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 2.0[b]	(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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