

Chapter 5: Guidelines for Beef Cattle Husbandry

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

FACILITIES AND ENVIRONMENT

Range and Pasture Systems

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

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

Special consideration needs to be given to environmental factors that affect grazing beef cattle. In areas where heat stress is common, provision of shade (preferably trees) to decrease the solar heat load is the most practical intervention in pasture and range systems. The need for artificial shade should be assessed after careful consideration of naturally occurring sources. Heat stress typically is evidenced by increased mean and amplitude of body temperature (Hahn, 1995). Decreased feed intake (Robertshaw, 1987) and changes in body weight and condition can be used as indicators to monitor prolonged heat stress of grazing livestock. In areas where exposure to extreme cold is likely, provision of shelter for grazing beef cattle may be

desirable. Grazing beef cows decrease grazing time and forage intake as ambient temperature decreases below 0°C (Adams et al., 1986), although such changes are small in adapted beef cows (Beverlin et al., 1989). Cattle use windbreaks to decrease wind chill and prevent exposure to blowing snow, although it has not been clearly established that windbreaks improve animal performance (Krysl and Torell, 1988). Supplementary feed is needed during periods of heavy snow cover that preclude grazing.

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

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

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

Feedlot and Housing Systems

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

Proper airflow and ventilation are essential in intensive facilities. In feedlots, cable or wire fencing has minimal effect on natural airflow in summer. However, high airflow

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

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

Sunshades for cattle can provide the margin of survival for animals that are unconditioned to a sudden heat wave (Hahn, 1995). Shades should be 3.6 to 4.2 m (12 to 14 ft) high in areas with clear, sunny afternoons (e.g., southwestern United States) to permit maximum exposure to the relatively cool northern sky, which acts as a radiation sink. In areas with cloudy afternoons (e.g., eastern United States), shades 2.1 to 2.7 m (7 to 9 ft) in height are more effective, as they limit the diffuse sky radiation received by animals beneath the shades. The amount of shade needed for young cattle is .7 to 1.2 m² (7.5 to 13 ft²) per animal, and larger cattle need 1.8 to 2.5 m² (19.4 to 27 ft²) per animal. Shades are strongly recommended for sick cattle or for animals in hospital pens. Under conditions of heat stress, water requirements of cattle are increased dramatically, and increased access to water should be considered.

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

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

front of the feed bunks and around water troughs and shelters should be considered in dirt pens.

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

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

Floor or Ground Area

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

Open feedlot pens need to be sloped to promote drainage away from feedbunks, waterers, pen dividers, and resting areas. Space allocations are related directly to slope. In temperate midwestern climates, the following relationships have been found to be workable (MWPS, 1987): 2% slope, 37 to 74 m² per animal (400 to 800 ft² per animal); 2 to 4% slope, 23 to 37 m² (250 to 400 ft²); and 4% or greater slope, 14 to 23 m² (150 to 250 ft²). Space allocations can be less in drier parts of the country. In the Southwest, at 0% slope, typical allocations are 14 to 23 m² per animal (150 to 250 ft² per animal). In other regions, space allocations may need to be increased above midwestern norms in consideration of such factors as soil type and rainfall distribution.

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

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

BEEF CATTLE HUSBANDRY

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

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

^aPrimarily based on MWPS (1987).

^bValues are on a per animal basis in a pen environment.

^cIn favorable (e.g. dry) climates, area accommodations may be less than indicated in this table.

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

Intensive Laboratory Environments

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

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

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

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

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

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

FEED AND WATER

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

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

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

SOCIAL ENVIRONMENT

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

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

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

HUSBANDRY

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

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

Dystocia Management

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

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

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

STANDARD AGRICULTURAL PRACTICES

Castration

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

It is strongly recommended that calves be castrated at the earliest age possible. Calves heavier than 230 kg should be locally anesthetized when surgical methods of castration are used or when the spermatic cords are crushed. There are several methods for castrating cattle, including surgical removal of the testicles using a knife or scalpel and cutting or crushing the spermatic cords with an emasculator or emasculator. Bloodless castration procedures utilizing specialized application instruments are acceptable for older animals; no advantage to use of anesthesia is apparent when such bloodless castration is practiced (Chase et al., 1995). Whatever the method of castration, the procedures

should be conducted by or under the supervision of a qualified, experienced person and carried out according to manufacturer recommendations and accepted husbandry practices (Battaglia and Mayrose, 1981; Ensminger, 1983).

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

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

Dehorning

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

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

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

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

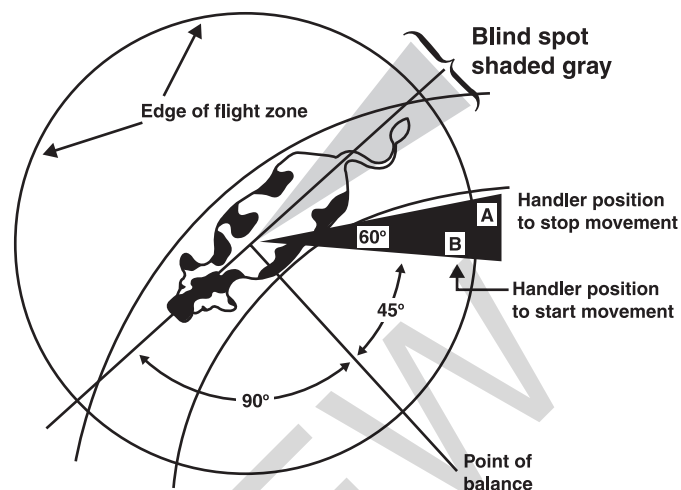


Fig. 5-1. Flight zone diagram showing the most effective handler positions for moving an animal forward. (From Grandin, 1993a).

HANDLING AND TRANSPORTATION

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

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

Cattle are sensitive to intermittent loud noises, high frequency, and hissing sounds. Sensitivity is highest at frequencies of 8000 Hz (Grandin, 1989, 1993a). Machinery or other items emitting high frequency noise, hissing sounds, or intermittent loud noise in cattle handling areas should be silenced or removed. Cattle possess panoramic vision (Figure 5-1), but they perceive depth poorly, especially when moving with their heads raised. Consequently, items that create sharp contrasts of light (e.g., shadows) cause balk-

ing (Grandin, 1989, 1993a, 1994). Also, cattle tend to move from a dark to a light area more easily. It is generally recommended that cattle handling facilities, such as crowding pens, chutes, races, ramps, and crowding gates, have solid walls to decrease balking. Loading ramps should have an angle of 20% or less and should provide adequate traction to prevent slipping and falling.

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

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

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

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

before they become debilitated, infirm, and weak can greatly decrease the incidence of downed cattle.

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

EUTHANASIA

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

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

REFERENCES

- Adams, D. C., T. C. Nelsen, W. L. Reynolds, and B. W. Knapp. 1986. Winter grazing activity and forage intake of range cows in the northern Great Plains. *J. Anim. Sci.* 62:1240-1246.
- AVMA. 1993. Report of the AVMA Panel on Euthanasia. *JAVMA* 202(2):229-249.
- Battaglia, R. A., and V. B. Mayrose, ed. 1981. *Handbook of Livestock Management Techniques*. Burgess Publ. Co., Minneapolis, MN.
- Beverlin, S. K., K. M. Havstad, E. L. Ayers, and M. K. Petersen. 1989. Forage intake responses to winter cold exposure of free-ranging beef cows. *Appl. Anim. Behav. Sci.* 23:75-85.
- Chase, Jr., C. C., R. E. Larsen, R. D. Randel, A. C. Hammond, and E. L. Adams. 1995. Plasma cortisol and white blood cell responses in different breeds of bulls: a comparison of two methods of castration. *J. Anim. Sci.* 73:975-980.
- Ensminger, M. E. 1970. *The Stockmen's Handbook*. 4th ed. Interstate Printers & Publ., Inc., Danville, IL.
- Ensminger, M. E. 1983. *Animal Science*. 5th ed. Interstate Printers & Publ., Inc., Danville, IL.

- Ewbank, R. 1993. Handling cattle in intensive systems. Pages 59-73 in *Livestock Handling and Transport*. T. Grandin, ed. CAB Int., Wallingford, Oxon, UK.
- Farm Animal Welfare Council. 1981. Advice to Agricultural Ministers of Great Britain on the Need to Control Certain Mutilations on Farm Animals. Farm Animal Welfare Council, Ministry of Agriculture, Food and Fisheries, Middlesex, UK.
- Fraser, A. F., and D. M. Broom. 1990. Cattle welfare problems. Pages 350-357 in *Farm Animal Behaviour and Welfare*. Bailliere-Tindall, London, UK.
- Fusco, M., J. Holechek, A. Tembo, A. Daniel, and M. Cardenas. 1995. Grazing influences on watering point vegetation in the Chihuahuan desert. *J. Range Manage.* 48:32-38.
- Grandin, T. 1989. Behavioral principles of livestock handling. *Prof. Anim. Sci.* 5(4):1-11.
- Grandin, T. 1991. Recommended Animal Handling Guidelines for Meat Packers. AMI, Chicago, IL. (Now located in Arlington, VA.)
- Grandin, T. 1993a. Behavioural principles of cattle handling under extensive conditions. Pages 43-58 in *Livestock Handling and Transport*. T. Grandin, ed. CAB Int., Wallingford, Oxon, UK.
- Grandin, T. 1993b. Handling facilities and restraint of range cattle. Pages 75-94 in *Livestock Handling and Transport*. T. Grandin, ed. CAB Int., Wallingford, Oxon, UK.
- Grandin, T. 1994. Solving livestock handling problems. *Vet. Med. (Oct)*: 989-998.
- Hafez, E.S.E., ed. 1975. *The Behaviour of Domestic Animals*. 3rd ed. Williams & Wilkins, Baltimore, MD.
- Hahn, G. L. 1995. Environmental influences on feed intake and performance of feedlot cattle. Pages 207-225 in *Proc. Symposium: Intake by Feedlot Cattle*. Publ. 942. Oklahoma Agric. Exp. Stn., Stillwater, OK.
- Holechek, J. L., R. D. Pieper, and C. H. Herbel. 1995. *Range Management-Principles and Practices*. 2nd ed. Prentice-Hall, Englewood Cliffs, NJ.
- Krysl, L. J., and R. C. Torell. 1988. Winter stress conditions in beef cattle. Nevada Coop. Ext. Fact Sheet 88-13. Univ. Nevada-Reno, Reno, NV.
- Loxton, I. D., M. A. Toleman, and A. E. Holmes. 1982. The effect of dehorning Brahman crossbred animals of four age groups on subsequent body weight gain. *Aust. Vet. J.* 58:191-193.
- Manser, C. E. 1994. The influence of factors associated with lighting on the welfare of farm animals. Report to the Farm Animal Care Trust. 49 pp.
- Mench, J. A., J. C. Swanson, and W. R. Stricklin. 1990. Social stress and dominance among group members after mixing beef cows. *Can. J. Anim. Sci.* 70:345-354.
- MWPS. 1987. *Beef Housing and Equipment Handbook*. 4th ed. MWPS, Iowa State Univ., Ames, IA.
- NRC. 1987. *Predicting Feed Intake of Food-Producing Animals*. Natl. Acad. Press, Washington, DC.
- NRC. 1996. *Nutrient Requirements of Beef Cattle*. 7th rev. ed. Natl. Acad. Press, Washington, DC.
- Prigge, E. C. 1976. Page 48 in *Castration time on feedlot performance and carcass evaluation*. The Stress Calf Study Group. Univ. California 15th California Feeders Day.
- Ramsay, W. R., H.R.C. Meischke, and B. Anderson. 1976. The effect of tipping of horns and interruption of journey on bruising in cattle. *Aust. Vet. J.* 52:285-286.
- Robertshaw, D. 1987. Heat stress. Pages 31-35 in *Proc. Grazing Livestock Nutrition Conference*, Jackson Hole, WY, July 23-24, 1987. Univ. Wyoming, Laramie, WY.
- Stricklin, W. R., and C. C. Kautz-Scanavy. 1984. The role of behaviour in cattle production: a review of research. *Appl. Anim. Ethol.* 11:359-390.
- Tennessen, T., M. A. Price, and R. T. Berg. 1985. The social interactions of young bulls and steers after re-grouping. *Appl. Anim. Behav. Sci.* 14:37-47.
- Wiepkema, P. R. 1985. Abnormal behaviours in farm animals: ethological implications. *Neth. J. Zool.* 35:279-299.
- Worrell, M. A., D. C. Clanton, and C. R. Calkins. 1987. Effect of weight at castration on steer performance in the feedlot. *J. Anim. Sci.* 64:343-347.