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Livestock Behavior as Related to Handling Facilities Design

Temple Grandin

Grandin Livestock Handling Systems
617 E. Apache Blvd., Tempe, AZ 85281

Abstract

A knowledge of the behavior of different species of livestock as well as different breeds within a particular species is essential to the proper planning of a handling facility. An optimal facility should incorporate features which minimize stress on the animal and maximize the efficiency of movement from holding pen to slaughter area. Handler awareness of the animals' perception of critical distance, flight zone and personal space requirements also reduces problems with blocking and alarm behavior. Many improvements can be made with relative ease, thus enabling already existing facilities to upgrade their operations.

Introduction

The breed of animal, its degree of tameness and the type of environment in which the animal is raised can affect its behavior and ease of handling at the slaughter facility. For example, animals which have been raised on the range and away from people will have a larger 'flight zone' and may panic and become agitated when a handler approaches within 50 feet (15m). Animals which have been raised in close confinement on either solid concrete or slatted floors can also be difficult to handle on occasion. It is, therefore, essential to assess all the behavioral aspects of different species of livestock when designing slaughter handling facilities.

Breed and Behavior

Cattle

Cattle with Brahman or Zebu breeding are more excitable and harder to handle than English breeds such as Hereford and Angus. Brahman type cattle (Bos indicus) are more difficult to block at gates (Tulloh, 1961) and tend to become excited and ram fences. Agitation in Brahman cattle is readily displayed by tail swishing; the excited animal will stand its tail straight up (Kiley, 1976). Angus breed cattle are more nervous than Herefords or Shorthorns (Bos taurus), but they also have the tendency to be stubborn and refuse to move (Tulloh, 1961). Holstein cattle tend to move slowly.
The Brahman cross and Brahman type cattle can become so stressed and disturbed that they will lie down and become immobile. Brahmans have been observed lying down in the single file leadup chute, particularly after being prodded repeatedly with electric prods (Fraser, 1960). When a Brahman lies down and becomes submissive, the animal must be left alone for about five minutes; otherwise, it may go into shock and die. This problem rarely occurs in English cattle or in other European cattle such as the French Charolais.

Pigs
Social and sensitive by nature, pigs respond to gentle and considerate handling. However, this may not always be the case in pigs which have been raised in close confinement on either solid concrete or slatted floors. Confinement-raised hogs tend to be more balky, have trouble negotiating obstacles and are difficult to drive because they are not acclimated to walking and moving. Such pigs, therefore, must be moved slowly to prevent them from becoming overheated and stressed. In Europe, confinement-raised hogs are moved with a trolley which slowly nudges them along rather than with a handler who drives the hogs down the alley.

Sheep
There are distinct differences in the way various breeds of sheep react during handling (Shupe, 1978; Whateley et al., 1974). According to Shupe (1978), Ramboullet sheep tend to bunch tightly together and remain in the group, while crossbred Finn sheep tend to turn, face the handler, and maintain visual contact. However, if the handler penetrates the collective flight zone of a group of Finn sheep, they will turn and run past the handler (Shupe, 1978).

Extensive studies reported by Whateley et al., (1974) indicate that Cheviots and Perendales are the easiest to drive into a crowding pen, and that Romney, Merino-Romney cross and Dorset-Romney cross are the most difficult. The Romney tends to follow the leader but is easily led into blind corners; the Cheviots have a strong instinct to maintain visual contact with the handler and display more independent movements than other breeds.

Visual Perception and Behavior
Visual Field
The visual perception of livestock is a major factor in the design of handling facilities. Cattle and sheep have 360° panoramic vision, a binocular visual field of 25° to 50° and relatively poor depth perception (Prince, 1970) [Fig. 1]. Swine have a wide angle 310° visual field, a binocular visual field of 30° to 50°, and are better able to judge distances (Prince, 1970). The wide angle vision of cattle, sheep and swine suggests that single file lead up chutes, crowding pens, and the curved holding lane should have high solid sides to prevent the animals from seeing moving objects and people outside the facility, especially where animals are crowded (Rider et al., 1974; Grandin, 1977).

Color Discrimination
Until recently, many researchers believed that livestock were unable to distinguish colors and viewed their environment in gradations of gray. However, Hebel and Sambraus (1976) reported complete color vision in swine and partial color blindness in herbivores such as cattle and sheep. Color discrimination tests conducted on 18 month old Friesian heifers showed that the animals had discrimination for all colors except blue and purple; however, orange and yellow were confused (Thines and Soffie, 1977). In a study conducted by Webb (1966), cattle approached yellow lights more readily than other colors, and exhibited no reaction to infrared lamps.

Visual Perception, Lighting and Floor Design
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**Visual Perception and Behavior**

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**Visual Perception, Lighting and Floor Design**

The wide angle vision and poor depth perception of livestock partially ac-
counts for the animals' reluctance to cross shadows, drain grates and other high contrast objects. Lighting and flooring are, therefore, important elements to consider in the design of livestock handling facilities.

Experiments conducted with pigs, sheep and cattle indicate that illumination should be even and diffuse (Lynch and Alexander, 1973; Ralph, 1975). Shadows and bright spots can cause all species of livestock to balk, although cattle and sheep are the most seriously affected (Kilgour, 1976a). Fig. 2 shows pigs avoiding the shadow of fence rails. It has been observed in both cattle and sheep that the animals are reluctant to enter dark areas but will move toward an illuminated area (Kilgour, 1971; Shupe, 1978). The inside of a building should be well illuminated; however, bare light bulbs emitting harsh light should be avoided. Observations at large cattle handling facilities indicate that cattle are more easily forced into a dark building if the animals are lined up in single file before they pass into the building. In a slaughter plant where the cattle refused to enter the dark building from the bright daylit holding pen, the problem was solved by extending the single file lead up chute at least 15 ft (4.5 m) past the dark entrance out into the holding pens. This distance can be shortened for hogs or sheep.

Lynch and Alexander (1973) have suggested that livestock movements through a handling facility could be facilitated by illuminating areas in front of the cattle and darkening areas behind them. Since cattle will move towards the light in a darkened building (Ministry of Agriculture, 1957), a bright lamp installed over the stunning pen in beef slaughter plants can improve the accuracy of stunning. The light causes the animals to look up and thus hold their heads up. Stunning pen designs which allow light to shine under the discharge door at the floor level should be avoided as the cattle will almost always put their heads down toward the source of the light, making stunning very difficult.

Solid sunshades should be used in livestock handling areas to avoid the bright stripes of light on the ground. Slatted sunshades emit a zebra striped pattern of light which the animals will often refuse to cross. Alternating patterns of light and dark have such a strong deterrent effect on cattle that highway engineers in the western United States are able to prevent cattle from crossing highways by painting a series of stripes across the road, replacing the more expensive steel cattle guards. A livestock handling facility should be painted one solid color to avoid any disturbing contrasts, and stockyard drains should be placed where the animals will not have to cross over them. Sudden discontinuities in the floor level or texture are undesirable (Lynch and Alexander, 1973) and substantial downward slopes should be avoided in stockyards, crowding pens and single file chutes to the stunning area, especially in swine facilities (Kilgour, 1976b). However, a slight slope for drainage of 1/4 inch to the foot (2 cm perimeter) or less will not cause handling problems.

Cattle will often balk and refuse to pass under an overhead walkway or through a door if the entrance appears to be too low for their bodies. In one slaughter plant, cattle weighing 1000 lbs (450 kg) balked at the entrance door which was 6 ft (1.8 m) high. Taking photographs at the animal's eye level is a useful way to assess shadow areas and other obstacles. The pictures will reveal and duplicate what the facilities may look like to an animal with poor depth perception.

**Following Behavior**

Following behavior in cattle and sheep is related to the animals' strong instinct to maintain visual contact with each other (Kilgour, 1971). Cattle will stand at a 120° angle tangent to each other (Strickland, 1978); sheep will stand at 110° angle relative to each other (Crofton, 1958). This corresponds to the angle between the optic axis of the animals' eyes.
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A well designed facility should take advantage of the animals' natural following tendency (Hafez et al., 1969). Cattle and sheep more readily enter a facility or move through a narrow chute if they can see the animal ahead (Ewbank, 1961; Ralph, 1975; Shupe, 1978). The strong following instinct in cattle may cause two animals to jam together at the entrance to a restrainer conveyor or at the transition point between the single file leadup chute and the crowding pen. It is, therefore, of utmost importance that there be a smooth transition between the crowding pen and the single file lead-up chute to prevent bunching and jamming. Since the following instinct is strongest in sheep, the use of a Judas goat or a trained sheep is recommended to lead the animals into the slaughter plant (Kilgour, 1976a; T. Grandin, personal observation).

Swine display a less pronounced following instinct, but will follow a leader when that leader is an established member of the social group. Meese and Ewbank (1973) stated, "... groups of pigs which had been previously established before introduction to the site showed a greater proportion of leadership resulting in the whole group following than did groups which were unacquainted before introduction to the site."

Hafez et al. (1969) reported on a cattle study conducted by Beilharz and Mylea in 1963 that "...leaders of forced movements were low in the dominance order, whereas, leaders of voluntary movements tended to have higher social rank." Observations of cattle have indicated that the rough aggressive cattle tend to be the last animals to enter the single file lead-up chute from the crowding pen. Dove et al. (1974) reported that in Corriedale sheep the dominant members were farthest from the people during handling; the submissive sheep were the closest.

**Critical Distance**

Flight distance must be taken into consideration when cattle or sheep are being handled, although it is less important with pigs. Observations of cattle indicate that there is a 'critical distance' that a handler must maintain between himself and the cattle for the most effective movement. The critical distance is 5 feet (1.5 m) to 25 feet (7.61 m) for fattened cattle and up to 100 feet (30.5 m) for free-range cattle (Grandin, 1976a). Brahman breed cattle usually have a larger critical distance than English breeds.

The critical distance has been described as a "circle of safety" or flight zone around the animal (C. Williams, Livestock Consultant, personal communication). When a handler penetrates the flight zone the animal will move away. If the handler gets too close, the animal will turn back and run past the handler, or break and run from the handler. Conversely, when the handler retreats and moves out of the flight zone, the animal will stop moving. If the animals attempt to turn back, the handler should immediately retreat in order to increase the distance between himself and the animals before advancing again. Handlers should refrain from leaning over the single file shoot and deeply penetrating the animal's flight zone. This is a major cause of animals rearing up and jumping out of the chute. An animal will attempt to maintain the critical distance at all times; thus for the most efficient movement of livestock, the handler should position himself on the boundary of the flight zone (Figs. 3 and 4).
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Handling Groups

Groups of five to twenty head of cattle can be driven more easily with a minimum of excitement by a single handler if the handler is positioned at a 45° to 60° angle tangent to the shoulder of the leader rather than behind the animal (C. Williams, personal communication). When the handler, positioned on the boundary of the collective flight zone for the group, penetrates that boundary, both cattle and sheep will move in unison as each animal maintains visual contact with its neighbors. An experienced handler can keep a group of cattle moving by concentrating on moving the leaders.

Herd Behavior

Cattle and sheep are herd animals, and isolated individuals may become stressed and agitated (Ewbank, 1968). This is particularly a problem in Brahman type cattle. If a lone animal is left in the crowding pen after the other animals have entered the single file lead up chute, it may attempt to jump the fence and rejoin its herd mates. The lone animal may also become agitated and attack the handler. The majority of serious handler injuries occur when a lone steer or heifer charges. When a group of cattle is being walked up to the plant and one of the animals turns back and runs past the handler, another two or three head should be allowed to go back with it. It will be much easier and much safer for the handler to bring up three head than to attempt to drive up a lone, frightened steer. Moreover, the handler must be cautious not to penetrate the animal’s flight zone too deeply, especially if it is cornered in a confined area such as a crowding pen. With all types of livestock following behavior can be used to increase efficiency, reduce stress and facilitate the flow of animals. However, following behavior can create problems where balky, hard to handle animals follow each other in the wrong direction.

Separation from the herd is extremely stressful for both cattle and sheep. Lynch and Alexander (1973) reported an increase in leucocytes in the milk of a dairy cow who was left locked in her stanchion after her herd mates had moved elsewhere. Sheep which were handled individually for shearing or became isolated exhibited stress through higher heart rates (Kilgour, 1976a; Kilgour and de Langen, 1970).

Equipment Design and Behavior

Solid Fences

Stockmen have learned from experience that all species of livestock can be handled more efficiently with less excitement and stress if all the areas where the animals are crowded have high solid sides which prevent them from seeing people and other moving objects outside the facility (Fig. 5). Nontransparent plastic or burlap also gives the appearance of a solid wall and thus discourages break-out attempts and balking (Burnell, 1967; Oelofse, 1970). Livestock should not be able to see under, over or through the fence in the single file lead-up chute, in the crowding pen or in the holding lane prior to entering the crowding pen. Sheep moved more rapidly through a chute which had solid sides (Hutson and Hitchcock, 1978).

The solid fence ensures that only the handler will enter the animal's flight zone and avoids a situation in which the animals are driven towards a visible person (Kilgour, 1976b; Ralph, 1975). The solid sides also prevent the animals from seeing highly reflective or flapping objects which may cause balking (Shupe, 1978).

Cable fence is not recommended for any type of livestock handling facility and should be used only for pens which house animals on the farm. Excited animals in a strange environment are unable to see cable fence and are likely to run into it and injure themselves. Therefore, installation of a belly rail is recommended so that animals can see the fence. Gates in cattle stockyards should be solid to prevent ramming by the animals, and the pens should be constructed from substantial pipe.

Solid fences are recommended in all areas where animals are crowded during movement to the stunning area. It has been observed in both pigs and cattle that if the animals moving in the drive alley can see other animals in the pens, they will tend to stop and sniff at each other through the fence (T. Grandin, personal observation). In stockyards or in drive alleys where animals will pass in the opposite direction, the fence between them should be solid and high enough to prevent the animals from seeing each other. In crowding pens for sheep, pigs or cattle, the crowding gate should also be solid; otherwise, the animals will turn and face the gate instead of the entrance of the single file lead-up chute. Kilgour (1976a) reported that advancing sheep will turn back if they see the sheep behind them. The solid crowding gate also prevents cattle or sheep from seeing light through the gate and turning towards it.
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The principle of solid fences is akin to that of putting blinkers on a harness horse. The only thing the animals should see is the rear of the animal in front moving through the facility in the proper direction. However, animals must always be able to see a pathway of escape (Kilgour, 1976a). Livestock have often been observed refusing to enter a place which appears to be a dead end. Kilgour (1971) reported that cattle will stop 20 ft (6 m) to 27 ft (8 m) from the end of a dead-end alley and sheep will stop at 10 ft (3 m) to 14 ft (4 m). Therefore, solid fences or gates are not recommended at the entrance to the single file lead-up chute. These sliding gates and one-way gates should be constructed so that the animals can see through them to enable an approaching animal to see another animal in front moving down the single file chute.

There is one exception to the rule of solid fences in the single file lead-up chute for all species of livestock. If two single file chutes are placed side by side, the fence in between should be constructed from bars to enable the animals to see through it (Fig. 6). The natural following behavior will increase the flow of livestock through the lead-up chutes. However, outer fences should be solid to prevent the animals from seeing people or moving objects outside the chute.

Curved Chutes and Catwalks

A curved single file lead-up chute or wide curved holding lane is more efficient and minimizes excitement in all species of livestock (Grandin, 1977; Kilgour, 1971; McFarlane, 1976; Rider et al., 1974). The curved chute principle not only facilitates the natural following behavior of cattle and sheep but also has the advantage of preventing the animals from seeing the stunning pen until they are about to enter.

Personal observations indicate that a curved single file lead-up chute or curved wide drive alley should have a catwalk along the inner radius. This enables the animal to maintain visual contact with the handler; it also facilitates the animal's natural tendency to circle the handler. The catwalk should be alongside the fence rather than overhead to allow the animals to see the handler, especially in areas where animals are crowded. If the cattle or sheep cannot determine the location of the handler, they are more likely to scatter and mill around rather than move away from the handler in an orderly manner (C. Williams, personal communication). Where catwalks are required in the holding pen area for safety or insurance purposes (e.g., with wild cattle), they should also be installed alongside the fence lines.

Aroused Alarm Behavior

An excited animal often triggers a disturbance in a group which may be transmitted to all individuals (Crofton, 1958). Sheep form a more cohesive group than cattle and the entire flock may often react to a disturbance by bolting off to one side in a manner similar to a school of fish. Pigs will squeal an alarm call which triggers other pigs in the group to squeal and become agitated.

A disturbance may be caused by inept handling procedures or by a shortcoming in facility design. For example, handling facilities must be sturdy and feel solid to the animals; restraining chutes or restrainer conveyors should have solid sides that do not give when the animal moves. Moreover, equipment should have simple controls which maximize the chance of restraining the animals on a first attempt (Ewbank, 1961, 1968). It has been found that if one animal balks and refuses to enter a squeeze chute restrainer, the next animal in line will have a greater tendency to do the same (Grandin, 1975). Hence, the disturbance appears to disrupt the following behavior of the animals. Therefore, livestock handling equipment which is designed with behavioral principles in mind can help minimize excitement and reduce stress in the animals.

Prods

An electric prod, when used properly, is probably less stressful and more efficient than having the handler yell at or hit the animals to make them move. Electric prods should be used only in the single file lead-up chute to the stunning pen or restrainer and not in the stockyard or pen area. The battery-operated prod, which uses several thousand volts and practically no amperage, is the safest. It has two contact points which produce a localized shock on the animal's skin, causing the animal to move away from the shock. Livestock will often move readily when they hear the buzzing sound of a battery-operated prod without being touched by it due to prior conditioning on the farm or ranch.

In many slaughter plants, electric prods are wired to a fence charger or some other electrical source. One disadvantage of this type of system is that in order for the animal to feel the prod, the current has to ground out through its feet instead of passing through the two contact points on the skin. If the animal is wet, the current tends to make the animal tingle all over, thus blocking the directional stimulus.
The principle of solid fences is akin to that of putting blinkers on a harness horse. The only thing the animals should see is the rear of the animal in front moving through the facility in the proper direction. However, animals must always be able to see a pathway of escape (Kilgour, 1976a). Livestock have often been observed refusing to enter a place which appears to be a dead end. Kilgour (1971) reported that cattle will stop 20 ft (6 m) to 27 ft (8 m) from the end of a dead-end alley and sheep will stop at 10 ft (3 m) to 14 ft (4 m). Therefore, solid fences or gates are not recommended at the entrance to the single file lead-up chute. These sliding gates and one-way gates should be constructed so that the animals can see through them to enable an approaching animal to see another animal in front moving down the single file chute.

There is one exception to the rule of solid fences in the single file lead-up chute for all species of livestock. If two single file chutes are placed side by side, the fence in between should be constructed from bars to enable the animals to see through it (Fig. 6). The natural following behavior will increase the flow of livestock through the lead-up chutes. However, outer fences should be solid to prevent the animals from seeing people or moving objects outside the chute.

**Fig. 6**
Fences in two adjacent single file chutes are constructed from bars to facilitate following behavior. The outer fences should be solid.

Curved Chutes and Catwalks
A curved single file lead-up chute or wide curved holding lane is more efficient and minimizes excitement in all species of livestock (Grandin, 1977; Kilgour, 1971; McFarlane, 1976; Rider et al., 1974). The curved chute principle not only facilitates the natural following behavior of cattle and sheep but also has the advantage of preventing the animals from seeing the stunning pen until they are about to enter.

Personal observations indicate that a curved single file lead-up chute or curved wide drive alley should have a catwalk along the inner radius. This enables the animal to maintain visual contact with the handler; it also facilitates the animal’s natural tendency to circle the handler. The catwalk should be alongside the fence rather than overhead to allow the animals to see the handler, especially in areas where animals are crowded. If the cattle or sheep cannot determine the location of the handler, they are more likely to scatter and mill around rather than move away from the handler in an orderly manner (C. Williams, personal communication). Where catwalks are required in the holding pen area for safety or insurance purposes (e.g. wild cattle), they should also be installed alongside the fence lines.

**Aroused Alarm Behavior**
An excited animal often triggers a disturbance in a group which may be transmitted to all individuals (Crofton, 1958). Sheep form a more cohesive group than cattle and the entire flock may often react to a disturbance by bolting off to one side in a manner similar to a school of fish. Pigs will squeal an alarm call which triggers other pigs in the group to squeal and become agitated.

A disturbance may be caused by inept handling procedures or by a shortcoming in facility design. For example, handling facilities must be sturdy and feel solid to the animals; restraining chutes or restrainer conveyors should have solid sides that do not give when the animal moves. Moreover, equipment should have simple controls which maximize the chance of restraining the animals on a first attempt (Ewbank, 1961, 1968). It has been found that if one animal balks and refuses to enter a squeeze chute restrainer, the next animal in line will have a greater tendency to do the same (Grandin, 1975). Hence, the disturbance appears to disrupt the following behavior of the animals. Therefore, livestock handling equipment which is designed with behavioral principles in mind can help minimize excitement and reduce stress in the animals.

**Prods**
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The advantage of wired systems is that there are no batteries to replace. However, wiring the prods directly to house current (115 volts AC) is totally unacceptable. Wiring in a resistor such as a light bulb is also hazardous not only to the animals but also to people. If an animal bellows or squeals when touched by the prod, too much current is being applied and a step-down transformer should be used. In permanently wired prods, the voltage between the end of the prod and a perfect ground should not exceed 50 volts AC. The best prods use a transistorized power source of 5000 or more volts with less than 20 milliamps of current. The best tool for handling hogs in the stockyards and crowding pen is a canvass slapper, while cattle will move readily in response to a waving piece of plastic.

Handlers commonly make the mistake of prodding an animal when it has no place to go. When an animal balks after it has been prodded up to a closed gate, it will be more likely to balk when it is prodded up to the stunning pen or restrainer after the gate is opened. Inexperienced handlers often find it difficult to refrain from poking at livestock and are constantly prodding the animals to make them move up to the head of the line or to move less than an animal's length. This tends to make the animals balky or stubborn. A smoother flow is achieved if the handler waits until the single file lead-up chute has enough room for at least five animals before attempting to fill it from the crowding pen. This facilitates the animal's natural tendency to follow the leader. If the handler attempts to push only one animal in the single file lead-up chute at a time, the flow will be uneven and animals will tend to turn back and mill around the crowding pen. This principle applies to all species.

Electric prods should never be used to make animals back up. Prodding any type of livestock on the head or nose in an attempt to make the animal move in for at least five animals before attempting to fill it from the crowding pen. This facilitates the animal's natural tendency to follow the leader. If the handler attempts to push only one animal in the single file lead-up chute at a time, the flow will be uneven and animals will tend to turn back and mill around the crowding pen. This principle applies to all species.

Pen Dimensions and Behavior

Social Hierarchy

All species of livestock have a social hierarchy of dominant and subordinate animals (Hafez and Bouissou, 1975; Albright, 1976). Dominance hierarchies reduce conflict and establish an order for access to resting places, water and feed (Albright, 1976). When strange groups of cattle or swine are mixed together, the animals will fight to determine the status of each animal in the group from the most aggressive (dominant) to the most timid (submissive) animal (Symoens and Van den Brande, 1969). Unlike cattle and pigs, sheep do not fight to establish a dominance order. Although they do become stressed when mixed with strangers and will not integrate into a flock for weeks (Kilgour, 1976a; Winfield and Mullaney, 1973). Kilgour (1976a) states, "Though sheep will not fight, they will remain a separate entity even in small enclosures."

Conflicts which lead to fighting and stress can be avoided by keeping animals that have been raised together and, hence, recognize each other, housed together in separate pens. However, further research is needed to determine the optimal number of animals to place in each pen. The group has to be small enough so that the animals can recognize each other and maintain hierarchical relationships. Forty to 50 head of large steer appears to be a reasonably sized group to pen together (T. Grandin, personal observation).

Swine stockyards should be large enough to hold pigs from either three or four farms or small enough to hold a truckload from one farm. There tends to be more fighting among pigs mixed together from only two farms. Pigs housed together from 'multi' or 'single' farms tend to fight less than the 'two farm' pigs, although the question of how stressed the pigs are even with less fighting still needs to be answered.

Long, Narrow Pens

Research conducted on the social hierarchy of livestock indicates that the shape of a pen may be as important in reducing stress as the amount of floor space which is allotted to each animal (Kilgour, 1976b). Livestock which can spread out to increase the distance between individuals and accommodate their need for personal space are less likely to be stressed (Kilgour, 1976b). The concept of personal space has been described by Strickland (1978) as "a bubble-like force field which surrounds the animal. It may be thought of as a space-helmet type phenomenon which also exists in humans." When another individual gets too close, an animal will move away to prevent its personal space from being violated.

Observations on all species of livestock indicate that the animals have a more acute sense of personal space when standing or lying around the perimeter of a holding pen (Strickland, 1978). Pigs will actually fight over a spot near a fence when the entire center portion of a large pen is empty (T. Grandin, personal observation). Moreover, cattle prefer to stand or lie around the perimeter of a pen even when the sides of the pen are covered with plywood to prevent the animals from seeing out (Strickland, 1975).

Strickland (1975) compared square, round, triangular and rectangular pens and the relationship between floor area and the length of the perimeter fence. A triangle has a higher ratio of perimeter:area than a square, and a circle has the lowest perimeter:area ratio. The long, narrow rectangular pen has the largest amount of perimeter fence in relation to floor space. A 12 ft (3.5 m) x 80 ft (23.5 m) long, narrow pen has 960 sq ft (82.25 sq m) and a total of 184 lineal ft (52 ft) of perimeter fence, and a 31 ft (9.5 m) x 31 ft (9.5 m) square pen of approximately the same area has only 124 lineal ft (36.6 m) of perimeter fence. In a 12 ft (3.5 m) x 80 ft (23.5 m) long narrow holding pen, 18 animals would have at least 10 ft (3 m) of perimeter fence per animal, while in a square pen with the same amount of floor space, each animal would have less than 7 ft (2.1 m) of perimeter fence. Thus, a long, narrow pen more readily facilitates the 'personal space' requirement of livestock and reduces the incidence of fighting (Grandin, 1978a; Strickland, 1978).

Less fighting occurred among dairy cows when the feed bunks were placed along the perimeter fences instead of in the middle of the pen (C.W. Arave, Utah St. Univ., personal communication). Kilgour (1976b) also reported that oblong-shaped pens were superior to square pens for housing bulls. In a study conducted by Grandin (1978b), one group of steers placed in a long narrow pen 24 hours prior to slaughter had fewer dark-cutting carcasses than cattle placed in a square pen. When animals fight prior to slaughter, the incidence of dark-cutting beef or pale, soft exudative pork can increase (Grandin, 1978b). The animals in
**Review Articles**

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Animals
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because they facilitate one-way traffic flow and handling. Fig. 7 illustrates long narrow pens which have been built on a 60° angle to eliminate the 90° corner. Animals enter through one end and exit through the other.

**Fig. 7**
Long narrow diagonal pens for holding cattle.

**Round Pens**
The round pen system has been widely used for capturing wild horses in the western United States, capturing wild animals in Africa and handling large groups of sheep and cattle in Australia (Daly, 1970; Diack, 1974; Grandin, 1978c; Taber and Cowan, 1971; Ward, 1958). Round pens allow an excited animal to run in a circle without pile-ups in corners. The reduced length of perimeter fence in relation to the floor area in a round pen is an advantage for crowding pens which are used to direct the livestock to enter the single file cute to the stunning area. In a round crowding pen the animals tend to stay together in a cohesive group and circle instead of spreading out along a fence. The round crowding pen also takes advantage of the animal's natural tendency to circle the handler. Thus, the handler can move the livestock with less excitement, thereby reducing stress in the animals.

Round pens should not be used where animals are waiting prior to slaughter after they have been unloaded from the trucks. Animals in the holding pen need the security of an enclosure with a longer fence line where they can have their personal space.

**Behavioral Responses to Sound and Odor**

**Hearing/Sound**
Excessive noise can be stressful to livestock as well as to people working in slaughter plants and stockyards. The National Institute of Occupational Safety and Health (NIOSH) (1978) recommends 85 dB as the maximum level of noise per 8-hours for people. The current allowable noise level in factories for eight hour exposure is 90 dB. Louder noises can be tolerated for shorter periods of time.

Table 1 gives the decibel readings for common sounds. Cattle and sheep are more sensitive to high frequency sounds than humans. Studies indicate that the auditory sensitivity of cattle is greatest at 8000 Hz, while in sheep the greatest auditory sensitivity is at 7000 Hz (Ames, 1974). The human ear is most sensitive at 1000 to 3000 Hz.

**TABLE 1**

<table>
<thead>
<tr>
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<tr>
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From Peterson and Gross 1972 in Lipscomb (1978). This chart is based on sound measurements taken using the A frequency weighting function. The A-weighted sound level scale is the most commonly used for noise measurement (Lipscomb 1978). The decibel scale is logarithmic (does not increase in a linear fashion).

Sudden, loud 'impact type' sounds are particularly stressful and frightening to animals. Ames (1974) exposed sheep to three different types of sound at 75 dB or 100 dB. The sounds were white noise (a static hiss), instrumental music, and
the large square pen also appeared to be more active, presumably due to the larger amount of floor space per animal.

Long narrow pens are also a good design for slaughter plant holding pens because they facilitate one-way traffic flow and handling. Fig. 7 illustrates long narrow pens which have been built on a 60° angle to eliminate the 90° corner. Animals enter through one end and exit through the other.

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In a study conducted by Webb (1966), a boar exposed to a 120 dB recording of a thunderstorm crouched down, quivered and refused to move. Falconer and Hetzel (1964) reported that the sound of exploding firecrackers and barking dogs caused visible fright and an increased level of thyroid hormone in sheep.

Sudden noises that alarm or frighten the animal will usually result in alterations in heart beat (Ames, 1974). The ring of a loud outdoor telephone bell, for example, raised a calf’s heart rate from 50 to 70 beats per minute (T. Camp, USDA Experimental Station, College Station, TX., personal communication).

Soft background music is recommended for all types of livestock in the stockyards, while the volume should be increased as the animals approach the stockyard and stunning area. There, the music was just barely audible over the noise of the plant machinery which registered approximately 90 dB. The cattle heard music from the time they were unloaded from the trucks until they were stunned. Observations in the plant indicate that the cattle appeared to be calm when the music was playing, but that handling problems with balky or excited cattle occurred when the music system was not working. The plant slaughtered large numbers of Brahman and Brahman cross type cattle which tend to be more nervous and excitabla than English cattle. Plant employees speculated that the music sounded familiar to the cattle as they moved from the stockyards to the stunning areas and as a consequence reduced fear.

Another benefit of the music system is that it provides a better environment for the people working in the stockyards and the pens. The employees enjoyed the music and appeared to have a more positive attitude toward their jobs. This in turn helps to prevent the employees from venting their frustrations through abuse of the animals. Cattle appear to prefer instrumental music to loud rock and roll (Webb, 1966). However, in pig slaughter, Kilgour (1978) suggests a noisy environment to prevent the alarm call squeal of one pig from creating a disturbance throughout the entire group. Pigs are very vocal animals and communicate vocally to each other. Hence, the use of loud music may help mask alarm squeals. Pigs could perhaps remain calmer by listening to tape recorded grunts of contentment throughout the restrainer and stunning area. There is, however, a level where noise probably becomes stressful to pigs.

In cattle and sheep slaughter plants, noise should be minimized wherever possible. Balky cattle will refuse to move or will move away from noisy equipment. Lambs are also stressed by noise, but they will usually not move away from the source. Webb (1966) reported that Shropshire sheep appeared to be agitated by loud 120 dB noises of many types, but they would not move. Cattle moved away more readily from sounds which were pulsed two to four times per second than from a steady tone (Webb, 1966). Pigs, however, remained still and did not move away from the source of a pulsed tone at 120 dB.

All types of livestock react negatively to the sound of people yelling. A skilled, quiet handler who makes only a small "ssshh" noise can move more livestock per hour than a handler who yells. Yelling at cattle has the same effect as penetrating the animal’s flight zone too deeply (C. Williams, personal communication).

There are many areas in the slaughter plant and in the stockyards where noisy equipment should be silenced to reduce handling problems. In a study conducted by Grandin (1975), a motor driving a hydraulically actuated squeeze chute in a feedlot was located directly in front of the chute. As a steer entered the chute, it had to walk directly toward the noisy motor. Fifty percent of the cattle refused to enter the chute after one prod. When the motor was moved to one side, the incidence of backing dropped to 32%. Hydraulic equipment can also be engineered for sound reduction. All air operated equipment should be checked for leaks and supplied with mufflers.

Air leaks can cause balking problems. At one slaughter plant, cattle were observed refusing to walk past a certain point in the main drive alley due to a leak in an air line. At another plant, the air valve which operated the tail gate on the stunning pen hissed when the gate opened, causing the animal to back up in the single file lead-up chute. It is of the utmost importance that a stream of air from a valve does not blast in an approaching animal’s face. This will cause nearly 100% backing. The exhausts from hand air valves and solenoid valves should be piped outside if possible.

One-way gates in the single file lead-up chute should be counterweighted to close gently after the animal walks through. If the gate makes a loud clanging noise, the next animal in line will usually attempt to back up. Padding the stops on the gates with rubber prevents the noise of metal hitting metal. Shackle chain returns should also be equipped with rubber bumpers to reduce the sound of clanging metal. These modifications also prolong the life of the equipment.

Noise appears to be a major problem in all steel construction for livestock handling facilities. However, one advantage of steel construction is that changes or modifications to a steel chute or pen are easily made. Single file lead-up chutes and in-line tail gates are quieter, rustproof and better suited to plants that have no plans to modify the facility after it is built. Concrete or steel is recommended over wood for most new facilities. Proper construction, such as welded rather than bolted plates and sheets embedded in concrete can eliminate some of the noise. Coating metal with sound-damping material is also effective, but may be costly and require extra maintenance.

Smell

The sense of smell seems to be particularly acute in cattle. The smell of blood appears to disturb cattle, and they will often refuse to enter a stunning pen if there is blood on the floor. Keeping the blood washed out reduces problems with balky cattle. Cattle displayed a greater incidence of backing and refusing to enter a squeeze chute when an animal was being castrated (Grandin, 1975). The following animal stopped before entering the squeeze chute and sniffed the blood which had dripped on the floor. Slaughter plant employees report that cattle are often balky and refuse to enter the plant when the wind is blowing odors.
mucellaneous noises of roller coasters, trains and fog horns. Sheep exposed to the 75 dB levels gained weight faster during a feed trial than either the controls or the sheep exposed to 100 dB. The heart rate in sheep during exposure to the instrumental music was significantly lower than the heart rate in sheep exposed to white noise or the miscellaneous sounds, suggesting that soothing sounds reduce stress. The animals exposed to 100 dB appeared more stressed and had the lowest weight gains.

In a study conducted by Webb (1966), a boar exposed to a 120 dB recording of a thunderstorm crouched down, quivered and refused to move. Falconer and Hetzel (1964) reported that the sound of exploding firecrackers and barking dogs caused visible fright and an increased level of thyroid hormone in sheep.

Sudden noises that alarm or frighten the animal will usually result in alterations in heart beat (Ames, 1974). The ring of a loud outdoor telephone bell, for example, raised a calf's heart rate from 50 to 70 beats per minute (T. Camp, USDA Experimental Station, College Station, TX., personal communication).

Soft background music is recommended for all types of livestock in the stockyards, while the volume should be increased as the animals approach the noisy equipment in the stunning area. A large beef slaughter plant in the southwestern United States installed a music system which played throughout the stockyard and stunning area. The music was just barely audible over the noise of the plant machinery which registered approximately 90 dB. The cattle heard music from the time they were unloaded from the trucks until they were stunned. Observations in the plant indicate that the cattle appeared to be calm when the music was playing, but that handling problems with balky or excited cattle occurred when the music system was not working. The plant slaughtered large numbers of Brahman and Brahman cross type cattle which tend to be more nervous and excitable than English cattle. Plant employees speculated that the music sounded familiar to the cattle as they moved from the stockyards to the stunning areas and as a consequence reduced fear. Another benefit of the music system is that it provides a better environment for the people working in the stockyards and in the plant. The employees enjoyed the music and appeared to have a more positive attitude toward their jobs. This in turn helps to prevent the employees from venting their frustrations through abuse of the animals.

Cattle appear to prefer instrumental music to loud rock and roll (Webb, 1966). However, in pig slaughter, Kilgour (1978) suggests a noisy environment to prevent the alarm call squeal of one pig from creating a disturbance throughout the entire group. Pigs are very vocal animals and communicate vocally to each other. Hence, the use of loud music may help mask alarm squeals. Pigs could perhaps remain calmer by listening to tape recorded grunts of contentment. Another benefit of the music system is what it provides a better environment for the people working in the stockyards and in the plant. The employees enjoyed the music and appeared to have a more positive attitude toward their jobs. This in turn helps to prevent the employees from venting their frustrations through abuse of the animals.

In cattle and sheep slaughter plants, noise should be minimized wherever possible. Balky cattle will refuse to move or will move away from noisy equipment. Lambs are also stressed by noise, but they will usually not move away from the source. Webb (1966) reported that Shropshire sheep appeared to be agitated by loud 120 dB noises of many types, but they would not move. Cattle moved away more readily from sounds which were pulsed two to four times per second than from a steady tone (Webb, 1966). Pigs, however, remained still and did not move away from the source of a pulsed tone at 120 dB.

All types of livestock react negatively to the sound of people yelling. A skilled, quiet handler who makes only a small "ssshh" noise can move more livestock per hour than a handler who yells. Yelling at cattle has the same effect as penetrating the animal's flight zone too deeply (C. Williams, personal communication).

There are many areas in the slaughter plant and in the stockyards where noisy equipment should be silenced to reduce handling problems. In a study conducted by Grandin (1975), a motor driving a hydraulically actuated squeeze chute in a feedlot was located directly in front of the chute. As a steer entered the chute, it had to walk directly toward the noisy motor. Fifty percent of the cattle refused to enter the chute after one prod. When the motor was moved to one side, the incidence of backing dropped to 32%. Hydraulic equipment can also be engineered for sound reduction. All air operated equipment should be checked for leaks and supplied with mufflers.

Air leaks can cause balking problems. At one slaughter plant, cattle were observed refusing to walk past a certain point in the main drive alley due to a leak in an air line. At another plant, the air valve which operated the tail gate on the stunning pen hissed when the gate opened, causing the animal to back up in the single file lead-up chute. It is of the utmost importance that a stream of air from a valve does not blast in an approaching animal's face. This will cause nearly 100% backing. The exhausts from hand air valves and solenoid valves should be piped outside if possible.

One-way gates in the single file lead-up chute should be counterweighted to close gently after the animal walks through. If the gate makes a loud clanging noise, the next animal in line will usually attempt to back up. Padding the stops on the gates with rubber prevents the noise of metal hitting metal. Shackles chain returns should also be equipped with rubber bumpers to reduce the sound of clanging metal. These modifications also prolong the life of the equipment.

Noise appears to be a major problem in all steel construction for livestock handling facilities. However, one advantage of steel construction is that changes or modifications to a steel chute or pen are easily made. Single file lead-up chutes and metal in a building are quiet, rustproof and better suited to plants that have no plans to modify the facility after it is built. Concrete or steel is recommended over wood for most new facilities. Proper construction, such as welded rather than bolted plates and sheets embedded in concrete can eliminate some of the noise. Coating metal with sound-damping material is also effective, but may be costly and require extra maintenance.

Smell

The sense of smell seems to be particularly acute in cattle. The smell of blood appears to disturb cattle, and they will often refuse to enter a stunning pen if there is blood on the floor. Keeping the blood washed out reduces problems with balky cattle. Cattle displayed a greater incidence of backing and refusing to enter a squeeze chute when an animal was being castrated (Grandin, 1975). The following animal stopped before entering the squeeze chute and sniffed the blood which had dripped on the floor. Slaughter plant employees report that cattle are often balky and refuse to enter the plant when the wind is blowing odors.
from the plant toward the stockyards. (It may be that the unfamiliar odors cause the cattle to refuse to approach the source of the smell.) Sheep may also be disturbed by slaughter plant odors, but pigs appear not to be affected by either the smell or sight of blood and have been observed both eating blood and wallowing in it.

Some of the handling problems caused by the smell of blood and other slaughter plant odors could be reduced by designing ventilation systems which direct the odors away from incoming cattle. When a new plant is designed, the rendering plant should be located as far away from the stockyards as possible. Air curtains can also be used to block or divert odors.

Conclusions

Many of the recommendations in this review are relatively obvious, but it is clear that numerous slaughter plants either do not follow optimal handling practices or suffer from shortcomings in construction. Points which should be included in the planning of any new facility, or upgrading of existing facilities, are: 1) breeds to be handled; 2) visual factors; 3) pen construction; 4) chute construction; 5) handler training; 6) noise levels and types; and 7) odors. The answers cannot always be determined by reference to common sense, and more attention should be paid to researching into some of these questions.

References

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**Conclusions**

Many of the recommendations in this review are relatively obvious, but it is clear that numerous slaughter plants either do not follow optimal handling practices or suffer from shortcomings in construction. Points which should be included in the planning of any new facility, or upgrading of existing facilities, are: 1) breeds to be handled; 2) visual factors; 3) pen construction; 4) chute construction; 5) handler training; 6) noise levels and types; and 7) odors. The answers cannot always be determined by reference to common sense, and more attention should be paid to research into some of these questions.

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**REVIEW ARTICLES**


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**LEGISLATION and REGULATION**

**Horse Racing and Drug Abuse**

The Humane Society of the United States (HSUS) and the American Horse Protection Association (AHPA) have drafted legislation to curb the abuse of drugs in horse racing. The bill, which will be introduced in the House by Representative Bruce Vento (D-Minn.) in early 1980, proposes the following:

1. Prohibition of all pre-race administration of medications capable of affecting a horse's performance at the time of the race;
2. Prohibition of numbing an animal's legs with ice, dry ice or any other chemical agent on the day of the race, and elimination of the practice of permanent numbing through surgical neurectomy;
3. Establishment of uniform pre-racing inspection and drug testing programs;
4. Strict enforcement of penalties for persons convicted of wrongfully drugging or numbing a racehorse.

Drug abuse in the horse racing industry is a complicated issue. States vary in their interpretations of the question of when legitimate use grades into manipulation for profit at the risk of both horse and jockey. For example, phenylbutazone ("bute"), a potent anti-inflammatory with significant beneficial properties, is routinely prescribed to reduce pain and restore some degree of function to arthritic or otherwise inflamed joints in horses. However, by relieving pain, phenylbutazone permits the racing of a horse on an injured limb, which not only prevents healing but also aggravates the condition. Deprived of the warning signal of pain, whether through medication or physical means such as numbing, an unsound horse can race, do itself further injury, and in the most serious cases, break down on the track. According to a study by sportswriter Russ Harris, on-track breakdowns at Philadelphia's Keystone Racetrack increased 400% after the legalization of bute in Pennsylvania.

Other instances of drug abuse in horse racing involve the misapplication of a drug to mask disease or even confuse detection of illegal substances in the animal's system. Furosemide (Lasix) is a diuretic prescribed for the relief of hypertension in humans. Several states allow furosemide to be used for treatment of nosebleeds in racehorses, although the Food and Drug Administration (FDA) has never approved the drug for this purpose. HSUS field investigator Marc Paulhus explained that "nosebleed" is a misleading term for epis-taxis (pulmonary hemorrhage) induced by the stress of racing. Dr. George Maylin, of the Cornell University School of Veterinary Medicine, stated that in clinical trials, some, but not all "bleeders" respond to furosemide therapy. However, the exact pharmacological mechanism by which furosemide alleviates bleeding is unknown. Furosemide also increases urinary output, thus giving rise to the argument that administration of the drug leads to dilution of other chemicals (such as narcotics).