inhalation, bite wounds
Pneumocystis	*Pneumocystis curinii*	Cattle, sheep	Inhalation

[a]After Acha and Szyfres (1989).

TABLE A-2. Pre-anesthetic, Anesthetic, and Analgesic Agents Suitable for Agricultural Animals.[a]

Generic name	Trade name	Route of administration[b]	Purpose
		Pre-anesthetic agents	
Atropine sulfate	Atropine sulfate	i.m. 10-20 min prior to anesthetic induction	Decrease saliva production and to prevent bradycardia.
Chlorpromazine hydrochloride	Thorazine	i.v. or i.m.	Tranquilization.
Acepromazine maleate	Acepromazine maleate	i.m.	Tranquilization.
Diazepam	Valium	i.m.	Sedation.
		Inhalation anesthetics	
Halothane	Fluothane		Most widely used inhalant anesthetic. Depth of anesthesia is rapid, and recovery is prompt and smooth. Will initiate malignant hyperthermia, and human health concerns are associated with anesthetic waste gas.
Methoxyflurane	Metafane, Penthrane		May be superior to halothane for muscle relaxation and postoperative analgesia. Low vaporization rate thus can only be used after induction with another agent.
Isoflurane	Aerrane		Very safe general anesthesia with good surgical analgesia.
		Injectable general anesthetics	
Pentobarbital sodium	Sodium pentobarbital	i.v.	20-30 min of relatively safe anesthesia.
Thiopental sodium	Veterinary pentothal kit	i.v.	Short surgical anesthesia or induction prior to inhalation anesthesia.
Ketamine hydrochloride	Ketaset	i.v. or i.m.	Cataleptic general anesthesia, poor visceral analgesia. Usually used in combination with other anesthetic agents.
Tiletamine and zolazapam	Telazol	i.v. or i.m.	Similar to ketamine but better relaxation.
Xylazine hydrochloride	Many commercially available	i.v. or i.m.	Used in combination with other agents to improve muscle relaxation during surgery.
		Local anesthetics	
Lidocaine hydrochloride	Many commercially available	Epidural or infiltration	For producing epidural, nerve conduction, and infiltration anesthesia.
Meprivacaine hydrochloride	Carbocaine-V	Infiltration, nerve block, intra-articular, and epidural	Produces rapid and marked local anesthesia lasting for several hours.
Procaine hydrochloride	Epidural injection	Epidural	For use as an epidural block.
		Analgesic agents	
Oxymorphone hydrochloride	P/M Oxymorphone, Numorphan	i.v.	Opioid used for increased and prolonged analgesia. Often used with other anesthetic agents.
Butorphanol tartrate	Torbugesic, Torbutrol	i.v., i.m., or s.c.	Synthetic opioid analgesic, five times the potency of morphine. Less respiratory or cardiovascular depression.
		Nonsteroidal anti-inflammatory agents[c]	
Aspirin	Many commercially available	Oral	
Flunixin meglumine	Banamine, Finadyne	i.m. or i.v.	
Phenylbutazone	Burazolidin	Oral or i.v.	Has been associated with blood dyscrasia and disturbances of gastrointestinal tract, kidney, and liver.

[a]All agents are prescription drugs and require a veterinary prescription. If not approved for use in food-producing animals, they can only be used by following the FDA extralabel food provisions as described in Chapter 3.

[b]Intramuscularly (i.m.), intravenously (i.v.), or subcutaneously (s.c.).

[c]Produces analgesia by reducing inflammation.

TABLE A-3. Agents and Methods of Euthanasia by Species.[a]

Species	Acceptable	Conditionally acceptable
Birds	Inhalant anesthetics, CO, CO_2 barbiturates	N_2, Ar, cervical dislocation, decapitation
Horses	Barbiturates, chloral hydrate, chloral hydrate-$MgSO_4$-pentobarbital	Penetrating captive bolt, gunshot, electrocution
Ruminants	Barbiturates	Penetrating captive bolt, gunshot, electrocution, chloral hydrate
Swine	Barbiturates, CO_2	Inhalant anesthetics, CO_2, penetrating captive bolt, gunshot, electrocution, chloral hydrate

[a]Refer to the reference for mode of action, rapidity, ease of performance, safety for personnel, species suitability, efficacy, and comments: (*1993 Report of the AVMA Panel on Euthanasia.* JAVMA 202(2):229-249).

Appendix 3

ORGANIZATIONS

Agriculture and Agri-Food Canada. Sir John Carling Building, 930 Carling Avenue, Ottawa, ON, Canada K1A OC5. Phone: 613-759-1101, FAX: 613-759-1040, URL: http://www.agr.ca

Agri-Education, Inc. 801 Shakespeare Ave., Stratford, IA 50249. Phone: 515-838-2793, toll free: 1-800-55-DAIRY, e-mail: agri-ed@netins.net

American Association for Laboratory Animal Science (AALAS). 70 Timber Creek Drive, Suite 5, Cordova, TN 38018. Phone: 901-754-8620, FAX: 901-753-0046, e-mail: aalas.org, URL: http://www.aalas.org/

American Dairy Goat Association (ADGA). 209 W. Main St., Spindale, NC 28160-1540. Phone: 704-286-3801.

American Dairy Science Association (ADSA). 1111 North Dunlap Ave., Savoy, IL 61874. Phone: 217-356-3182, FAX: 217-398-4119, URL: http://www.adsa.uiuc.edu

American Humane Association (AHA). 236 Massachusetts Ave. NE, Suite 20, Washington, DC 20002. Phone: 202-543-7780, FAX: 202-546-3266.

American Meat Institute (AMI). 1770 N. Moore Street, Arlington, VA 22209-1903. Phone: 703-841-2400.

American Meat Science Association (AMSA). 9140 Ward Parkway, Kansas City, MO 64114. Phone: 816-444-3500, FAX: 816-444-0330.

American Registry of Professional Animal Scientists (ARPAS). 1111 North Dunlap Avenue, Savoy, IL 61874. Phone: 217-356-3182, FAX: 217-398-4119.

American Sheep Industry Association (ASIA). 6911 S. Yosemite, Englewood, CO 80112. Phone: 303-771-3500.

American Society of Agricultural Engineers (ASAE). 2950 Niles Road, St. Joseph, MI 41085-9601. Phone: 616-429-0300.

American Society of Animal Science (ASAS). 1111 North Dunlap Ave., Savoy, IL 61874. Phone: 217-356-3182, FAX: 217-398-4119, URL: http://www.asas.uiuc.edu

American Veal Association (AVA). 4714 Orchard St., Harrisburg, PA 17109-1712. Phone: 717-540-3812.

American Veterinary Medical Association (AVMA). 1931 North Meacham Road, Suite 100, Schaumburg, IL 60173-4360. Phone: 800-248-2862, FAX: 708-925-1329, URL: http://www.avma.org/

Animal Welfare Information Center (AWIC). National Agricultural Library, 10301 Baltimore Avenue, Beltsville, MD 20705-2351. Phone: 301-504-6212, FAX: 301-504-7125, e-mail: awic@nal.usda.gov, URL: http://www.nalusda.gov/awic

Applied Research Ethics National Association (ARENA). 132 South Boylston Street, Boston, MA 02116. Phone: 617-423-4112, FAX: 617-423-1185, e-mail: prmr@aol.com, URL: http://www.aamc.org/research/prmr/arena/

Association for the Assessment and Accreditation of Laboratory Animal Care International (AAALAC International). 11300 Rockville Pike, Suite 1211, Rockville, MD 20852-3035. Phone: 301-231-5353, FAX: 301-231-8282, e-mail: accredit@aaalac.org, URL: http://www.aaalac.org

Canadian Council on Animal Care (CCAC). Constitution Square, Tower II, 315-350 Albert, Ottawa, ON, Canada K1R 1B1. Phone: 613-238-4031, FAX: 613-238-2837, e-mail: ccac@carleton.ca

Centers for Disease Control and Prevention (CDC). 1600 Clifton Road NE, Atlanta, GA 30333. Phone: 404-639-3311, e-mail: netinfo@cdc.gov, URL: http://www.cdc.gov

Federation of Animal Science Societies (FASS). 1111 North Dunlap Ave., Savoy, IL 61874. Phone: 217-356-3182, FAX: 217-398-4119, e-mail: fass@assochq.org, URL: http://www.fass.org

Grandin Livestock Handling Systems, Inc. 1205 West Elizabeth, Suite E122, Fort Collins, CO 80521. URL: http://www.grandin.com

Institute for Laboratory Animal Resources (ILAR). National Research Council, National Academy of Sciences, 2101 Constitution Avenue NW, Washington, DC 20418. Phone: 202-334-2590, FAX: 202-334-1687, e-mail: ILAR@nas.edu, URL: http://www2.nas.edu/ilarhome

Livestock Conservation Institute (LCI). 1910 Lydia Drive, Bowling Green, KY 42104. Phone: 502-782-9798, FAX: 502-782-0188, URL: http://www.lcionline.org

Midwest Plan Service (MWPS). 122 Davidson Hall, Iowa State University, Ames, IA 50011-3080. Phone: 515-294-4337, toll free: 800-562-3618, FAX: 515-294-9589, e-mail: djunod@iastate.edu, URL: http://www.eng.iastate.edu/coe/abe/mwps

Minnesota Turkey Grower's Association. 2370 Wycliff St., St. Paul, MN 55114-1257. Phone: 612-646-4553.

National Association of Animal Breeders/Certified Semen Services (NAAB). PO Box 1033, Columbia, MO. Phone: 573-445-4406 or 573-445-9451, FAX: 573-446-2279, e-mail: naab-css@naab-css.org

National Cattlemen's Beef Association (NCBA). 1310 Pennsylvania Avenue, NW, Suite 300, Washington, DC 20004-1701. Phone: 202-347-0228, FAX: 202-638-0607, e-mail: cows@beef.org, URL: http://www.beef.org

National Pork Producers Council (NPPC). PO Box 10383, Des Moines, IA 50306. Phone: 515-223-2600, e-mail: pork@nppc.org, URL: http://www.nppc.org

National Mastitis Council, Inc. (NMC). 2820 Walton Commons West, Suite 131, Madison, WI 53718-6797. FAX: 608-224-0644, URL: http://www.nmonline.org/

National Research Council (NRC). 2101 Constitution Avenue, Washington, DC 20418. Publications available through National Academy Press. Phone: 202-334-3324, FAX: 202-334-2793, e-mail: slubeck@nas.edu, URL: http://www.nap.edu

Northeast Regional Agricultural Engineering Service (NRAES). Cooperative Extension, 152 Riley-Robb Hall, Ithaca, NY 14853-5701. Phone: 607-255-7654, FAX: 607-254-8770, e-mail: nraes@cornell.edu, URL: http://www.rcwpsun.cas.psu.edu/NRAES/index.html

Occupational Health and Safety Administration (OSHA). 820 F Street NE, Suite 440, Washington, DC 20002. Phone: 202-523-1452, FAX: 202-523-3573, URL: http://www.osha.gov

Office for Protection from Research Risks (OPRR). National Institutes of Health, 6100 Executive Blvd., Suite 3B01, Rockville, MD 20892. Phone: 301-496-7163, FAX: 301-402-2803. OPRR Document Library e-mail: oprr@od6100m1od.nih.gov, URL: http://www.nih.gov:80/grants/oprr/library-animal.html

Poultry Science Association, Inc. (PSA). 1111 North Dunlap Ave., Savoy, IL 61874. Phone: 217-356-3182, FAX: 217-398-4119, URL: http://www.psa.uiuc.edu

Scientists Center for Animal Welfare (SCAW). 7833 Walker Drive, Suite 340, Greenbelt, MD 20770. Phone: 301-345-3500, FAX: 301-345-3503, e-mail: scaw@erols.com, URL: http://www.erols.com/scaw/

United Egg Producers (UEP). 1303 Hightower Trail, Suite 200, Atlanta, GA 30350.

United States Department of Agriculture, Animal and Plant Health Inspection Service (USDA, APHIS). 4700 River Road, Unit 84, Riverdale, MD 20737-1234. Phone: 301-734-4981, FAX: 301-734-4328, e-mail: sstith@aphis.usda.gov, URL: http://www.aphis.usda.gov

Universities Federation for Animal Welfare (UFAW). 8 Hamilton Close, South Mimms, Potters Bar, Herts, EN6 3QD, United Kingdom. Phone: 44-1707-65802, FAX: 44-1707-649279, e-mail: hubrecht@ufaw.org.uk, URL: http://www.users.dircon.co.uk/~ufaw3/

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