

Handling and Transport of Agricultural Animals Used in Research

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Researchers and technicians who work with agricultural animals should understand the basic principles of livestock behavior during handling. An understanding of behavior will improve animal welfare, reduce stress, which could confound research results, and prevent injuries to both people and animals. Calm animals are easier to handle than agitated fearful animals. If an animal becomes agitated, it takes 20 to 30 minutes for it to calm down. Waiting for it to calm down will make handling and restraint easier. Stress associated with transportation, restraint, or handling diminishes immune function in cattle, pigs, and sheep (Kelley et al. 1981; Mertsching and Kelley 1983; Blecha et al. 1984; Coppinger et al. 1990). Detrimental effects of handling and transit stress on rumen and reproductive function in cattle and sheep were shown by Doney et al. (1976), Galyean et al. (1981), Hixon et al. (1981), and Stoebel and Moberg (1982; Grandin, 1997a). Good handling and transport procedures will reduce detrimental physiological changes.

Vision and Handling

The wide-angle vision of livestock affects their behavior during handling and transport. Cattle and pigs have a visual field in excess of 300° (Prince 1977). In sheep, the visual field ranges from 191° to 306°, depending on the amount of wool on the head. There is a small area of depth perception in front of the animal's nose. Loading ramps and handling chutes should have solid sidewalls to prevent animals from seeing distractions outside the chute (Rider et al. 1974; Grandin 1980a, 1982). Seeing moving objects or people through the sides of a chute can cause livestock to balk or become agitated. Solid chute sides are especially important if the animals are not completely tame or are unaccustomed to the facility. The crowd pen which leads up to a single-file chute should also have solid fences. Restricting vision helps to reduce stress (Douglas et al. 1984; D.M. Kinsman, pers. com.). Stress can be reduced in wild cattle by confining them in a darkened box (Hale et al. 1987). The use of a darkened enclosure is especially recommended for wildlife in general. Blindfolding with a completely opaque cloth has a calming effect on cattle (Mitchell, et al., 2004). When cattle become fearful the whites of their eyes will become visible (Sadem, et al., 2006).

Livestock have depth perception (Lemman and Patterson 1964), but their ability to perceive depth while moving with their heads up is probably poor. To see depth on the ground, an animal would have to stop and lower its head. This may explain why livestock lower their heads and stop to look at strange things on the ground. Cattle, pigs, sheep, and horses will often balk and refuse to walk over a drain grate, hose, puddle, shadow, bright spot, or change in flooring surface or texture (Lynch and Alexander 1973; Grandin 1980b, 1982; Grandin, 1996; Grandin and Johnson, 2005). In areas where animals are handled, illumination should be uniform and diffuse to minimize shadows and bright spots. To facilitate livestock movement in chutes, the entrance must not appear to be a dead end. Curved chutes work more efficiently than straight chutes for cattle because they prevent the cattle from seeing the activity at the other end. However, they must be laid out properly to avoid the appearance of a dead end. For information on chute design, refer to Grandin 1980a, 1980b, 1982, 1983a, 1984b, 1990, 2000)

Livestock have a tendency to move from a dimly illuminated area to a more brightly illuminated area, provided the light is not glaring in their eyes (Lynch and Alexander 1973; van Putten and Elshoff 1978; Grandin 1980a; Grandin, 2001). A spotlight directed onto a ramp or other apparatus will often facilitate entry, but the light must not shine directly into the eyes of approaching animals. Research by Phillips et al. (1987) indicated that pigs reared indoors preferred to walk up a ramp illuminated at 80 lux, which was similar to the illumination of their living quarters. A dimly illuminated ramp with less than 5 lux was avoided. There was also a tendency to avoid an excessively bright ramp illuminated with 1,200 lux. At night a light inside a truck will facilitate loading.

Moving or flapping objects can also disrupt handling. Fan blades or a flapping cloth can cause balking. Animals may refuse to walk through a chute if they can see motion ahead

(Grandin 1987). A coat hung over a fence will often cause animals to balk. They may also refuse to walk over floor drains or areas where the floor color or texture changes.

Contrary to popular belief, livestock have color perception. Numerous investigators have now confirmed this for cattle (Thines and Soffie 1977; Darbrowska et al. 1981; Gilbert and Arave 1986), pigs (Klopfer and Butler 1964; Hebel and Sambraus 1976), sheep (Munkenbeck 1982), and goats (Buchenauer and Fritsch 1980). A study of the eye's retina indicated that cattle, sheep, and other grazing animals are dichromats. They see yellow and blue easily but are colorblind for red (Jacobs, et al., 1998). Handling facilities should be painted one uniform color. All species of livestock are more likely to balk at a sudden change in color or texture.

Hearing and Handling

Cattle and sheep are more sensitive than people to high-frequency noises (Ames and Arehart 1972; Kilgour 1983; Heffner and Heffner, 1998). The auditory sensitivity of cattle is greatest at 8,000 Hz and that of sheep at 7,000 Hz (Ames 1974a). The human ear is most sensitive at 1,000 to 3,000 Hz. Loud or novel noises can be highly stressful to livestock. Sheep exposed to exploding firecrackers or noises in a slaughter plant have increased thyroid hormone and cortisol levels (Falconer and Hetzel 1964; Pearson et al. 1977). Dairy cows exposed to exploding paper bags produce only 70% of the normal amount of milk (Ely and Petersen 1941). A loud ringing bell from an outdoor telephone will raise a calf's heart rate by fifty to seventy beats (T. Camp, pers. com.). Yelling at cattle is highly stressful and should be avoided (Waynert et al., 1999; Pajor et al., 2002). Physiological changes induced by sudden noises could alter the results of experiments.

Animals will readily adapt to reasonable levels of continuous sound, such as white noise, instrumental music, and miscellaneous noises. Continuous exposure to loud sounds over 100 dB has been reported to reduce daily weight gain in sheep (Ames 1974a). However, continuous background sound at lower levels can actually improve weight gain in some cases. Ames found that sheep exposed to 75 dB of miscellaneous noises (roller coasters, trains, horns, etc.), white noise, or instrumental music gained weight faster than controls without continuous background sound.

Livestock producers and researchers have learned from experience that continuous playing of a radio with a variety of talk and music will reduce the reaction of pigs to sudden noises. Providing controlled amounts of continuous but varying background sound may help prevent experiments from being confounded by extraneous noises.

In facilities where livestock are handled for experimental or veterinary procedures, sudden or novel noises should be avoided. It may be advisable to have the same radio station or background sound that is provided in the living quarters. Research is needed to determine if exposing animals to sounds they may hear while being handled and tested in their living quarters will reduce stress.

The sound of banging metal can cause balking and agitation. Rubber stops on gates and squeeze chutes will help reduce noise. The pump and motor on a hydraulic squeeze chute should be located away from the squeeze. If the pump is noisy, replace it with a quieter vane pump. The loud sound of a noisy pump is also stressful to people. Equipment that produces a high-pitched whine will cause livestock to become agitated and difficult to handle.

Flight Zone

An important principle of livestock handling is the flight zone. The flight zone is the animal's personal space. Understanding of the flight zone can reduce stress on livestock and help prevent injuries. Animals that are trained to lead with a halter or they allow people to touch them are completely tame and have no flight zone. Animals that are not completely tame will have a flight zone and will move away when people approach.

The size of an animal's flight zone will vary depending- on its tameness or wildness. The flight zone of extensively raised cows may be as much as 50 m (164 ft), whereas the flight zone of feedlot cattle may be only 2 to 8 m. Animals housed in a research facility for several weeks will have a flight zone up to 2 m. When cattle, pigs, or sheep first arrive at a research facility, they may have large flight zones. The size of the flight zone will slowly diminish during long-term experiments if animals are handled gently. If animals are handled roughly, the size of the flight zone may increase. Animals with a large flight zone become stressed when the flight zone is deeply penetrated and they are unable to move away.

The edge of the flight zone can be determined by slowly walking up to an animal. The circle in Figure 1 represents the edge of the flight zone. When a person enters the animal's flight zone, it will turn and move away. When cattle or sheep are facing towards a handler, the handler is outside the flight zone. When the flight zone of a group of bulls was invaded in one experiment by a mechanical trolley, the bulls moved away and maintained a constant distance between themselves and the trolley (Kilgour 1971). The best place for a handler to work is on the edge of the flight zone (Grandin 1980b). This will cause the animals to move away in an orderly manner. They will stop moving when the handler retreats from the flight zone. To make an animal move forward, a person should stand in the area marked A and B on Figure 1. To make the animal back up, a person should stand in front of the point of balance (Kilgour and Dalton 1984).

A handler should avoid deep penetration of the flight zone. Many people make the mistake of getting too close when cattle are being driven down an alley or into an enclosed area such as a crowd pen. If the handler deeply penetrates the flight zone, the cattle may turn back and run over him. If the cattle start to turn back, the handler should retreat from the flight zone. Cattle will sometimes rear up and become agitated while waiting in a single-file chute. A common cause of this problem is a person leaning over the chute (Grandin 1980b, 1983a). The cattle will usually settle back down and stop rearing if the handler backs up and retreats from the flight zone. Inexperienced handlers sometimes try to push a rearing animal back down into a chute. The animal will often react to this by becoming increasingly frantic. Both the handler and the animal have a greater likelihood of being injured.

Extremely tame livestock are often difficult to drive because they no longer have a flight zone. These animals should be led with a feed bucket or halter. The size of the enclosure that livestock are confined in may affect flight zone size. Experiments indicated that sheep confined in a narrow alley had a small flight zone compared to animals confined in a wide alley (Hutson 1982).

Persuaders

A skillful handler can induce cattle to move with a minimal use of persuaders such as whips or electric prods. Prods should never be used on sows, boars, or sheep, and they should be used very sparingly on cattle and market-weight hogs. Repeated electric prodding of pigs will cause the heart rate to increase with each successive prod (van Putten and Elshof 1978), causing the pigs to lie down when their heart rates reach dangerously high levels (Mayes and Jesse 1980). Benjamin et al. (2001) reported that aggressive handling with multiple shocks from an electric prod greatly increased lactate and glucose levels compared to gentle handling. With cattle the only time electric prods may be required is when persuading a stubborn animal to enter a truck or squeeze chute. In biomedical research facilities, electric prods can be eliminated if animals are handled gently by skillful people. In high-speed commercial cattle facilities the use of electric prods is preferable to hitting or excessive tail twisting.

Cattle must never be prodded or have their tails twisted if a chute gate is closed and they have no place to go. The handler must wait until the gate is open before attempting to drive an animal to it. Driving an animal into a dead end will cause balking and agitation. When one

animal balks, balking tends to spread down a whole line of cattle. Handlers must reward an animal for moving by stopping tail twisting or prodding. The animal will quickly learn that it can avoid being prodded or having its tail twisted if it moves promptly. Cattle should be induced to enter a squeeze chute at a walk. Running into tile headgate can cause shoulder bruises. When wild cattle are handled, a skillful squeeze-chute operator slows the animals down in tile squeeze before they reach the headgate.

Cattle can be moved easily in pens by the use of a stick with a piece of plastic or a stick flag attached to the end. The animals will readily move away from the flag or plastic. Handler should use the flag to quietly turn and guide animals. Do not wave it hard. Handlers must be patient and allow the leaders to get ahead of the rest of the animals. Handling will often proceed more rapidly if a handler waits for the leader to move.

When swine are handled, a portable solid panel should be used to move them (Grandin 1986). Pigs respect the solid barrier and will be less likely to turn back on the handler. Sorting of pigs can be also facilitated by separating them with a portable panel. Panels are available commercially, or they can be made from a 1.2 m (4 ft.) by 76 cm (30 in.) piece of plywood with two handholds on the top. Other good driving aids are a plastic paddle, a stick with a flag on the end and large flags made from plasticized cloth.

Animal movement through chutes can also be expedited by feed rewards. Hutson (1985) reported that rewarding sheep with barley grain facilitated movement the next time they went through the chute.

Herd Animals

All livestock are herd animals, and they are likely to become highly agitated and stressed when they are separated from their herd mates. Physiological changes which occur during isolation may affect the results of experiments. If livestock have to be housed in individual pens, design the pens so that the animals can see, hear and preferably touch each other.

Isolation is a strong stresser. Restraint and isolation in a small box reduces immune response in pigs (Mertsching and Kelley 1983). Isolation is also highly stressful in sheep and cattle (Ewbank 1968; Kilgour and DeLangen 1970; Rushen 1986). A dairy cow left alone in a stanchion has increased leucocytes in her milk (Lynch and Alexander 1973). When cattle and other large animals are separated from their herdmates, they may become agitated and injure handlers; many serious accidents are caused by a single frantic bovine (Grandin 1987). If an isolated animal becomes agitated, put other animals in with it. When a single animal is removed from its home pen for testing, it is often advisable to have a "buddy" to keep the animal company.

Point of Balance Principles

Understanding the point of balance will greatly facilitate the movement of grazing animals. The point of balance is located at the shoulder. Cattle, sheep or pigs will move forward when a person is behind the point of balance in position B on Figure 1. If a person is in front of the point of balance, the animal will move backwards. A common mistake is to stand at the animal's head and poke it on the rear. This does not work.

How to Handle and Move Cattle

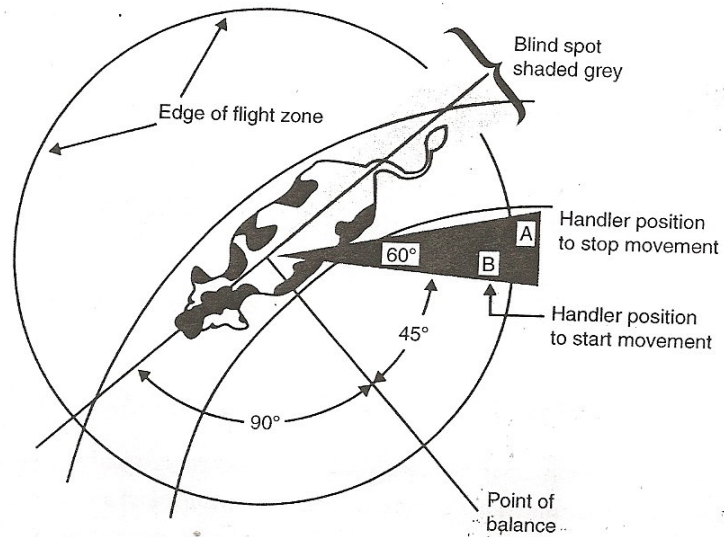


Figure 1.

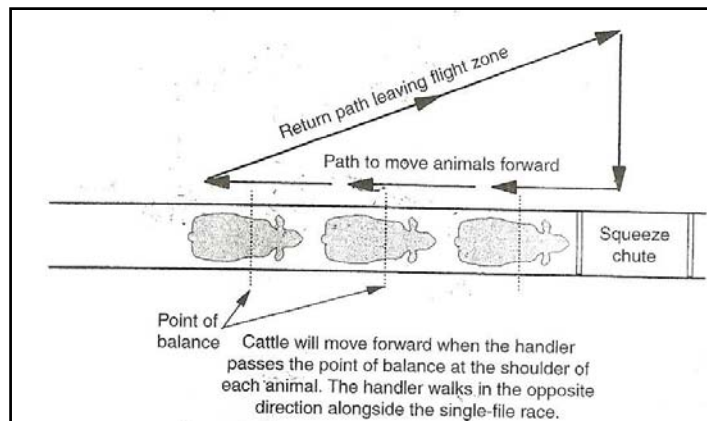


Figure 2.

Figure 2 illustrates a movement pattern to get cattle into a squeeze chute. When a person quickly walks inside the flight zone in the opposite direction of desired movement the animal will move forward when the handler crosses the point of balance. The person must walk quickly otherwise the animal will back up (Grandin 2000).

Effects of Environment and Experience

The previous experiences of an animal will affect how it reacts to handling or experimental testing. An animal's stress reaction to a handling procedure such as transportation or restraint depends on three important factors: genetics (Tulloh 1961; Dantzer and Mormede 1983; Marshall-Nimis et al. 1986), individual differences (Ray et al. 1972; Syme and Elphick 1982/1983), and previous experiences (Luyerink and Van Baal 1969; Jones and Faure 1981; Hemsworth et al. 1986). Facility design can have a strong influence on experience. Poor design will increase stress. Animals become excited very quickly, but it can take twenty minutes to four

hours for heart and breathing rates to return to normal (Stermer et al. 1981; Stephen and Adams 1982). This is why it is essential to prevent excitement. It takes an animal a long time to calm down.

Sheep raised in a barn in close contact with people have a less intense physiological response to handling than sheep raised on pasture (Reid and Mills 1962). The cattle used in the transportation studies discussed previously were not accustomed to frequent handling. Animals accustomed to such use would probably have fewer detrimental physiological changes. Hails (1978) reported that calves lost less weight the second time they were transported. Hens which are not accustomed to being caught and handled have lowered egg production, but production is not affected in hens accustomed to frequent handling (Hughes and Black 1976). Piglets and chicks accustomed to repeated gentle handling by people approach people more readily as adults in an open-field test. Handling by people does not, however, increase approach toward a novel object, suggesting that handling by people specifically reduces fear of people but not fear of novel objects. Animal fears are highly specific. They may associate a particular thing such as a black hat the person was wearing with a painful or frightening experience (Grandin and Johnson, 2005). Animals should be tamed and accustomed to handling before experiments are started. They can easily adapt to gentle nonaversive procedures with no effect on weight gain. In one experiment, daily weighing in good facilities did not affect weight gain (Peischel et al. 1980). In another experiment, weekly walks in the aisle had no effect on the weight gain of pigs (Grandin 1989a). Antelopes which had been carefully trained to voluntarily cooperate with blood sampling had almost baseline levels of cortisol (Phillips et al., 1998).

Environmental Stimulation

Environmental stimulation will reduce excitability and help animals to be less stressed by handling or unexpected stimuli such as an intense thunderstorm. Pigs raised with access to hanging rubber-hose toys and with weekly petting are less excitable than pigs raised with no extra environmental stimulation (Grandin 1987, 1989a). Pigs raised outdoors with a variety of playthings and daily petting are more willing to approach a strange man and walk through a narrow chute than pigs raised indoors in small, barren pens with minimal contact with people. In a choice test, pigs prefer pliable objects such as rubber hoses or cloth strips; chains are least preferred. Animals can adapt to irregularities in their routine if the irregularities are introduced gradually. If animals become accustomed to several different people handling them, they will be less likely to become stressed by a new person.

Loading confinement-reared pigs into a vehicle is difficult compared to loading pigs reared outdoors (Warriss et al. 1983). How a baby piglet is handled will affect its behavior later in life. Piglets, which are handled and gently petted, will approach a strange man more readily at twenty-four weeks of age (Hemsworth et al. 1986). Providing animals with a stimulating environment will help prevent stereotypies and other symptoms of sensory deprivation (Grandin 1989a).

Previous Experiences and Genetic Factors

Animals remember painful or frightening experiences. Cattle and sheep remember an aversive experience for many months (Hutson 1985; Pascoe 1986). Livestock which have had an aversive handling experience will be more stressed when they are handled in the future. In one experiment, cows which had been shocked by an electro immobilizer had elevated heart rates the next time they approached the place where the shock occurred (Pascoe 1986).

Cattle handled roughly in poorly designed facilities have higher heart rates than cattle handled calmly in well-designed facilities (Stermer et al. 1981). Chickens handled gently have lower corticosterone levels than chickens handled roughly (Broom et al. 1986). Livestock which are handled gently will be quieter and less stressed when they are handled in the future. Often the stress of rough handling is greater than the stress or pain of a procedure. Hemsworth et al. (1981) found that sows that feared the presence of a person bore fewer

piglets. When animals perceive people or handling procedures as threatening, stress and physiological changes occur. To minimize stress, painful procedures should never be done in the home pen or the restraint chute used for data collection, but rather in a different place. It is important that animals be able to trust people in their home quarters. This enables them to be relaxed with their regular handlers. It has been found that animals are able to differentiate between the "nice" person that feeds them and the "mean" person that does painful procedures (Fell and Shutt 1989). An animal's first experience with a new person, place or piece of equipment should be positive to help prevent the formation of a far memory (Grandin, 1997).

Animals can be trained to voluntarily enter a comfortable restraint device for nonpainful procedures. They can do this with little or no stress. For example, monkeys can be trained to present their arms for blood tests in return for a food reward. A skillfully administered blood test causes little or no pain. Handlers and researchers should avoid painful procedures, such as restraint with nose tongs in a chute that is used for recording physiological responses. If an animal fears the chute, the accuracy of experimental measures may be affected.

Genetic factors interact with experience and affect an animal's reaction to handling. For example, Brahman and Brahman-cross cattle are more excitable than Hereford cattle. Both excitable-temperament and calm-temperament animals will react favorably to gentle handling, but it may take longer to get the more excitable animal to become calm during handling. I have been observing increasing problems with very nervous, excitable pigs, which are difficult to drive up a chute. This problem is most evident in hybrid pigs selected for rapid weight gain and leanness. If the present trend continues, humane handling and transport of large numbers of pigs on trucks and in slaughter plants will become more and more difficult. Pig breeders should start selecting for temperament to prevent serious welfare and meat quality problems.

The temperament problem is independent of the so-called halothane stress gene. Pigs which are homozygous for the porcine stress syndrome (PSS) gene often die during transport. It is advisable to purchase pigs which are halothane negative to avoid death during handling or experiments. Some genetic lines of pigs which have been selected to grow rapidly may develop leg problems and become too heavy if they are used in long-term biomedical experiments. The use of slower growing genetics would be recommended.

Behavioral Principles of Restraint

For all species, observations, and practical experience has shown that there are three basic behavioral principles that apply to both holding a small animal in your hands or holding a large animal in a device such as a squeeze chute.

1. Never trigger the fear of falling

The animal must stand on a non-slip surface. Animals panic when they start to slip. Exam tables for dogs should be covered with a rubber mat and cattle squeeze chutes must have cleats on the floor. The restraint device must hold the animal upright in a balanced position. If the animal feels as if it will topple sideways, it may struggle. Restraint devices that hold an animal with its feet off the ground must fully support the body. The Panepinto sling for pigs and the center track restrainer are two devices that hold animals in a comfortable balanced upright position (Panepinto 1983, Grandin 2003). When small animals are picked up with your hands, the body should be fully supported.

2. Slow steady motion is calming

Sudden jerky motion frightens animals. This principle applies to both the movement of a person's hands and movement of a mechanical restraining device. An animal should be touched with a steady motion. Do not sneak up on it or suddenly grab at it. Restraint devices powered by

hydraulics should have control valves with good throttling ability and work like a car accelerator. How far the lever is pushed determines the speed of movement (Grandin 1992 and 2000).

3. Optimum Pressure is best

Holding an animal either too loosely or too tightly will cause struggling. It must be held tight enough to feel held but not so tight that it hurts. Even pressure over wide areas of the body works best. A common mistake is squeezing an animal tighter when it struggles. A piglet will fall asleep in a padded restrainer that applies pressure to both sides of the body (Grandin, et al., 1999).

4. Block vision of grazing animals

If the animal is completely tame this is not required. Animals with a flight zone are calmer when they are blindfolded (Mitchell et al., 2004). The blindfold must be completely opaque. Solid sides on chutes help keep wild animals calmer.

Voluntary Restraint

Well-designed restraint devices which enable an animal to remain in a comfortable position will reduce stress and facilitate handling. Restraining chutes must be easy to operate. Fumbling and failure; to restrain an animal on the first attempt will often result in increased excitement (Ewbank 1968).

Animals that are handled gently can be trained to voluntarily accept restraint in a comfortable device (Panepinto et al. 1983; Grandin 1984a, 1989b). This reduces both stress and injuries. However, animals will not voluntarily enter a restraint device which causes pain. To make the restraint device comfortable, head stanchions should be constructed from round pipe. Cleats should be provided so that a halter can be used to restrain an animal's head for blood testing. Cattle restrained with nose tongs become more difficult to restrain in the future. They fling their heads to avoid attachment of the painful tongs. When a halter is used, restraining the head becomes easier with successive tests. Many cattle will voluntarily turn their heads to expose the jugular. To train animals to accept restraint voluntarily, the restraining device must be introduced gradually and gently with feed rewards, which should be a real treat, such as barley or horse feed. The first step is to allow an animal to walk through the restrainer for the feed reward. The second step is to have the animal stand in the restrainer without being fully restrained. On the fourth or fifth pass through the restrainer, the animal should be gently restrained. If it resists and struggles, it must not be released until it stops struggling; otherwise it will be rewarded for resisting. Animals that are released while resisting are more likely to resist restraint in the future. An animal that struggles during restraint should be stroked and offered feed until it calms down. Stress can be reduced by taming animals prior to training them to enter a restraint device voluntarily.

Restraint of Cattle

There are many different types of squeeze chutes for restraining cattle, including both manually and hydraulically operated models. To avoid serious injuries to cattle held in a hydraulic chute, the pressure relief valve must be correctly set. The hydraulic system should bypass to the tank at a low enough pressure so that an animal is held snugly but shows no signs of discomfort such as labored breathing. The animal should not vocalize (moo or bellow) in direct response to being caught in the chute. To minimize noise, purchase a chute with a vane pump. Less expensive gear pumps are very noisy. A squeeze chute that closes evenly on both sides is recommended. This enables an animal to stand in a balanced, relaxed position. Avoid squeeze chutes with only one movable side.

Tilt tables and straps are sometimes used to restrain cattle. A complete squeeze chute that tilts is more comfortable for the animal than a tilt table with straps. Other types of restraint systems are the V and double-rail restrainers that are used in packing plants. Variations of these systems could be adapted for research use (Giger et al. 1977; Grandin 1986, 1989c). Pigs will

relax and go to sleep when they are held upright in a padded, V -shaped squeeze chute (Grandin1989c).

Headgate Types and Cattle Safety

It is essential to use a squeeze chute or headgate that is appropriate for the intended task. If an animal is going to be confined in the headgate or squeeze for a long period of time, a headgate with straight vertical neck bars is recommended (Grandin 1980c; Grandin, 1997b). This design provides maximum safety for the animal. If control of head movement is desired, use a halter to hold the head. Straight bar-stanchion headgates are recommended for biomedical, physiological, and reproductive research restraint.

Pressure exerted by a headgate against the windpipe or carotid arteries can choke and kill an animal (White 1961; Fowler 1978). A headgate with straight vertical neck bars avoids pressure on these critical areas.

If the headgate is to be used in an agricultural research facility where large numbers of cattle have to be handled rapidly, a curved bar stanchion provides a good compromise between head control and livestock safety. Since a curved stanchion increases the possibility of choking, it must be used in conjunction with a complete squeeze chute. If an animal tries to lie down while it is held in a curved stanchion, pressure on the carotid arteries can kill it. An animal that becomes unconscious must be released instantly to avoid death.

A curved bar stanchion is safe for cattle if a few simple precautions are taken. Never leave an animal unattended. Adjust the squeeze so that it is narrow enough at the bottom to prevent the animal from lying down. The proper spacing between the squeeze sides is 16 cm (6 in) for 90-kg (200-lb) to 180-kg (400-lb) calves, 20 cm (8 in) for 272-kg (600-lb) to 362-kg (800- lb) animals, and 30 cm (12 in) for cows and steers. The space should be 36 to 41 cm (14 in to 16 in) for large bulls (Grandin 1983). The measurements are taken on the inside of the chute at floor level. If a hydraulic chute is used, it should have a hydraulically adjustable bottom. These narrow adjustments are not required with a straight bar stanchion because an animal can lie down with no danger of choking.

A group of tame cattle can be held in row stanchions with a feed trough in front of them. Many large dairies have rows of automatically locking straight bar stanchions. When the cows come in to eat, they lock themselves in. Cattle can also be held in such stanchions for experiments that last several weeks. Never use this type of equipment with untamed, wild cattle. The animals must be tamed and accustomed to head restraint before experiments are started.

Agricultural versus Biomedical Handling

Livestock used in research are handled in two different settings. The first is agricultural research. The effects of new treatments on conditions such as weight gain, disease resistance, and reproduction are studied. Handling facilities used for agricultural research should be similar to good facilities on feedlots, ranches, and farms (Figure 3).

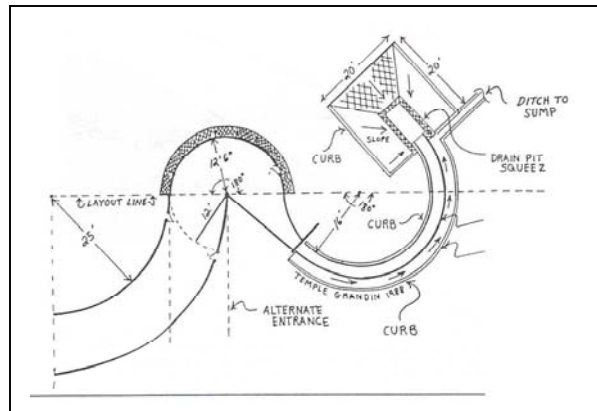


Figure 3. Layout of a curved cattle-handling facility for either agricultural research or commercial use.

Livestock handled under agricultural conditions often have large flight zones and are not tame. The facilities must be designed to handle them. Veterinary research facilities usually require agricultural handling equipment, because incoming animals are often wild.

The other use for livestock in research involves fields such as physiology, biotechnology, and medicine. Here researchers may be working with a few animals that are accustomed to handling procedures. An elaborate feedlot type handling facility is not required to handle two or three tame halter broken calves or pigs. Researchers must be careful not to use a facility that is inappropriate. I once observed a disastrous mess at a laboratory which did research on cattle vaccines. Big, wild calves were brought into isolation rooms and restrained in head stanchions designed for tame dairy cows. The result was terrible. The calves fought the stanchions and fell down and injured themselves. The resulting stress affected the results of the vaccine experiments. These animals should have been tamed and trained to accept restraint in the stanchions before the experiment started. The other alternative would have been the installation of equipment capable of handling wild cattle. A complete squeeze chute would have been required. Wild cattle held in a squeeze chute would be less likely to injure themselves or their handlers.

How to Read This Chart

Check a weather forecast for temperature and humidity. Locate the expected temperature in the column on the left. Extend that temperature in a straight line across the chart until it intersects with a line from the expected relative humidity.

Temperatures above 100 degrees F are always DANGER, and if the relative humidity is above 25 percent, the situation is EMERGENCY.

If the intersection of temperature and humidity on the chart is in the ALERT range, load 10 percent fewer hogs (see Hog Loading Guide) and plan to deliver them to market by 11a.m.

If the index is in the DANGER zone, load 20 percent fewer hogs and haul them at night.

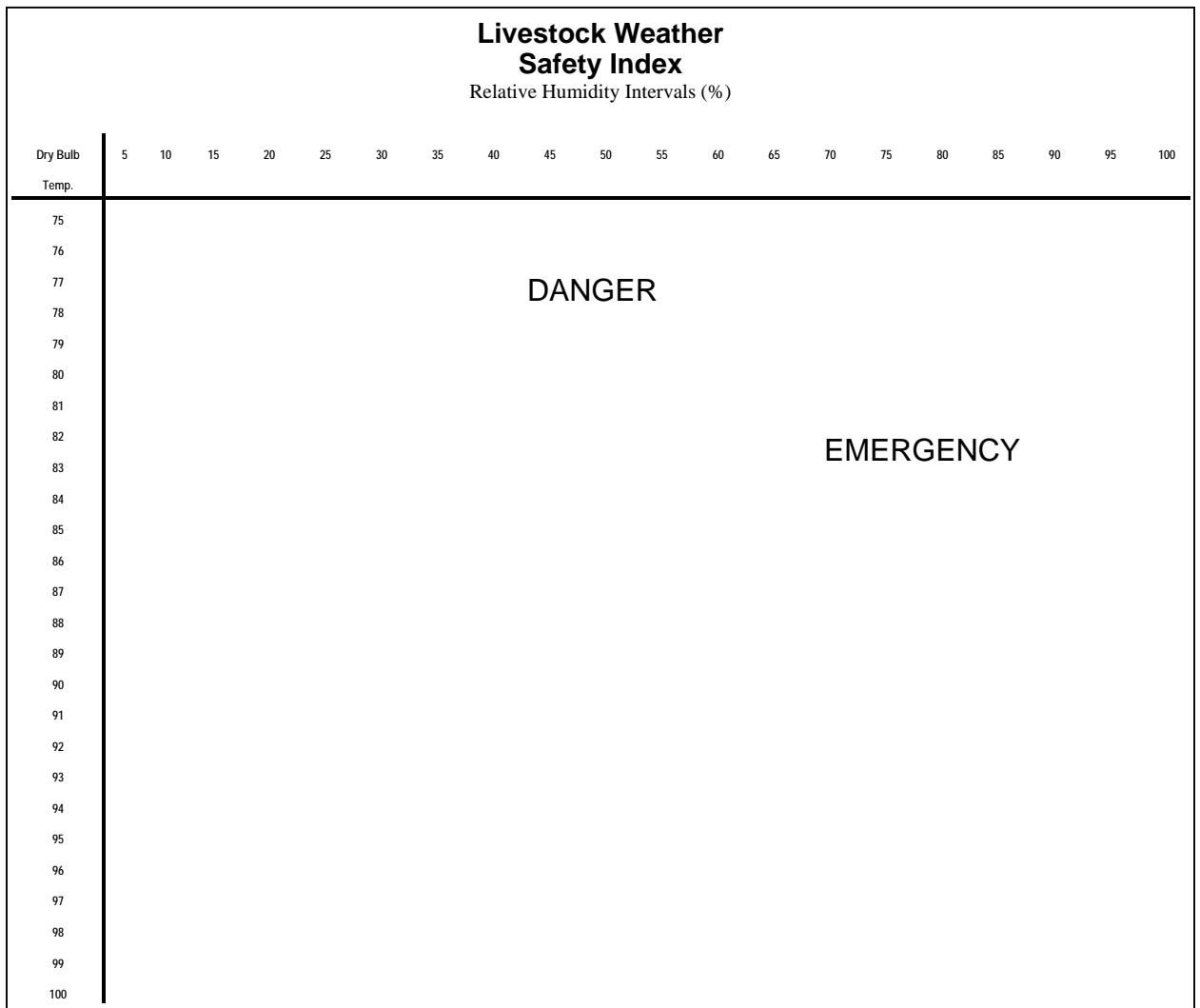


Figure 4. National Institute of Animal Agriculture

Flooring and Ramps

Hard-troweled, smooth concrete floors should never be installed in animal-handling facilities. I have been in many research facilities with slick floors where it was nearly impossible to handle animals without having them slip and fall. Floors in areas where animals have to walk must be grooved to provide a nonslip surface. A basic principle is the wilder the animal, the deeper the grooves which will be required.

Ramps for loading animals onto trucks or for getting them into equipment such as metabolism cages or experimental chambers must not be too steep. Animals can be injured if they fall on a ramp. A pig's heart rate increases as the angle of the ramp increases (van Putten and Elshof 1978). The heart will beat more slowly when a pig is descending rather than ascending (Mayes and Jesse 1980). On a hot day, stress-susceptible pigs can die from overexertion.

Permanently installed, nonadjustable ramps should not exceed a slope of 20° for cattle and pigs (Grandin 1983b). Adjustable ramps should not exceed an angle of 25°. In a preference test, pigs preferred a ramp sloped at 20° to 24°. They seldom walked up a ramp sloped at 28° to 32° (Phillips et al. 1987). Ramps for sheep may be made slightly steeper.

Stair steps are recommended on concrete ramps, because they are easier to walk on after a ramp becomes worn or dirty. Recommended step dimensions for cattle and horses are a 10-cm (4-in) rise and a 30-cm (12-in) tread length (Grandin 1983b). A 5-cm (2-in) rise and a 25-cm (10-in) tread width works well for pigs and sheep. Smaller steps should be used for pigs weighing less than 23 kg (50 lbs).

An alternative to steps is cleats. Each cleat should be 5 x 5 cm for cattle and 2.5 x 2.5 cm for pigs and sheep. Cleats should be spaced 20 cm (8 in) apart for large pigs and cattle (Mayes 1978). For small 16-kg (35-lb) pigs, a cleat spacing of 10 cm (4 in) is recommended (Phillips et al. 1987).

A ramp for loading and unloading should have a level landing, so that an animal has a level surface to walk on when it leaves the truck. This will help prevent injuries. The landing should be 1.5 m (5 ft. long) for cattle and 1 m (3 ft. long) for pigs. Loading ramps and the pen that leads to the ramp should have solid fences. A common mistake is to build a ramp that is too wide. Ramps for moving cattle in single file should be 71 cm (28 in) to 76 cm (30 in) wide. For pigs, the width should be 45 cm (18 in). This same width will also work for the smaller sheep breeds. For large-fleeced sheep, a 51-cm (20-in) to 56-cm (22-in) chute may be required. (For further information on loading-ramp design, see Grandin 1987, 1990.)

Heat and Cold Stress

The most common cause of death during transport is exposure to excessive heat or cold stress. The National Institute of Animal Agriculture publishes a booklet which contains heat-stress and cold-stress charts for livestock. High heat and humidity are especially detrimental to hogs because their sweat glands do not respond to heat (Curtis 1981). To avoid stress and death, hogs should not be shipped when heat and humidity are in the danger zone on the weather safety index (Figure 4). Heat builds up rapidly in a stationary vehicle or an airplane sitting on a runway. Summer truck shipments should be scheduled to avoid late-afternoon heat. Air shipments should avoid departure or arrival times in the afternoon or early evening. Trucks containing livestock should be kept moving during hot weather. When the temperature is over 27°C (80°F), pigs should be sprinkled with water prior to loading. But never put cold water on a pig that is suffering from heat stress. The shock to its system will kill it. Provide shade and wet the ground around the pig to aid cooling by evaporation. When the temperature is over 15°C, trucks transporting pigs should be bedded with wet sand or shavings. Straw may cause the pigs to overheat during warm weather. During cold weather, on the other hand, straw is recommended to keep pigs warm and

protect them from wind chill. Extremely lean pigs may require extra protection from cold. In Canada and northern areas of the United States, the slotted sides on semitrailers need to be partially closed in.

Figures 5 and 6 are wind-chill charts for pigs, cattle, and sheep. Many people do not realize that animals in a truck are sometimes exposed to dangerously low wind-chill factors. Cattle are heavy-duty outdoor animals which can withstand extremely cold temperatures provided their coat is dry. Freezing rain which wets an animal in a moving truck can cause death, because when the coat becomes wet, its ability to insulate is lost.

Vibration Stress and Other Transportation Hazards

There has been very little research on the reduction of vibration stress in trucks. Relatively inexpensive pneumatic suspension systems are now available for livestock semi trailers. Most new livestock semi trailers are equipped with pneumatic suspensions. In one experiment, a combination of vibration and noise in a simulated transport vehicle caused a greater rise in respiration in rabbits than noise alone (Stephen and Adams 1982). For calves, a vibration frequency of 2 hz was more stressful than 12 hz (Van de Water et al., 2003).

Overloading of trucks and other transport vehicles can cause injuries. Practical experience and research studies indicate that there is an optimal density; too many cattle are as bad as too few. The National Institute of Animal Agriculture, American Meat Institute, and the U.S. Department of Agriculture have guidelines for optimum loading densities for trucks, ships, and airplanes.

Ames Wind Chill Indexes

For Cattle with Summer Coats and Shorn Sheep (Dry Animals)							
Actual Temperature (Fahrenheit)							
Wind speed mph	-10	0	10	20	30	40	50
10	-20	-10	0	9	19	29	39
20	-37	-27	-17	-7	2	12	22
30	-53	-43	-33	-23	-13	-3	6
40	-60	-50	-40	-30	-20	-10	0
For Sheep with Full Fleece (Dry Animals)							
Actual Temperature (Fahrenheit)							
Wind speed mph	-10	0	10	20	30	40	50
10	-10	0	9	19	29	39	49
20	-13	-3	6	16	26	36	46
30	-20	-10	0	9	19	29	39
40	-31	-21	-11	-1	8	18	28

Figure 4. Ames's (1974b) wind-chill charts for cattle and sheep.

Windspeed in MPH	Actual Air Temperature						
	50	40	30	20	10	0	-10
5	48	36	27	17	5	-5	-15
10	40	29	18	5	-8	-20	-30
15	35	23	10	-5	-18	-29	-42
20	32	18	4	-10	-23	-34	-50
25	30	15	-1	-15	-28	-38	-55
30	28	13	-5	-18	-33	-44	-60
35	27	11	-6	-20	-35	-48	-65
40	26	10	-7	-21	-37	-52	-68
45	25	9	-8	-22	-39	-54	-70
50	25	8	-9	-23	-40	-55	-72

Figure 5. Livestock Conservation Institute Wind-chill chart

Some of the worst animal welfare problems that occur during transport and handling involve newborn calves and crippled animals. Downed crippled livestock must never be dragged. Dragging a crippled animal is a violation of the 1978 Humane Slaughter Act. Severely crippled animals that arrive at a research facility should be euthanized. Transport of newborn calves under five days of age should not be allowed. It is extremely difficult to humanely handle an animal that is unable to walk unaided. Transport and sale in livestock markets of underage calves is not permitted in England and some parts of Canada, such as Alberta, where Regulation 269/79 applies. I recommend as criteria for transport that a calf must have a dry coat and a dry umbilical cord and be able to stand and walk without assistance. Researchers who use calf serum should make sure that they obtain it from laboratories that collect it in a humane manner (collection procedures of some Mexican companies are incredibly cruel).

Employee Attitudes

Good facilities make good handling possible, but management must constantly monitor employee behavior. During my travels I have observed that farms, slaughter plants, and laboratories where humane practices occur have a manager who enforces a policy of gentle handling. Facilities where brutal handling prevails almost always have lax management and very little supervision. The attitude of the employees is often a reflection of the attitude of management. When management considers humane treatment of animals important, that attitude will permeate an entire organization. Employees can become numb when they handle many animals every day. Every large feedlot, farm, slaughter plant, or laboratory needs someone in management to be the "conscience" for the facility, with the authority to discipline employees and to correct deficient facilities. This person must not be so involved in day-to-day operations as to become numbed but on the other hand must not be so detached as to cease caring.

Seabrook (1984) and Hemsworth and Coleman, 1998 and Hemsworth et al., 2002 both report that employee attitudes affect animal productivity and behavior. The bottom line is that a little tender loving care really pays. Stockmen that have a good relationship with their animals have more productive animals.

Conclusion

Cattle, pigs and sheep have wide-angled vision and are more sensitive to high-frequency noise than humans. Solid fences or chutes, loading ramps and crowd pens will help keep livestock calmer and facilitate movement. Moving livestock will be easier and less stressful if the handler works on the edge of the animal's flight zone. An animal's previous experiences affect its reaction to handling. Animals with previous experience with gentle handling will be calmer and less stressed when they are handled in the future. Livestock can be easily trained to voluntarily enter a comfortable restraining device. Head stanchions with straight, vertical neckbars are recommended for biomedical research because they will not choke an animal if it lies down. During transport it is important to protect livestock from windchill and from heat stress. A combination of high temperature and humidity can cause death losses in pigs. Observations at many facilities have indicated that facilities that have humane handling have management that insists on it. Facilities with poor practices have management that places a low priority on good treatment.

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