Chapter 5: Animal Handling and Transport

Handling refers to how agricultural animals are touched, moved, and interacted with during husbandry procedures. Transport means when agricultural animals are moved by vehicles or vessel from one place to another.

Performance standards during handling include careful, considerate, respectful, calm, human interactions with animals in as positive a manner as is possible. Animals handled in a respectful manner will be calmer and easier to handle than animals handled in a rough or disrespectful manner.

Whenever possible, animals should be moved at a normal walking speed, and acclimating the animals to handling and close contact with people will reduce stress (Grandin, 1997a; Fordyce, 1987; Boandl et al., 1989). Research clearly shows that animals that are handled in a negative manner and fear humans have lower weight gains, fewer piglets, and give less milk and reduced egg production (Hemsworth, 1981; Barnett et al., 1992; Hemsworth et al., 2000). Cattle that become agitated during restraint in a squeeze chute or exit from the squeeze chute rapidly have lower weight gains, poorer meat quality, and higher cortisol levels compared with calmer animals (Voisinet et al., 1997a,b; King et al., 2006).

Socialization of agricultural animals with humans should be done when feasible when small numbers of animals are used for research. Socialization and gentling 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 handling of birds and increase feed efficiency, body weight, and antibody responses to red blood cell antigens (Gross and Siegel, 2007). For example, Gross and Siegel (1982a,b) and Jones and Hughes (1981) 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. When large numbers of animals are housed under commercial conditions, socialization may not be possible, but the lightness can be reduced if a person either walks through the flock herds or groups of animals or walks by their cages on a daily basis.

Calm animals will also provide more accurate research results that are less confounded by handling stress. Handling and restraint stresses can significantly alter physiological measurements. Beef cattle not accustomed to handling had significantly higher cortisol levels after restraint compared with dairy cattle that were accustomed to handling (Lay et al., 1992a,b). Prolonged 6-h restraint of sheep where they could not move resulted in extremely high cortisol levels of >110 ng/mL (Apple et al., 1993). Aggressive handling should never be used for farm animals. Multiple shocks with an electrical prod more than doubled the levels of lactate and glucose in pigs compared with careful handling without electric prods (Benjamin et al., 2001; Brundige et al., 1998). Transportation performance standards include movement of animals with minimal risk of injury or death to animal or handler. Transportation is only performed when necessary. Making the transport experience more comfortable for each species should be a priority for animal handlers.

BIOMETRONIC VERSUS AGRICULTURAL RESEARCH REQUIREMENTS

For research results to be applicable to commercial agriculture, the animals have to be handled and housed in conditions similar to those on commercial farms. In these situations, many of the animals may not be accustomed to close contact with people, and commercial handling equipment such as cattle squeeze chutes and other specialized equipment will be required. In another type of research, an agricultural animal may be used for biomedical research and housed in small indoor pens that are not similar to commercial conditions. Biomedical researchers have conditioned and trained animals to cooperate with injections, restraint, and other procedures. Primates, pigs, and sheep can be easily trained to voluntarily enter a restraint device or hold out a limb for various procedures (Panepinto, 1983; Grandin, 1989a; McKinley et al., 2003; Schapiro et al., 2005). Hutson (1985) reported that providing food rewards to sheep made them more willing to move through a han-
Extensively raised grazing animals that arrive at a research facility may have a large flight zone. The size of the flight zone will gradually diminish if they are handled calmly and have frequent contact with people. Farm animals are social and a lone animal separated from its herdmate often becomes severely agitated. Many injuries to both people and animals occur when a single lone animal runs into a fence or charges. An agitated lone animal can be calmed by putting some other animals in with it.

Cattle and sheep will follow a leader (Arnold, 1977; Dumont et al., 2005). When one of the animals starts to move, the others will follow. Natural following behavior can be used to facilitate calm movement of animals. If animals are calmly moving in the desired direction, the handler should back up and stop putting pressure on the flight zone. Continuous pressure on the flight zone may cause animals to start running, which is undesirable.

AIDS FOR MOVING ANIMALS

Animals in properly designed facilities may be moved using their natural behavior and without the use of any aids. The goals of movement should be to minimize stress to each individual animal, reduce fear, and maintain calmness in all animals. All handlers should be trained in the natural behavior of the species including their flight zone and in proper handler movement and interaction, and be able to recognize any signs of distress, anxiety, or behaviors that may result in injury or stress to the animals. When necessary, nonelectrical driving aids such as paddles, flags, and panels may be an adjunct with the use of natural behavior and handling skills. Handlers should be trained in the proper and effective use of each driving aid, which is appropriate to the species.

An electric prod should only be picked up and used in a specific situation where it is needed and then put away. Handlers have a better attitude toward the animals when electric shocks are not used (Coleman et al., 2003). Data collected at meat plants indicate that most cattle and pigs could be moved throughout an entire handling system without electric prods (Grandin 2005). On a ranch or feedlot, the use of electric prods should be limited to 10% or less of the cattle (NCBA, 2007).

When an electric prod needs to be used, it should be applied to the hindquarters of the animal. Usually 1 to 3 brief shocks are needed. If the animal does not respond, the use of the electric prod should be discontinued immediately. It should never be applied to sensitive areas of the animal such as the eyes, ears, genitals, udder, or anus. Battery-operated prods are recommended because they administer a localized shock between 2 prongs. Electric prods should not be used on newborn animals, debilitated weak animals, nonambulatory downed animals, or emaciated animals. Electric prods are highly stressful to pigs. Repeated shocks greatly increased the percentage of nonambulatory pigs (Benjamin et al., 2001). Multiple shocks and aggressive handling significantly increased blood lactate and other indicators of metabolic stress compared with gentle handling (Ritter et al., 2009). Pigs that become nonambulatory because of fatigue or porcine stress syndrome should not have electric prods used on them.

Some examples of the use of an electric prod as a last resort or if human or animal safety is in jeopardy are listed below:
of them. Removing distractions that cause animals to balk and stop will facilitate animal movement (Kilgour and Dalton, 1984; Grandin, 1996; Grandin and Johnson, 2005; Grandin, 2007a). A calm animal will stand and point its eyes and ears toward distractions that attract its attention. If the leader is allowed to stop and look at a distraction, it will often move forward and the other animals will follow. If the animals are rushed, they may turn back and refuse to move forward when they see a distraction. Distractions are most likely to cause balk- ing or other handling problems if the animals are not familiar with the facility. Experienced dairy cows will often ignore a distraction such as a floor drain, but new, inexperienced heifers will balk at it. Table 5-1 contains a list of distractions that may cause animals to balk and refuse to move. This list can be used as a guide for modifying handling facilities where excessive use of electric prods is occurring. In facilities where animals move easily and quietly and electric prods are seldom used, removal of distractions may not be needed.

**Facility Design Principles for all Species**

**Flooring.** For all species, nonslip flooring is essential (Grandin 1990, 2007b; Albright, 1995; Grandin and Deesing, 2008). Animals often become agitated when they start slipping. Handling and restraint will be safer and animals will remain calm if animals have nonslip flooring (e.g., grooved concrete, rubber mats, or metal rod grids). Handling facilities should have nonslip floors and good drainage.

**Equipment Maintenance.** Surfaces that contact the animals must be smooth and free of sharp edges that could injure animals. Sharp edges will cause bruises (Grandin, 1980c) and injury. Managers should routinely inspect equipment and have a program of regular maintenance based on use. Special attention should be paid to latches on restraint devices.

**Sanitation.** Managers should regularly inspect facilities to ensure cleanliness. When new facilities are being designed, ease of cleaning is an important part of the design. Concrete curbs can be used to direct manure to a drain. Hoses, shovels, and other tools that are needed for cleaning should be readily available. Sanitation equipment should be removed after routine cleaning.

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.

**GENERAL PRINCIPLES OF RESTRAINT AND HANDLING**

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 or teaching 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 before 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.
- **Electrical immobilization** must not be used as a method of restraint. It is highly aversive to cattle and sheep (Grandin et al., 1986; Lambooy, 1985; Pascoe and McDonnell, 1985; Rushen, 1986). Electrical immobilization must not be confused with electrical stunning that causes instantaneous insensibility or electric prod use that does not immobilize animals.
- **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.

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 several 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. Care should be exercised when mixing animals to minimize fighting, especially when animals are grouped together for the first time.
Dairy Cattle Handling

Mature milking dairy cows can be handled in head stanchions or a management rail (Albright and Fulwider, 2007). A complete squeeze chute is not required. Diagrams and pictures in Sheldon et al. (2006) illustrate methods for restraining tame dairy cows when they are held in a head stanchion. Young dairy heifers that are not accustomed to close contact with people are often handled most efficiently and safely in beeftype facilities with a squeeze chute.

Disturbances by veterinarians and other visitors can reduce milk yield (King, 1976). If the cows are accustomed to many people walking through the milking parlor, there may be no effect because the frequent visitors have become part of their normal routine. Dairy animals are able to discriminate between people who have handled them in a negative manner and people who handled them in a positive manner (dePassillé et al., 1996). They were most likely to avoid the negative handler when he was seen in the same location where the aversive events occurred.

Dairy bulls are usually more dangerous than beef bulls. Bull attacks are a major cause of fatalities when people are working with livestock. One of the reasons beef bulls are safer is that they are reared in a social group on a cow. Price and Wallach (1990) found that beef bulls attacked more often when they were raised in individual pens. A dairy bull calf raised to maturity alone in a pen is more likely to be dangerous than a bull that was always kept with other animals. If a bull is going to become dangerous, he is most likely to show aggression toward people at 18 to 24 mo. Handlers must learn to recognize signs of aggression that precede an attack such as the broadside threat. The bull will turn sideways to show how big he is before he attacks. Good descriptions are in Albright and Arave (1997) and Albright and Fulwider (2007). Bulls that show aggressive tendencies toward people should be culled or transferred to a secure facility.

Swine Handling

Snaring by the nose is a common method for holding swine for blood testing and other procedures. Good descriptions are in Battaglia (1998) and Sheldon et al. (2006). Snaring is probably stressful for pigs because they will attempt to avoid the snare after they have experienced snaring. For biomedical research, small pigs can be trained to enter the Panepinto sling (Panepinto, 1983). The animal is fully supported in a sling and its legs protrude out through leg holes. A panel is the best device for moving pigs (McClone et al., 2004). Non-electric driving aids such as cattle paddles and flags can also be used by properly trained people. Guidelines on electric prod use are in the section on driving aids.

Previous experiences with handling and the amount of contact with people will affect the ease of pig movement. Pigs with previous experiences of being calmly moved may be easier to move in the future (Abbott et al., 1997; Geverink et al., 1998). Calm, nonthreatening movements of people will reduce stress levels in pigs and make them more willing to approach people (Hemsworth et al., 1986).

Horse Handling

Teaching and research horses are usually handled using halters and lead ropes, and extra control may be achieved by using the chain of a lead shank placed over the horse’s nose. Only trained horses should be tied and only to solid objects that will not give way if the horse pulls back. Lead ropes attached to the halter should be tied with quick release knot. Horses should never be tied with a chain looped across the top of the nose. Cross-ties attached to each side of the halter should be equipped with panic-snaps or safety releases. A twitch may be applied to the horse’s upper lip as a short-term restraint procedure (Sheldon et al., 2006). The movement of a horse may be restrained in stocks and chutes. An equine stock or chute may be as simple as a rectangular structure with a nonslip floor. Other methods of restraint that may be applied by experienced individuals include front foot hobbles, sideline or breeding hobbles, or leg straps, but should be carefully considered depending on the training of the individual horse and the degree of restraint necessary.

Chemical restraint can be effective and should be administered by a qualified person. With some drugs, 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 painful procedures such as castration.

Sheep and Goat Handling

Sheep and goats show strong flocking behavior in pens as well as on pasture. Breed, stocking rate, topography, vegetation, shelter, and distance to water may influence flocking behaviors. Isolation of individual sheep or goats usually brings about signs of anxiety. Separations from the flock, herd, or social companions are important factors that cause sheep and goats to try to escape. Sheep and goats tend to follow one another even in activities such as grazing, bedding down, reacting to obstacles, and feeding (Hutson, 2007). When handling sheep and goats, these characteristic behaviors should be considered and used advantageously and, more importantly, for the best interest of the animal’s health and welfare.

Transportation of sheep and goats should take into consideration the climatic conditions and productive stage (e.g., late pregnancy or dams with young offspring) of the animals. Care should be exercised in the transport of animals, and special consideration should
Table 5-2. Recommended minimum area allowances in transportation accommodations for groups of animals used in agricultural research and teaching

<table>
<thead>
<tr>
<th>Species</th>
<th>Average BW (kg)</th>
<th>Average BW (lb)</th>
<th>Area per animal (m²)</th>
<th>Area per animal (ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle (calf)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>91</td>
<td>200</td>
<td>0.32</td>
<td>3.5</td>
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<tr>
<td></td>
<td>136</td>
<td>300</td>
<td>0.46</td>
<td>4.8</td>
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<tr>
<td></td>
<td>182</td>
<td>400</td>
<td>0.57</td>
<td>6.4</td>
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<td></td>
<td>273</td>
<td>600</td>
<td>0.80</td>
<td>8.5</td>
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<tr>
<td>Horned</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hornless</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Cattle (mature fed cows and steers)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>364</td>
<td>800</td>
<td>1.0</td>
<td>10.9</td>
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<tr>
<td></td>
<td>455</td>
<td>1,000</td>
<td>1.2</td>
<td>12.8</td>
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<tr>
<td></td>
<td>545</td>
<td>1,200</td>
<td>1.4</td>
<td>15.3</td>
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<tr>
<td></td>
<td>636</td>
<td>1,400</td>
<td>1.8</td>
<td>19.0</td>
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<tr>
<td>Small pigs</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.54</td>
<td>10</td>
<td>0.060</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>9.07</td>
<td>20</td>
<td>0.084</td>
<td>0.90</td>
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<tr>
<td></td>
<td>13.60</td>
<td>30</td>
<td>0.093</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>22.70</td>
<td>50</td>
<td>0.139</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>27.20</td>
<td>60</td>
<td>0.158</td>
<td>1.70</td>
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<tr>
<td></td>
<td>31.20</td>
<td>70</td>
<td>0.167</td>
<td>1.80</td>
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<td></td>
<td>36.30</td>
<td>80</td>
<td>0.177</td>
<td>1.90</td>
</tr>
<tr>
<td></td>
<td>40.80</td>
<td>90</td>
<td>0.195</td>
<td>2.10</td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market swine and sows</td>
<td>45</td>
<td>100</td>
<td>0.22</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>91</td>
<td>200</td>
<td>0.32</td>
<td>3.5</td>
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<tr>
<td></td>
<td>114</td>
<td>250</td>
<td>0.41</td>
<td>4.3</td>
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<tr>
<td></td>
<td>136</td>
<td>300</td>
<td>0.46</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>182</td>
<td>400</td>
<td>0.61</td>
<td>6.6</td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>27</td>
<td>60</td>
<td>0.20</td>
<td>2.1</td>
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<tr>
<td></td>
<td>36</td>
<td>80</td>
<td>0.23</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>100</td>
<td>0.26</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>120</td>
<td>0.30</td>
<td>3.2</td>
</tr>
<tr>
<td>Shorn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full fleece</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loose horses</td>
<td>250 to 500</td>
<td>550 to 1100</td>
<td>0.7 x 2.5</td>
<td>2.3 x 8.2</td>
</tr>
<tr>
<td>Fowls &lt;6 mo</td>
<td>1.0 x 1.4</td>
<td>3.3 x 4.6</td>
<td>1.4</td>
<td>15.2</td>
</tr>
<tr>
<td>Young horses 6-24 mo</td>
<td>0.76 x 2.0</td>
<td>2.5 x 6.0</td>
<td>1.2</td>
<td>16.5</td>
</tr>
<tr>
<td>1.2 x 2.0</td>
<td>3.9 x 6.6</td>
<td>2.4</td>
<td>25.8</td>
<td></td>
</tr>
</tbody>
</table>

1 Adapted from data of Grandin (1981, 2007c); Cregier (1982); Whiting and Brandt (2002); Whiting (1999); ILAR Transportation Guide (2006); and National Pork Board (2008) *Trucker Quality Assurance Handbook*.

Intraperitoneal and venous puncture, and artificial insemination, often require at least 2 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, 1989).

When large numbers of birds housed under commercial conditions are to be moved or treated, handling methods need to be compatible with the housing systems involved (Weeks, 2007). 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 wing with subsequent exertion of excessive force in moving the bird. No types of poultry should be picked up by one wing. Gregory and Wilkins (1989) found that when laying 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. On com-
**Thermal Environment on the Vehicle**

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. The values for cattle are conservative especially for heat-tolerant Brahman and Brahman crosses (Grandin, 1981, 2007c).

Animals should be protected from heat stress while in transit. For all species, heat will build up rapidly in a stationary vehicle unless it has mechanical ventilation. Arriving vehicles should be promptly unloaded and vehicles should start moving promptly after loading. If a loaded truck has to be parked during hot weather, fans or water misters should be provided to keep animals cool. Chickens and pigs are especially prone to heat stress. Banks of fans beside which a loaded truck can park are used extensively in the pork and poultry industries. Further information on the thermal environment can be found in the National Research Council’s *Guidelines for Human Transportation of Research Animals* (ILAR Transportation Guide, 2006). The thermal neutral zones for different animals can be found in Roberts (2004). Means of protection include shading, wetting, and bedding with wet sand or shavings when livestock are at high density (e.g., on a track) and air speed is low (e.g., the truck is parked) during hot weather.

During transportation, animals should also be protected from cold stress. Wind protections should be provided when the effective temperature in the animal’s microenvironment is expected to drop below the lower critical level. Recommendations for protecting animals from cold stress are in Grandin (2007c) and the National Pork Board (2008) *Trucker Quality Assurance Handbook* (Table 5-3). 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 animals will spend more than a few minutes in the transport vehicle. This is especially important for pigs to reduce death losses (Sutherland et al., 2009). Currently there are no trucking quality assurance recommendations for space allowance of weaned pigs during transport in the United States. A space allowance of 0.06 and 0.07 was preferable to 0.05 m²/pig when transporting weaned pigs between 60 and 112 min in summer (28.4 ± 1.2°C) and winter (10.5 ± 6.15°C) based on neutrophil-lymphocyte ratio and behavior (Sutherland et al., 2009). However, the effect of space allowance on the welfare of weaned pigs may differ when for transport durations longer than 112 min. Sufficient bedding must be provided so that it stays dry.

**Table 5-4. Recommended dimensions of transportation accommodations for horses and ponies used in agricultural research and teaching**

<table>
<thead>
<tr>
<th>Trailer or van dimension</th>
<th>(m)</th>
<th>(ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling for horse height</td>
<td>1.7-2.0</td>
<td>5.6-6.5</td>
</tr>
<tr>
<td>1.5-1.6 m (15 to 16 hands)</td>
<td>2.0-2.2</td>
<td>6.5-7.0</td>
</tr>
<tr>
<td>Width</td>
<td>1.2</td>
<td>4</td>
</tr>
<tr>
<td>Single or tandem</td>
<td>1.7-2 ×</td>
<td>5.6-6.6 ×</td>
</tr>
<tr>
<td>Two horses abreast</td>
<td>1.8-3.1</td>
<td>5.9-10.2</td>
</tr>
</tbody>
</table>

*One hand is about 10 cm (4 in).*

**Vehicle Recommendations**

Truck beds for livestock transport 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, 1990). 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 (Houp, 2007). 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 doubled-decked cattle trucks (Grandin et al., 1999; Stull, 1999; Houp, 2007).

Many teaching and research activities require the frequent transport of animals for short distances. Careful loading and unloading will reduce stress. On short trips, loading and unloading is the most stressful part of the journey. On short trips, pigs remain standing (Guise et al., 1998) and they can be stacked at a higher density than on longer trips where the animals will need more space to lie down. For heavy (129-kg) pigs, increasing the floor spaces from 0.39 to 0.48 m²/pig reduced transport deaths from 0.88 to 0.36% on trips lasting approximately 3 h (Ritter et al., 2006). 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 side 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.
blankets, especially if air flow cannot be controlled (as in stock trailers that are not fully loaded).

**Poultry Transport**

Unlike the loading ramp and chute system used for livestock, poultry on commercial farms 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, 1989), and mortality have been associated with poor catching and loading techniques (Weeks, 2007). Also, poorly feathered birds have greater body heat loss than well-feathered birds. The thermal neutral zone ranges from 8 to 18°C and 24 to 28°C for well-feathered chickens and poorly feathered chickens, respectively, under typical transit conditions of low air movement and high humidity (Webster et al., 1992). Increased time in transit, feed and water deprivation, and fatigue can cause increased death loss and stress. Therefore, these factors should be minimized.

**Transport Distance and Duration**

Most of the animals transported for use in research and teaching will be transported short distances for durations less than 6 h. In these situations, the amount of time on a transport vehicle does not become a welfare issue. A high percentage of the animals will be transported for less than 2 h. United States regulations specify that livestock have to be unloaded, fed, and watered after 28 h on a vehicle without food or water during interstate transport. The US Humane Slaughter Act requires that livestock in the lairage (stockyards) of a slaughter plant must have access to water in all of the holding pens. People who use agricultural animals in research and teaching need to keep the time that livestock or poultry are on vehicles as short as possible. There may be situations where research has to be conducted on a commercial farm, feedlot, or slaughterhouse when the researcher has no control over the transport conditions.

**Regulatory Requirements for Transport**

Transporters must comply with all county, state, and federal animal health regulations and identification requirements before transporting livestock and poultry. When animals are transported across state lines or from foreign countries, federal regulations for vaccinations, veterinary inspections, and health certificates must be complied with. There are different regulations for each species, and each state may also have regulations for health certificates. State animal health laws apply to all animals transported within a state. Some western states have brand inspection laws that require certificates of ownership and inspection of the livestock by an inspector. In some states animals transported short distances must have certificates. Transporters should be knowledgeable of regulatory requirements. International regulations for transporting animals have recently been summarized (ILAR Transportation Guide, 2006).

**Lairage Recommendations Before Slaughter**

After the animals are unloaded from the transport vehicle, lairage pens should be provided. There must be sufficient space for all of the animals to lie down at the same time without being on top of each other. Table 5-5 lists some examples of recommended space requirements (Grandin, 2007c).

**Emergency Procedures for the Research Facility and Transporters**

Both research facilities and people transporting animals should have a list of emergency contact phone numbers. The following numbers should be on the list. For the contacts other than the police, fire, and ambulance, phone numbers for work, home, and mobile should be listed.

- Police (telephone number)
- Fire (telephone number)
- Ambulance (telephone number)
- Emergency contact 1 and emergency contact 2

Transporters should have numbers they can call if they have an accident. Some of the contacts that should be included are persons who can bring portable panels, loading ramps, or other equipment for reloading escaped animals after an accident.

**REFERENCES**


Chapter 1: Institutional Policies

Scientific and professional judgment and concern for the humane treatment of animals are required for the proper care of 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; Granstrom, 2003). Critical components of such a program should include 1) clearly established lines of authority and responsibility; 2) an active Institutional Animal Care and Use Committee (IACUC); 3) procedures for self-monitoring of the IACUC through semi-annual review of programs and facility oversight by the institutional officer; 4) appropriately maintained facilities for proper management, housing, and support of animals; 5) an adequate program of veterinary care; and 6) training and occupational health programs for individuals who work with the animals (ARENA/OLAW, 2002). 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 chief executive officer or responsible administrative official of the institution should appoint a committee, the IACUC, to monitor the care and use of agricultural animals in agricultural research and teaching activities. The IACUC 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 (no individual category should be over-represented):

- A scientist 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, a member of the clergy, 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; and
- Other members as required by institutional needs and applicable laws, regulations, and policies.

Because of experience and training, however, one individual may adequately fulfill more than a single role on the IACUC, but the committee should not have fewer than 5 members. 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 several different types of committee structures, including a single institutional committee, unit committees (e.g., departmental, college, or program) that review agricultural as well as biomedical uses of animals. The overriding goal should be to facilitate centralized, uniform, and high-quality oversight of the institution's animal care program.
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 IACUCs are not ordinarily constituted to function as scientific peer-review committees, the IACUC should be judicious in reviewing the merit of proposed research and teaching activities (Mann and Prentice, 2004). Institutions should consider developing other mechanisms for peer merit review of research projects that have not already been reviewed by outside agencies. Although qualified peer review of research and teaching is important to consider, such peer review does not eliminate the need for the IACUC to thoughtfully review animal use.

Institutions must develop policies for animal care and use related to research conducted off site as well as research using privately owned animals on and off site. The fact that research is conducted off site does not lessen the responsibility of the institution to assure appropriate and humane animal care and use.

IACUCs are encouraged to work 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 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; also, 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 and approved by the IACUC.

**WRITTEN OPERATING PROCEDURES**

It is important to develop written policies or procedures for animal care and husbandry in the form of written operating procedures for each operating unit in the program. The IACUC must review and approve all written operating procedures involving the potential to cause pain or distress and should review all written operating procedures pertaining to animal care and husbandry. The written procedures must be filed in the appropriate administrative office and in locations accessible to those individuals involved in carrying out the designated procedures and must be 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 Chapter 3 and Chapters 6 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 alleviating pain and distress should be reviewed and approved by the IACUC.

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 and records thereof must be provided for all agricultural animals used in research and teaching (see Chapter 2: Agricultural Animal Health Care). 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 to protect the animals from pathogenic organisms that can be transferred by humans. For additional details on biosecurity issues, see Chapter 3: Husbandry, Housing, and Biosecurity.

**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. Appropriate supervision should be provided to personnel until their competency is assured. Training programs should be tailored to institutional animal user needs but provide information about the humane care and use of agricultural animals, including, if applicable, 1) husbandry needs, proper handling, surgical procedures, and pre- and post-procedural care; 2) methods for minimizing the number of animals used and techniques for minimizing pain and distress, including the proper use of anesthetics, analgesics, tranquilizers, and nonpharmacologic methods; 3) methods for reporting deficiencies in the animal care program; 4) use of information services such as the Animal Welfare Informa-
kept of individual work assignments and should include the date and time of injuries or unusual illnesses. Supervisors should be instructed to fully inform personnel of potential health hazards, and personnel should be instructed to notify their supervisor if a zoonosis occurs.

**SPECIAL CONSIDERATIONS**

**Hazardous Materials**

The use of certain hazardous biological, chemical, or physical materials 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 materials and should ensure that staff members conducting and supporting research projects involving hazardous materials 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 materials, and additional requirements exist for those biological materials or toxins deemed as select agents by federal law. Further information about recommended practices and procedures can be found in publications by CDC and NIH (2000, 2007), CFR (2005), and NRC (1997).

**Genetically Engineered and Cloned Animals**

As advancements in research drive the discovery and development of new technologies, specific considerations may need to be made for the care and use of agricultural animals in research and teaching. Institutions, researchers, and IACUCs should assure that assessment of animal care and use protocols reflects differences in various animal technologies. Guidelines for research involving genetically engineered (GE) animals or livestock clones do not differ materially from those that apply to conventional animals used in research except under special conditions. The published scientific literature has not established the need for unique guidelines. The general standards of care associated with GE or cloned agricultural animals should be the same as those applied to all agricultural animals in research unless the specific genetic modification requires an alteration in management within the research environment to specifically facilitate animal welfare.

In the future, institutions may wish to establish guidelines used in keeping with federal, state, and local government regulatory requirements. The animal biotechnology industry recently released guidelines for research and development with GE animals as a stewardship program for GE animals (Biotechnology Industry Organization, 2009). The BIO Guidance provides information for the development and implementation of stewardship programs for all institutions and researchers that plan to engage in research and development, and possible commercialization, of GE animals.

**Research Involving Genetic Engineering of Agricultural Animals**

Genetic engineering of agricultural animals is the direct manipulation of an organism's genes, including heritable and nonheritable recombinant DNA constructs. Genetic engineering is different from traditional breeding, in which the organism's genes are manipulated indirectly. The genetic engineering of agricultural animals has been extensively reviewed (National Research Council, 2002; Council on Agricultural Science and Technology, 2003, 2007, 2009; Wheeler, 2007). All GE animals in the United States are in research and development, with currently only one approved product from a GE agricultural animal in the United States. Animal welfare for GE animals used in research is regulated by law, regulations, and guidelines of the US Department of Agriculture (USDA) and the National Institutes of Health (NIH). For animals used in biomedical research, their needs for thermal comfort, humidity control, floor space, and husbandry practices should be based on the performance standards outlined in this Ag Guide. Animals in certain biomedical settings and with certain genetic backgrounds may have special requirements that should be understood so that animals are comfortable. The same performance standards that indicate adequate animal welfare in an agricultural setting will apply for animals in a biomedical setting. Welfare of animals used in biomedical research is currently regulated by law, regulations, and guidelines of the USDA and the NIH. Specific information can be obtained by reviewing the NIH guidelines for research involving recombinant DNA molecules (NIH, 2002) and the Animal Welfare Act regulations overseen by USDA. Furthermore, the US Food and Drug Administration (FDA) recently released guidance for industry that may be helpful in the conduct of research with GE animals (FDA, 2009).

**Research Involving Cloning of Agricultural Animals**

Animal cloning is an assisted reproductive technology (FDA, 2008) similar to artificial insemination, embryo transfer, and in vitro fertilization. The current technique used for animal cloning is somatic cell nuclear transfer (SCNT). In research, GE animals may be produced using SCNT. There are no published US guidelines for unique requirements regarding the care and use of animal clones in research. The care and use of animal clones in research does not differ from care provided for conventional animals to assure good animal welfare and animal well-being. In addition, because the progeny of animal clones are not clones, clearly progeny do not require special consideration.


Chapter 2: Agricultural Animal Health Care

Agricultural animal health care involves proper management and husbandry as well as veterinary care. Proper management is essential for the well-being of 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, express some species-specific behavior, and be healthy. Specific operating procedures depend on factors that are unique to individual institutions. Well-trained and motivated personnel can often achieve high-quality animal care with less than ideal physical plants and equipment.

ANIMAL PROCUREMENT

When an institution acquires new animals, attention must be paid to applicable international, federal, and state regulations and institutional procedures, particularly those dealing with transportation and animal health. All animals must be obtained and transported legally. The attending veterinarian, in conjunction with the principal scientist, should formulate written procedures to assess the health status of a herd or flock obtained from a vendor before acquiring animals. The institution should develop a mechanism and process of control for animal acquisition that ensures coordination of resources that will preclude the arrival of animals in advance of preparation of adequate housing and appropriate veterinary quarantine procedures. Quality control for vendors and knowledge of the history of purchased animals is part of an adequate institutional veterinary care program. Animals of unknown origin or from stockyards should only be used if necessary; such animals may pose significant unknown health risks compared with animals of known origin and therefore should be handled appropriately. Newly acquired animals should undergo a quarantine and acclimation period, including preventive and clinical treatments as appropriate for their health status.

Acclimation and Stabilization

Newly arrived animals require a period of acclimation. Acclimation refers to a stabilization period, before animal use, which permits physiological and behavioral adaptation to the new environment. The attending veterinarian should establish general acclimation guidelines for each species. Any modifications to the general program should be discussed with the attending veterinarian before animals are shipped. In some cases, animals may require an extended acclimation period because of their history or health status. On the other hand, some studies, such as comparisons of metaphylactic treatments for shipping fever, need to begin as soon as animals arrive. Such exemptions from the acclimation period must be scientifically justified and approved by the Institutional Animal Care and Use Committee (IACUC).

Quarantine

Quarantine is the separation of newly received animals from those already in the facility or on the premises until the health of the new animals has been evaluated and found to be acceptable. The attending veterinarian should ensure that quarantine facilities or locations are appropriate and that quarantine procedures are consistent with current veterinary practices and applicable regulations. The quarantine period should be long enough to observe signs of infectious disease or obtain diagnostic evidence of infection status. Quarantine and testing of animals before introduction is especially important for herds or flocks that have attained specific-pathogen-free status, but these additions should be discouraged. If the health history of newly received animals is unknown, the quarantine program should be more comprehensive and sufficiently long to allow expression or detection of diseases present in the early incubation stage. Exceptions to quarantine practices should be approved by the attending veterinarian in advance of shipment of the animals.

The attending veterinarian, or skilled personnel under the direction of the attending veterinarian, should perform an initial examination and subsequent daily observations for newly arrived animals. Animals should be observed in quarantine until they are cleared for introduction into a herd or facility. During the quarantine period, animals should be vaccinated and treated for diseases and parasites as appropriate to protect their
and behavioral health events, as well as outcomes and levels of production. Medical records should comply with the American College of Laboratory Animal Medicine (ACLAM) (www.aclam.org/print/position_medrecords.pdf) statement on medical records (Field et al., 2007).

Group health records may be appropriate for animals that are kept as cohorts (e.g., in a colony, school, flock, herd, or room), particularly when animals undergo periodic evaluation by means of examining several representative individuals of the group. The institution, under the guidance of the attending veterinarian, should determine the method(s) by which medical records are maintained. Oversight of medical records is the responsibility of the attending veterinarian and the IACUC. When institutional representatives determine that a medical record should be created, the record typically contains the following information:

1. Identification of the animal(s) or group(s);
2. Clinical information, such as the animal’s behavior, results of physical examinations, and observed abnormalities, illnesses, and/or injuries;
3. Immunizations and other prophylactic treatments and procedures;
4. Documentation and interpretation of diagnostic tests;
5. Documentation of research interventions;
6. Treatments prescribed and administered;
7. Clinical response and follow up information;
8. Descriptions of surgical procedures, anesthesia, analgesia, and perioperative care;
9. Methods used to control pain and distress;
10. Documentation of resolution;
11. Documentation of euthanasia or other disposition; and
12. Necropsy findings if necropsy is indicated.

The record system must be structured so that information is easily collected, gathered, analyzed, summarized, and available to the veterinarian, the principal scientist, and the IACUC. The ACLAM statement on Medical Records for Animals used in Research and Testing suggests that:

Notations in the medical record should be made by individuals who have administered treatments, or made direct observations or evaluations of the animal(s) or their diagnostic results, or their designee. Individuals typically responsible for making notations in the record include veterinary staff (veterinarians and/or veterinary technicians), animal husbandry staff (animal care staff, managers, supervisors), and research staff (e.g., principal investigators, study directors and/or research technicians). All entries in the record should be dated, indicate the originator of the entry (e.g., initials, signature, and electronic signature) and be legible to someone other than the writer.

**Vermin Control**

Refer to Chapter 3: Husbandry, Housing, and Biosecurity for information on vermin control.

**SURGERY**

**Multiple Major Surgical Procedures**

The ILAR Guide differentiates major from minor surgery as follows: "Major survival surgery penetrates and exposes a body cavity or produces substantial impairment of physical or physiologic functions (i.e., laparotomy, thoracotomy, craniotomy, joint replacement, and limb amputation). Minor survival surgery does not expose a body cavity and causes little or no physical impairment (i.e., wound suturing; peripheral-vessel cannulation; such routine farm-animal procedures as castigation, dehorning, and repair of prolapses; and most procedures routinely done on an “outpatient” basis in veterinary clinical practice)." Minimally invasive surgery such as laparoscopy may benefit the animal relative to traditional surgical techniques.

Performance of more than one major survival surgical procedure on a single animal is discouraged but may be necessary to ensure or maintain the health of the animal. Long-lived animals may undergo multiple major surgeries, such as a cow that requires surgery for correction of displaced abomasum and cesarean section for therapeutic purposes. Multiple major survival surgeries performed for nontherapeutic reasons should be performed only when justified and must be reviewed and approved by the IACUC. Multiple major surgeries that produce minor physiologic or physical impairment and reduce overall animal use, such as multiple endoscopic laporotomies in sheep for reproductive purposes, might be appropriate. Likewise, multiple surgical procedures might be justified when they are related components of the same project (e.g., cannulation of the digestive tract at several locations).

**Anesthesia and Analgesia**

Certain animal husbandry-related procedures (standard agricultural practices) may be conducted without anesthesia after consideration and approval by the IACUC. These procedures should be performed early in the life of the animal in accordance with accepted veterinary practices. When surgery is performed on older animals, appropriate anesthesia and sterile instruments should be used, trauma minimized, and hemorrhage controlled. It is important that husbandry practices be established to minimize stress, prevent infection, and ensure the comfort of the animals during the recovery period. Specific recom-
care attendants or research staff should take immediate ameliorative action as necessary and contact the attending veterinarian.

Pain can be one of the earliest signs of disease or injury. Animals in pain may become less active, restless, may continually get up and down, and refuse to stay in one place, reduce feed consumption, grind their teeth, or vocalize. Some animals become less active, whereas others appear frightened or agitated. Animals in pain may resist handling or favor the painful area by adopting an abnormal stance or abnormal behavior.

In some cases, pain may not be noticed until a physiological act is induced such as swallowing, coughing, chewing, or defecating. The observer should try to determine whether pain appears to be constant or associated with a provoking act. Sudden, severe pain is often associated with fractures, rupture or torsion of visceral organs, or acute inflammatory processes and should be considered an emergency.

Relief of pain and/or distress in agricultural animals involves removing or correcting the inciting cause when possible, administering appropriate analesgesics, and taking steps to reduce stimulation of pain receptors (e.g., immobilizing a fracture, elevating an injured claw by securing a wood block under the opposite claw). Relief of pain should be one of the first tasks of the attending veterinarian, adhering to the following principles (Radostits et al., 1994):

- Relief of pain is a humane act;
- Relief of pain must be initiated promptly once it is deemed necessary;
- It may be necessary to protect animals in pain from self-injury.

The attending veterinarian must be familiar with analesgesics labeled for use in agricultural animals and must be able to prescribe and establish withdrawal times for extra-label use of analesgesics when indicated. Animals with severe or chronic pain that cannot be alleviated must be euthanized.

**ZOONOSES**

For the purposes of this guide, zoonotic diseases are defined as infectious diseases in agricultural animals used in research and teaching that can be transmitted to humans and a natural reservoir for the infectious agent is an agricultural animal. Table A1 in Appendix 2 contains a list of many, but not all, zoonotic pathogens, mode of transmission, disease signs in ruminants, and disease signs and symptoms in humans. A current list and incidence of notifiable diseases such as Q-fever (Coxiella burnetii) may be obtained from the US Centers for Disease Control and Prevention (http://www.cdc.gov/).

The attending veterinarian, working with the animal scientists, should establish appropriate preventive medicine programs and husbandry practices to decrease the likelihood of transmission of zoonotic agents. Each institution must have an appropriate occupational health and safety program for evaluating the human health risks associated with animal contact and must take steps to ensure that health risks for each individual are assessed and managed to an acceptable level.

**RESIDUE AVOIDANCE**

Residues of 3 groups of chemicals must be prevented from occurring in research animals if those animals, or their products, are going into the human food chain. These are 1) approved drugs used according to directions on the label, 2) drugs used in an extra-label fashion, and 3) other chemicals such as herbicides, pesticides, and wood preservatives. The Food Animal Residue Avoidance Database (FARAD; http://www.farad.org/) is a project sponsored by the USDA Cooperative State Research, Education and Extension Service. The FARAD Compendium of FDA Approved Drugs provides information about drugs that are available for treating animal diseases, the withholding times for milk and eggs, and pre-slaughter withdrawal times for meat. Information about the drugs approved for use in food animals in the United States is included in this online database (http://www.farad.org/). The FARAD compendium allows selection of over-the-counter products that satisfy particular needs as well as alerts to the need for veterinary assistance with prescription drugs; FARAD also supplies estimated meat and milk withdrawal times for extra-label use of drugs.

Drug administration to animals destined to enter the food chain requires special consideration. Before animals may be slaughtered for human or animal food purposes, time must be allowed for medications, drugs approved by the Food and Drug Administration (FDA), or substances allowed by the FDA for experimental testing under the Investigational New Animal Drug (INAD) exemption to be depleted from the tissues. Such use is only permitted when it adheres to the regulations in the Animal Medicinal Drug Use Clarification Act of 1994, Public Law 103-396 (http://www.fda.gov/cvm/amducato.htm). A record of the product used, dose, route of administration, duration of treatment, and period of withdrawal must be maintained. Adherence to proper withdrawal times must be ensured before animals are transported to the auction, market, or abattoir.

**Drug Storage and Control**

Pharmaceuticals intended for use in food-producing animals must be managed responsibly. Storage should be in an area that is clean and dry and that offers protection from changes in temperature, sunlight, dust, moisture, and vermin. The manufacturer's labeling should be consulted for specific information regarding appropriate storage conditions and product shelf-life. In addition, the integrity of product containers should
exposed to these chemicals. Examples are pesticides for insect control, herbicides, poisons for rodent control, wood preservatives, and disinfectants. Harmful products should be properly labeled and stored, a record of their purchase and expiration dates should be kept, and personnel must be informed of potential hazards and wear appropriate protective equipment. Chemicals must be stored, used, and disposed of in a manner that prevents contamination of animals and residues in milk, meat, or eggs.

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 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 to minimize stress and avoid pain and injury (Grandin, 1983a,b). Refer to Chapter 5: Animal Handling and Transport for additional information. Personnel should be trained on the use of hydraulically operated restraint devices to prevent potential injury. Extended physical restraint should be reviewed and approved by the IACUC.

EUTHANASIA

Protocols for euthanasia should follow current guidelines established by the American Veterinary Medical Association (AVMA; www.avma.org) and copies of the protocols should be made available to all personnel who euthanize animals. The agents and methods of euthanasia appropriate for agricultural animals are available in the AVMA (2007) Guidelines for Euthanasia (http://www.avma.org/issues/animal_welfare/euthanasia.pdf) or subsequent revisions of that document. Refer to Chapters 6 through 11 for species-specific information on euthanasia and slaughter.

Euthanasia is the procedure of killing an animal rapidly, painlessly, and without distress. Euthanasia must be carried out by trained personnel using acceptable techniques in accordance with applicable regulations and policies. The method used should not interfere with postmortem 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 the normal behavior of agricultural animals and how handling and restraint affect their behavior. The equipment and materials required to perform euthanasia should be readily available, 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.

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 before unconsciousness (AVMA, 2007). For this reason, anesthetic agents are generally acceptable, and animals of most species can be quickly and humanely euthanized 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 (insensibility) has been fulfilled (Lucke, 1979).

TRANSGENIC AND GENETICALLY ENGINEERED AND CLONED ANIMALS

Recent years have seen a growing interest in the development and use of transgenic and genetically modified agricultural animals for agricultural and human therapeutic purposes. A transgenic animal is one that carries a foreign gene that has been deliberately inserted into its genome. Genetically engineered animal models require deliberate modification of the animal genome by moving a desired trait into the genome. These modifications are accomplished by microinjection, retroviral transfection, and a variety of other techniques.

It is important not to confuse genetically engineered animals with cloned animals. Genetically engineered animals may be produced by cloning as well as other techniques noted above. The progeny of cloned animals are not properly termed "cloned animals." It is also important to distinguish between research and commercial application of cloning techniques. Cloning technology has been reviewed by the FDA and is one of several commercially available assisted reproductive technologies including in vitro fertilization and embryo transfer (FDA, 2008, 2009). As advancements in research continue and new technologies are developed, specific considerations may need to be made for the care and use of agricultural animals.

Both transgenic and genetically engineered animal models may have physiologic or phenotypic problems including abortions, large offspring, enlarged umbilicus, retained placenta, hydrops, multiple births, and placenta deformities. The scientist is responsible for identifying physiologic and phenotypic changes and must have a plan to address changes that affect animal health to facilitate and ensure animal welfare.

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 different 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 moulting 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; Rodenburg and Koene, 2004). 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 Passillé, 1992; Mason and Mendl, 1993; Miltöchner et al., 2001). Indicators in 4 catego-
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; Mittelholzer and Laube, 2003).

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

To overcome shortcomings of using ambient temperature as the only indicator of animal comfort, thermal indices have been developed to better characterize the influence of multiple environmental variables on the animal. The temperature-humidity index (THI), first proposed by Thom (1959), has been extensively applied for moderate to hot conditions, even with recognized limitations related to airspeed and radiation heat loads (NOAA, 1976). At the present time, the THI has become the de facto standard for classifying thermal environments in many animal studies and selection of management practices during seasons other than winter (Hahn et al., 2003).

The THI has further been used as the basis for the Livestock Weather Safety Index (LWSI; LCI, 1970) to describe categories of heat stress associated with hot weather conditions for livestock exposed to extreme conditions. Categories in the LWSI are alert (74 < THI < 79), danger (79 < THI < 84), and emergency (THI > 84). Additionally, THI between 70 and 74 is an indication to producers that they need to be aware that the potential for heat stress in livestock exists.

The index (wind chill temperature index (°C) = 13.12 + (0.6215 × AT) − [11.37 × (WSPD)0.16] + [0.3965 × AT × (WSPD)0.16]), where AT = air temperature, °C, and WSPD = wind speed, m/s, is a physiological based model and accounts for inherent errors in the earlier wind chill index (WCI), which was not based on heat transfer properties of body tissues. However, the old WCI closely mimicked heat loss and equivalent temperature equations reported by Ames and Insley (1975) for sheep and cattle. Equations developed by Ames and Insley (1975) accounted for heat transfer through pelts and hides sections of previously harvested animals; however, they did not account for fat cover and other regulatory processes utilized in mitigating cold stress. In addition, body heat loss due to wind will be proportional to the surface area exposed and not the entire surface area of the body. This error was also inherent in the old WCI.

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 increase 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. Hot weather ventilation rates should be sufficiently high to maintain the relative humidity below 80% in an enclosed animal house (Curtis, 1983; Hinkle and Strombaugh, 1983) ex-
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 h of exposure daily to these gases. The concentration of ammonia 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 (Von Borell et al., 2007). 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 h daily without facemasks; allowable dust levels are 5 mg/m³ for respirable dust (particle size of 5 μm 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 for the maintenance of good health and physiological stability are not known for most animals. However, animals should be provided with both light and dark periods during a 24-h cycle unless the protocol requires otherwise. See Chapters 6 through 11 for references on lighting and photoperiod in individual species. 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; and
- 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 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.
in pairs or groups when possible. 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 (Gross and Siegel, 1982; Hemsworth et al., 1986, 1993). In some instances, one species can be used as a companion for another species (e.g., goats and horses; Gross and Siegel, 1982; Hemsworth et al., 1986, 1993). Temporary isolation is sometimes required for an animal’s safety (e.g., during recovery from surgery), but the animal should be returned to a social setting as soon as possible.

**Separation by Species**

Agricultural animals of different species are typically kept in different enclosures to reduce interspecies conflict, meet the husbandry and environmental needs of the animals, and facilitate research and teaching. However, some research protocols or curricula require species to be co-housed. Facility design and husbandry practices influence whether this can be accomplished in a manner that assures the well-being of the animals. Mixing of compatible species (e.g., sheep and cattle) can often be accomplished more easily in extensive production situations than in intensive housing situations. Some species can carry subclinical or latent infections that can be transmitted to other species that are housed in close proximity, causing clinical disease or mortality. Therefore, a qualified veterinarian or scientist should recommend appropriate health and biosecurity practices if species are to be co-housed.

**Separation by Source or Age**

Animals obtained from different sources often differ in microbiological status. It is usually desirable to keep these animals separated, at least until microbiologic status is determined (e.g., serologic testing, microbiologic culture, fecal flotation) or steps (e.g., vaccination, deworming, treatment, culling) are taken to protect against disease transmission. Separation of animals of different ages may also be advisable to reduce disease transmission and control social interactions. Placing animals in groups of similar age or size may allow more uniform access to feed and reduce injuries. All-in, all-out schemes are examples of age-group separation that are designed to minimize disease risk. However, mixed-group housing is acceptable if disease risk is low, husbandry practices are good, and social interaction is acceptable or necessary (e.g., calves nursing cows). A qualified veterinarian and animal facility manager should work together to devise housing configurations and husbandry practices that assure animal health and well-being while also meeting research and (or) teaching goals.

**HUSBANDRY**

**Animal Care Personnel**

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

It is the researcher facility management’s responsibility to ensure that personnel caring for agricultural animals used for research or teaching are appropriately qualified or trained. This responsibility may be delegated to an IACUC. Qualification by experience and (or) training must be documented. The animal facility manager must ensure that all animal care personnel are aware of their responsibilities during and outside normal work hours. Protocols for emergency care must be developed and made available to all personnel.

**Observation**

Animals in intensive accommodations should be observed and cared for daily by trained and experienced caretakers. Illumination must be adequate to facilitate inspection. In some circumstances, more frequent observation or care may be needed (e.g., during parturition, postsurgical recovery, confinement in a metabolism stall, or recovery from illness). Under extensive conditions, such as range or pasture, observations should be frequent enough to detect illness or injury in a timely fashion, recognize the need for emergency action, and ensure adequate availability of feed and water. A disaster plan must be developed for observing animals and providing care during emergency weather or health situations. Regardless of accommodations, such observations should be documented and husbandry or health concerns reported to the animal facility manager or attending veterinarian as appropriate.

**Emergency, Weekend, and Holiday Care**

There must be a means for rapid communication in case of an emergency. In emergencies, facility security and fire personnel must be able to contact staff members responsible for the care of agricultural animals. Names and contact information for those individuals should be posted prominently in the animal facility and provided to the security department or telephone center. If posting names and contact information poses privacy or security issues, a contact number for a security or command center should be used instead. The institution must ensure that emergency services can be contacted at any time by staff members.
screened with 1.3-cm (0.5-in) mesh, and ceilings with ridge vents should be screened with 1.9-cm (0.75-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 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.

Many agricultural institutions keep cats for pest-control purposes. Although the use of free-roaming cats is a traditional form of pest control for agricultural facilities, cats may limit the ability for baiting and may present hygiene or accident risks or serve as disease vectors (Van't Woudt, 1990; Van Sambeek et al., 1993; Vantassel et al., 2005). However, when cats are present, proper veterinary care and oversight should be provided to these animals. Veterinary care should include vaccinations, parasite control, and neutering.

**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, tialbiting, 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 IACUC. Recommendations regarding these practices for the different species are found in Chapters 6 through 11. The development and implementation of alternative procedures less likely to cause pain or distress are encouraged. Overall, best practices for pain prevention and control should be followed.

**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 killed (see Chapter 2 and Chapters 6 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. Postmortem 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. More information regarding sick, injured, and dead animals is available in Chapter 2: Agricultural Animal Health Care.

**HANDLING AND TRANSPORT**

Additional details on the handling, restraint, and transportation of animals are given in Chapter 5: Animal Handling and Transport.

**SPECIAL CONSIDERATIONS**

**Noise**

Noise from animals and animal care activities is inherent in the operation of any animal facility. Although differences exist in perceived loudness of the same sound (Algers et al., 1978a,b), occupational noise limitations have been established for workers, and employees should be provided appropriate hearing protection and monitored for their effects (Mitloehner and Calvo, 2008).

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 various strains of chickens (Mills and Faure, 1990).
appropriate, and institutions should implement appropriate precautions to protect the safety and well-being of the visitors and the animals.

Preventing the introduction of disease agents is a continuous challenge, particularly when teaching and research facilities allow public access. Herd health and sanitation programs should be in place to minimize exposure to pathogens.

Animal care personnel in research and teaching facilities should not be in contact with livestock elsewhere unless strict biosecurity precautions are followed. To reduce inter-building transmission of pathogenic microorganisms, careful attention should be given to traffic patterns of inter-building personnel and disease organisms in feed 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 rooms and buildings. Establishing a barrier between animals and visitors requires visitors to do some or all of the following: shower in/shower out (including washing hair), wear clean footwear (i.e., plastic boots), change to on-site clothes, and wear only on-site clothes. In addition, if personnel need to go back and forth between different phases of production, it is critical that they work from clean to dirty phases of the farm.

**Boot Cleaning and Disinfection**

The use of boot baths can prevent or minimize mechanical transmission of pathogens among groups of pigs. Visible organic material may be removed from boots using water and a brush or specific boot cleaning station. Boots may be disinfected by soaking in a clean bath of an appropriate disinfectant following the manufacturer’s guidelines for dilution rate and exposure time. Personnel should step into and scrub their boots in the boot bath upon entry and when leaving the room/facility. It is important to frequently empty, clean, and refill the boot bath to prevent it from being contaminated with organic matter. Disposable boots may be used.

**BIOCONTAINMENT**

High-consequence livestock pathogens (e.g., tuberculosis, foot and mouth disease) or the vectors (e.g., mosquitoes, ticks) responsible for transmission of disease cause high morbidity and mortality, and can have a significant regional, national, and global economic impact. The use of these pathogens in agricultural research brings several challenges when designing and operating an animal facility. The design of this type of facility should strive for flexibility, effective containment of pathogens, and minimizing the risk of exposure to personnel when zoonotic agents are utilized. The use of agricultural animals in high-consequence livestock pathogen research requires a thorough understanding of a variety of regulatory requirements and the concept of risk assessment. The USDA provides a list of livestock, poultry, and fish pathogens that are classified as “pathogens of veterinary significance” in Appendix D of the book *Biosafety in Microbiological and Biomedical Laboratories (BMBL; CDC, 2007)*. The use of these pathogens requires facilities to meet specific criteria for design, operation, and containment features, which are described in the BMBL. For the listed agents, criteria may include utilizing containment levels designated as Animal Biosafety Level (ABSL)-2, enhanced ABSL-3, BSL-3-Ag, or ABSL-4. Requirements for BSL-3-Ag facilities must be met when any of the listed pathogens are used in animals and the room housing the animals provides the primary containment (i.e., animals are housed in the room). When the studies can be accomplished in smaller species in which animals are housed in primary containment devices, which allows the room to serve as the secondary barrier, then enhanced ABSL-3 requirements can be utilized. Enhancements to ABSL-3 should be determined on a case-by-case basis, using risk assessment, and in consultation with the Animal and Plant Health Inspection Service (APHIS) of the USDA. In addition to the BMBL, facility design standards have been published by the USDA to guide the design of Animal Research Service (ARS) construction projects and contain useful information on the design of containment facilities for agricultural research. These standards include information on containment design that addresses hazard classification and choice of containment, containment equipment, and facility design issues for the different levels of biocontainment (ARS, 2002). Although published to provide guidance for National Institutes of Health (NIH)-funded construction projects and renovations for biomedical research facilities, the *NIH Design and Policy Guidelines (NIH, 2003)* contain useful information on construction of BSL-3 and ABSL-3 facilities. The use of recombinant DNA molecules in agricultural research can introduce additional considerations when designing an animal facility. Published guidelines provide recommendations for physical and biological containment for recombinant DNA research involving animals (NIH, 2002). These guidelines include a supplement published in 2006 that provides additional information specific to the use of lentiviral vectors (NIH, 2006). The Agricultural Bio-terrorism Protection Act of 2002 required the propagation of regulations that address the possession, use, and transfer of select agents and toxins that have the potential to pose a severe threat to plants or animals, and their products. The USDA/APHIS published the implementing regulation covering animals and animal products, which identifies those select agents and toxins that are a threat solely to animals and animal products (VS select agents and toxins) and overlap agents, or those agents that pose a threat to public health and safety, to animal health, or to animal products (CFR, 2005). Overlap select agents and toxins are subject to


LCI. 1970. Patterns of transit losses. Livestock Conservation, Inc., Omaha, NE.


Environmental enrichment involves the enhancement of an animal’s physical or social environment. Environmental enrichment is increasingly viewed as a significant component of refinement efforts for animals used in research and teaching, and should be considered where opportunities for social interactions are not available or where the animals’ physical environment is restricted or lacking in complexity.

Environmental enrichment has been shown to have wide-ranging physiological and behavioral effects on a variety of species of animals (Young, 2003) and can be particularly effective in the research setting to reduce the incidence or severity of undesirable or abnormal behaviors. Abnormal behaviors observed in farm animals include locomotor stereotypies such as weaving, pacing, and route-tracing and mouth-based behaviors such as wool-eating by sheep, feather pecking and cannibalism by poultry, bar biting by pigs, tongue rolling by cattle, and wind-sucking by horses (Price, 2008). These behaviors can cause injury to the animal performing them or to other animals in the social group and are most commonly observed in situations in which the quality or quantity of space provided to the animal is inadequate. Environmental enrichment may reduce the frequency or severity of these behaviors, or even prevent them from developing in the first place (Mason et al., 2007).

Unfortunately, the term “environmental enrichment” does not have a precise definition and is used inconsistently (Newberry, 1995; Young, 2003), often referring simply to changes that involve adding one or more objects to an animal’s enclosure rather than specifying the desired endpoints of these changes. Newberry (1995) suggested a useful concept: the endpoint of enrichment should be to improve the biological functioning of the animal. Therefore, goals of enrichment programs include 1) increasing the number and range of normal behaviors shown by the animal; 2) preventing the development of abnormal behaviors or reducing their frequency or severity; 3) increasing positive utilization of the environment (e.g., the use of space); and 4) increasing the animal’s ability to cope with behavioral and physiological challenges such as exposure to humans, experimental manipulation, or environmental variation. To accomplish these goals, enrichment strategies should be based on an understanding of species-specific behavior and physiology, and the enrichments provided should not only be attractive to the animals but also result in interest that is sufficiently sustained to achieve the desired performance outcomes. Bloomsmith et al. (1991) provided a useful categorization of enrichment types:

1. Social enrichment, which can involve either direct or indirect (visual, olfactory, auditory) contact with conspecifics (other individuals of the same species) or humans.
2. Occupational enrichment, which encompasses both psychological enrichment (e.g., devices that provide animals with control or challenges) and enrichment that encourages exercise.
3. Physical enrichment, which can involve altering the size or complexity of the animal’s enclosure or adding accessories to the enclosure such as objects, substrate, or permanent structures (e.g., nestboxes).
4. Sensory enrichment, or stimuli that are visual (e.g., television), auditory (music, vocalizations), or in other modalities (e.g., olfactory, tactile, taste).
5. Nutritional enrichment, which can involve either presenting varied or novel food types or changing the method of food delivery.

All of these types of enrichment have been assessed for use with agricultural animals. In the following sections, validated or potential enrichments for each species are discussed as appropriate. All agricultural animals are social (with the exception of the adult boar), and social behavior and management of social groups are covered in the respective species chapters; in this chapter, the focus is on indirect contact or contact with humans as substitutes for conspecific contact in situations in which animals must be individually housed. Genetic differences between breeds, lines, or strains of agricultural animals may be present that affect their use of, or responses to, enrichment (e.g., Hill et al., 1998).
activity performed after periods of deprivation (Houpt et al., 2001; Christensen et al., 2002; Chaya et al., 2006). Furthermore, horses provided with turn-out display more varied kicking behavior, which is believed to be associated with comfort (Hansen et al., 2007). In a study of racing horses, benefits of regular turn-out also included less aggression directed toward handlers (Drissler et al., 2006) and superior race and career performance (Drissler, 2006).

**Occupational Enrichment.** In the absence of turning out in paddocks or pastures, horses can directly perform behavior toward “toys” placed in the stall. Several commercially available products such as the large durable balls designed to be used with stabled horses can be provided, as well as homemade devices such as plastic jugs hanging on ropes. Scientific evidence regarding the efficacy of these products is lacking.

**Sensory Enrichment.** In many stables, it is common for background noise to be provided by a radio, with the assumption that this provides a calming effect on the horses and alleviates boredom. However, the presence or type of music was not found to significantly affect the behavior of ponies subjected to short-term isolation stress (Houpt et al., 2000). These authors speculate that background music may indirectly affect equine behavior through the attitudes of their human caretakers. Conversely, a synthetic Equine Appealment Pheromone product is commercially available, and there is minimal evidence that this product effectively reduces behavioral and physiologic fear responses of horses subjected to a stressful situation (Falewic et al., 2006).

**Nutritional Enrichment.** Opportunities to forage provide significant enrichment for stabled horses. Horses typically spend 10 to 12 h grazing per day (Ralston, 1984), and lactating mares spend 70% of their time grazing on pasture (Crowell-Davis et al., 1985). In the absence of foraging material, horses frequently may direct foraging toward the stall bedding or stall surfaces (Drissler et al., 2006), or may display oral stereotypes such as crib-biting, wind-sucking, shan chewing, hair eating, and wood chewing/licking. Undesirable oral behavior can be addressed by providing at least 6.8 kg of hay per day (McGreevy et al., 1995), providing multiple forages (Goodwin et al., 2002; Thorne et al., 2005), and dividing concentrate feed into smaller and more frequent meals throughout the day (Cooper et al., 2005). Horses provided with straw bedding perform less stereotypic behavior than those bedded on paper or shavings (Cooper et al., 2005). Several food toys are commercially available, which horses manipulate to obtain high-fiber food pellets. These food-balls result in increased foraging time (Winskill et al., 1996) and reduced stereotypic behavior (Henderson and Warner, 2001). Toys with round or polyhedral designs are most effective (Goodwin et al., 2007). These toys can be provided in the manger to prevent horses from ingesting.
Substrate: The provision of suitable substrate, such as friable litter material for turkeys and sawdust for ducks, facilitates both foraging and grooming behavior. Poultry would normally spend a large part of their day foraging, and increasing foraging opportunities can help to reduce the incidence of two abnormal behaviors, feather pecking and cannibalism (Newberry, 2004; Rodenburg and Koen, 2004). These behaviors are not related to aggression but, like aggression, are directed toward other birds in the flock. Feather pecking can consist of gentle pecking that does not result in the removal of feathers from the pecked bird or more severe pecking that results in feather loss (Savory, 1985). Having a feather removed is painful (Gentle and Hunter, 1991), and severe feather pecking can lead to birds having denuded areas that expose the skin to injury and impair thermoregulation. These denuded areas may also attract tissue pecking and cannibalism by other birds. Cannibalism involves the pecking and tearing of skin, underlying tissues, and organs. Cannibalistic pecking is most often directed toward the toes, tail, vent area, or emerging primary feathers on the wings and can cause high flock injury and mortality if birds are not beak- or bill-trimmed (Newberry, 2004; Riber and Mench, 2008). Outbreaks of feather pecking and cannibalism are difficult to control once started because these behaviors are socially transmitted among birds in the flock, so it is best to prevent their occurrence through early intervention.

Other factors such as nutritional deficiencies or environmental or management variables (such as high light levels or large group size) can contribute to outbreaks of feather pecking and cannibalism. There are also strong genetic effects (Kjaer and Hocking, 2004), and these behaviors are more difficult to control in some species or strains than in others. For example, Muscovy ducks are much more likely to engage in cannibalistic behavior than Pekin ducks (Gustason et al., 2007a, b), and providing Muscovy ducks with a variety of water- and food-based foraging enrichments was found to be ineffective in preventing cannibalism (Riber and Mench, 2008).

Aggressive behaviors in turkeys can be reduced by the provision of foraging materials. Martin et al. (2001) provided growing turkeys with straw and hanging chains and found reduced pecking injuries in both toms and hens. Sherwin et al. (1999) reared turkeys with a variety of pecking substrates (e.g., vegetable matter, rope, flexible plastic conduit, chains) and found that this reduced injuries due to wing and tail-pecking. These types of items can be effective in reducing behavior problems, even in cage environments. For example, chickens are attracted to and manipulate hanging strings (Jones, 2004), and providing these in cages was found to reduce feather damage, presumably because of reduced feather pecking, in caged laying hens (Jones et al., 2004).

If an appropriate substrate is provided, chickens and turkeys will dustbathe in long bouts on most days, particularly in sunny or bright locations in their enclosure. During dustbathing, loose particles are worked through the feathers and then shaken out. This improves feather condition by dispersing lipids (van Liere, 1992) and possibly serves to remove ectoparasites. Chickens will dustbathe in different types of loose material, but prefer litter with smaller diameter particles (e.g., peat or sand) to litter with larger diameter particles (e.g., wood shavings or paper bedding material; Shields et al., 2004); smaller particles are also more effective in penetrating the feathers.

Ducks maintain good plumage condition by water bathing. If swimming water is not provided for practical or hygienic reasons, providing a source of water that is at least deep enough for the ducks to immerse their heads and shake water over their body can help them to maintain good plumage, nostril, and eye condition, as can providing them with an overhead shower (Jones et al., 2000).

Bedding material can become contaminated with feces and produce unacceptable levels of atmospheric ammonia, if not well maintained. Wet or contaminated bedding can also cause foot and leg problems such as footpad dermatitis (Berg, 2004). Certain types of litter can also become aerosolized, creating excessive dust. When water is provided as a swimming, foraging, or grooming substrate for ducks, it must be changed frequently to prevent it from becoming contaminated. The resulting moisture in the environment can also lead to unacceptable levels of ammonia, and contact with feed and bedding that has become moldy because of excess moisture in the atmosphere predisposes ducks to infection with Aspergillus (Brown and Forbes, 1996).

Cover: Providing floor-housed chickens with cover in the form of overhead vertical panels has been shown to improve pen usage, increase resting and preening behaviors, and decrease the number of times that birds disturb one another (Newberry and Shackleton, 1992; Cornetto et al., 2002). Striped panels providing 67% cover are effective, and are preferred by the chickens to solid, transparent, or less fully striped panels (Newberry and Shackleton, 1992).

Objects: Several studies have investigated whether providing novel objects can decrease fear in poultry. Chicks provided with such objects were less fearful during several standardized tests (Jones, 1982), although the birds were not tested as adults to determine whether this effect persisted. Reed et al. (1993) reported that exposing laying hen chicks to novel objects, a radio playing a human voice, and human handling resulted in less fearfulness to novel stimuli and decreased injury from handling when the hens were adults. In contrast, Nicol and Scott (1990) found no reduction in fear in broiler chickens exposed to human handling and auditory and novel object enrichment, and Nicol (1992) actually found that novel object enrichment could increase fearfulness in broilers. Although chickens do show interest in exploring semi-unfamiliar environments (Newberry, 1999), novel objects and food can themselves cause fear.
mize regrouping and social stress are available and may be of use for certain research and teaching protocols or in certain herds (Stolba and Wood-Gush, 1984; Newberry and Wood-Gush, 1986; Wechsler, 1996; Weary et al., 1999b; Parratt et al., 2006).

When pigs must be isolated from conspecifics for experimental purposes, friendly social contact with familiar caretakers could be especially important. Pigs recognize familiar caretakers using visual (body size and facial features) as well as vocal and olfactory cues (Koba and Tanida, 2001). Caretakers can develop positive social contact with pigs by moving slowly and calmly, crouching to reduce apparent body size, avoiding aversive or inconsistent (sometimes pleasant and sometimes aversive) handling, and stroking or scratching pigs that approach (Hemsworth et al., 1996). When pigs have a positive attitude toward caretakers, they will approach confidently and seek interaction, which may have positive implications for handling strategies.

Providing companionship from familiar pen-mates and a warm, artificial ulder with flexible nipples can decrease distress in piglets that must be weaned at an early age for experimental reasons (Jeppesen, 1982; Weary et al., 1999a; Toscano and Lay, 2005; Widowski et al., 2005; Colson et al., 2006; Bench and Goyanou, 2007).

**Occupational Enrichment.** Occupational enrichment is achieved by allowing and promoting physical exercise, foraging, exploration, nest-building, playing, and manipulative and cognitive activities. Access to pasture, soil, straw, peat, mushroom compost, hay, bark, branches, logs, and other malleable materials helps to satisfy these urges. These materials provide an outlet for exploration, sniffing, biting, rooting, and chewing activities, reducing the likelihood that these behaviors will be redirected toward the bodies of pen-mates or pen fixtures. Such enrichment materials can lower the risk of injuries and harassment from tail biting, ear chewing, and belly nosing, as well as reducing aggressive behavior and wear and tear on housing fixtures (Fraser et al., 1991; Beattie et al., 1995; Lay et al., 2000; Hötzel et al., 2004).

Pigs are initially attracted to materials that are odorous, deformable, and chewable, but for sustained occupational enrichment, the best materials are complex, changeable, manipulable, destructible, and are ingestible or contain sparsely distributed edible parts (Van de Weerd et al., 2003; Bracke, 2007; Studnitz et al., 2007). Thus, pigs prefer to root in and manipulate materials such as corn silage mixed with straw, compost, turf, peat, forest soil, beets, spruce chips, and fir branches. Although somewhat less preferred than these materials, long straw is a useful enrichment material, being more effective than chased straw, sand, or ropes, and much more effective than indestructible objects such as hoses, chains, and tires (Tuytens, 2005; Van de Weerd et al., 2005; Scott et al., 2006; Jensen and Pedersen, 2007; Studnitz et al., 2007; Day et al., 2008; Zonderland et al., 2008). Unattached objects presented at floor level may be more attractive to pigs than hanging objects but lose their attractiveness when soiled with excreta (Van de Weerd et al., 2003).

Most research on enrichment materials has focused on straw. The amount of behavior directed toward long straw rather than toward pen-mates is proportional to the amount of straw provided (Kelly et al., 2000; Day et al., 2002). Although providing straw only after tail biting has started can reduce the behavior, it does not act as a complete curative. Providing straw from an early age helps to prevent tail biting, lowers aggression, and maintains normal activity (Day et al., 2002; Bolhuis et al., 2006; Chaloupková et al., 2007). However, the risk of tail biting is elevated, and activity is depressed, if pigs initially reared with straw are subsequently housed without straw (Day et al., 2002; Bolhuis et al., 2006). These findings highlight the importance of continuing an enrichment program once it has started.

Slatted floors and liquid-manure systems usually preclude the provision of ample amounts of long straw and other particulate foraging materials. In this situation, offering small amounts of such materials in racks or troughs, and replenishing the supply frequently, stimulates sniffing, rooting, and chewing while maintaining a degree of novelty that is important for sustaining the interest of curious pigs. When particulate materials cannot be used, hanging ropes with unraveled ends that can be pulled, shaken, chewed, and torn apart are the next best option (Jensen and Pedersen, 2007; Trickett et al., 2009). Less-destructible novel hanging objects can offer short-term enrichment by attracting exploration and stimulating play but they need to be changed frequently because pigs rapidly lose interest in such objects when they are no longer novel (Van de Weerd et al., 2003; Gifford et al., 2007). Enrichment materials and objects should be monitored to ensure that they do not cause health problems (e.g., strangulation, choking, poisoning, obstruction of the digestive tract, transmission of pathogens) or compromise food safety. Supplying ample free access to preferred enrichment materials and objects will minimize aggressive competition for these resources.

Offering opportunities for pigs to respond to environmental cues to find occasional food rewards and to work for access to foraging materials and hidden food treats can be rewarding (Puppe et al., 2007; de Jonge et al., 2008). This form of enrichment has been found to speed wound healing (Ernst et al., 2006).

At least 24 h before farrowing, provision of an earth or sand substrate along with straw, branches, or other nesting materials enables sows to address their strong motivation to engage in nest-building behavior, which, under natural conditions, involves digging a shallow depression with the snout and then gathering nesting materials such as long grass, twigs, and branches, carrying them to the nest site in the mouth, and arranging them into a nest (Jensen, 1989, 1993). Providing nest materials can contribute to early piglet survival although results are variable (Herskin et al., 1998; Jarvis et al.,
not especially attracted to enrichment materials that produce sound when manipulated (Van de Weerd et al., 2003; Bracke, 2007). On the other hand, habituation to a variety of environmental sounds should help to reduce fear when pigs are moved to new environments, and playing a radio (following habituation) may be useful for masking sounds on occasions when sudden, unpredictable, loud noises are anticipated, such as those generated during construction.

**Nutritional Enrichment.** When feeding concentrated diets, feed restriction is usually needed during pregnancy to prevent excessive weight gain, which may result in later difficulties during farrowing and lactation. Although the ration fulfills their nutrient requirements, the sows eat it quickly and are hungry for much of the day. The sows’ normal response is to forage for additional food. When sows are housed in an environment with no outlet for diverse foraging behaviors, aggression may increase, foraging behavior may be channeled into a few elements performed repetitively in stereotyped sequences (e.g., bar biting, sham chewing), or abnormal amounts of water may be consumed (Terlouw et al., 1991, 1993). These behaviors are reduced by providing straw and other ingestible foraging substrates that occupy the sows in diverse foraging activities and by feeding a diet high in fermentable nonstarch polysaccharides (e.g., sugar beet pulp, soybean hulls) to increase satiety (Spoolder et al., 1995; Meunier-Salaün et al., 2001; Robert et al., 2002; van der Peet-Schweren et al., 2003; de Leeuw et al., 2005). Although increasing the fiber content of the diet does not always influence stereotyped oral-nasal-facial behaviors (McGlone and Fullwood, 2001), the incidence of gastric lesions may be reduced in pigs given straw compared with those lacking access to roughage (Bolhuis et al., 2007).

Chewable and destructible but inedible substrates and objects such as ropes and cloth tassels are less satisfying to sows than straw or other fibrous materials but are better than hard, indestructible objects such as chains and stones toward which sows direct stereotypic behavior (Spoolder et al., 1995; Robert et al., 2002; Tuylens, 2005; Studnitz et al., 2007). Incorporating a nutritional reward in a rootable or chewable object increases its attractiveness over objects that do not provide food reinforcement (Day et al., 1996; Van de Weerd et al., 2006). Although stereotyped behavior peaks in the period immediately following a meal suggesting that limit-fed sows should be given concentrated feed in a single daily meal rather than multiple smaller meals, provision of small food rewards does not appear to cause stereotypic behavior when combined with loose housing in straw-bedded pens (Terlouw et al., 1993; Haskell et al., 1996). Under these conditions, limit-fed sows can be extensively occupied by provision of food in devices that require work to extract it (e.g., the Edinburgh foodball; Young et al., 1994). It is important to make sure that there are sufficient nutritional enrichment devices to avoid aggressive competition. In general, the benefits of environmental enrichment for pigs are likely to be greatest when multiple forms of enrichment are supplied (Olsen, 2001).

**General Considerations**

When providing animals with environmental enrichment, it is critical to assess outcomes to ensure that the enrichment program is effectively meeting the intended goals. Observations of animal behavior, health, performance characteristics, and use of the enrichments are important components of such an assessment. Behavioral observations might include assessments of the frequency of normal behaviors, the frequency and severity of stereotypies and injurious behaviors, and the frequency and severity of undesirable behaviors such as excessive fearfulness or aggression.

For outcomes to be assessed adequately, it is important that the individuals who are making the observations be appropriately trained in sampling methods and that these methods are standardized across raters. These types of observations are often made by the animal caretakers, because they are typically the individuals with the most day-to-day contact with the animals. As Nelson and Mandrell (2005) point out, caretakers should therefore be “encouraged to become knowledgeable about the behavior of individual animals, to be active participants in the implementation of the enrichment programs, and to be made aware of the special role they play in communicating the successes and failures of enrichment strategies” (p. 175). These individuals should also be encouraged to be creative in developing environmental enrichment programs for agricultural animals. Books and articles about farm animal behavior are useful resources. In addition, Young (2003) provides helpful information about designing and analyzing enrichment studies as well as a list of sources of general information about various environmental enrichment methods. There are important practical considerations involved in providing animals with enrichments, including those related to safety (Bayne, 2005). Although there are a limited number of published papers (and none involving farm animals), animals are periodically reported to sustain injuries from environmental enrichment; for example, intestinal obstruction due to the provision of foraging enrichments or items that can be chewed and ingested (Hahn et al., 2000; Seier et al., 2005). Young (2003) lists several considerations that should be taken into account when evaluating the safety characteristics of potential enrichment devices:

- Does the enrichment have sharp edges?
- Can the animal’s limbs or other parts of the animal’s body become trapped in any part of the enrichment?
- Can the enrichment be broken or dismantled by the animal, and if so, would the fragments or constituent parts pose a safety risk?
- Can the enrichment or any part of it be gnawed and swallowed?


Sherwin, C. M., P. D. Lewis, and G. C. Perry. 1999. The effects of environmental enrichment and intermittent lighting on the


