Chapter 8: Horses

Most horses are used for athletic competitions, companionship, or pleasure, but they also serve in a variety of agricultural and biomedical endeavors. Equine animals (horses, ponies, donkeys, and mules) are still commonly used as draft animals for plowing and transportation worldwide, especially by local communities (e.g., Amish) in the United States and among small-scale farmers in developing countries. Ranch horses are commonly used on cattle ranches and feedlots. Donkeys may be used to protect sheep and goats from predators while on pasture, and the biomedical industry uses equine animals, usually horses, for the production of antivenom serum, antibodies, and pharmaceutical products. For example, estrogens are extracted from pregnant mares' urine and used in the production of hormone replacement therapy for menopausal women.

Horses are commonly used in therapeutic riding programs for physically and mentally challenged people (Kaiser et al., 2006). In addition to research studies using equine animals to investigate questions pertaining specifically to this species, horses are used as models for human exercise physiology and aging (Malinowski et al., 2006; Gordon et al., 2007). The natural occurrence of metabolic disorders such as insulin resistance in horses mimic similar disorders in humans such that horses are used for research on the mechanisms and treatments of these disorders with human applications in mind (Hodavance et al., 2007). Whether horses are used for pleasure, work, teaching, research, or biomedical purposes, an appropriate and comprehensive level of animal care should be provided and implemented with all protocols.

FACILITIES AND ENVIRONMENT

Indoor Environment

Dimensions of indoor occupancy should be sufficient for a horse to make normal postural adjustments at will, unless the approved protocol requires otherwise. A reasonable area allowance in m^2 for a single horse is 2 to 2.5 times the height of the horse (at the withers) squared (Zeeb, 1981; Raabymagle and Ladewig, 2006), which permits essential movements, including lying down in sternal or lateral recumbency. Although horses can engage in slow-wave sleep while standing, rapid eye movement (**REM**) sleep occurs only when the horse is recumbent (Dallaire and Ruckebusch, 1974; Ruckebusch, 1975). Although the exact function and requirement needs of REM sleep may be unclear, the opportunity and space to experience REM sleep while in a recumbent position may be a consideration for suitable housing of horses.

Box stalls should be large enough to permit the horse to lie down, stand up, turn around, and roll (Table 8-1). A 3.7- × 3.7-m (12- × 12-ft) box stall should accommodate most light horse breeds. The recommended minimum area, including dimensions, for straight or tie stalls (including space for the manger) is shown in Table 8-1. General guidelines for metabolism stalls are given in Chapter 3: Husbandry, Housing, and Biosecurity.

Stall doors should be wide enough to permit the horse to safely enter and leave its stall comfortably. Stall doors should be either solid or made of material in which the horse cannot become entangled or injured. Stall doors may be sliding, hinged, or divided (Dutch). Divided doors allow the horse to have, in effect, a larger stall when it extends its head out, whereas closing of the top door will limit the visual field of the horse. Care must be taken when Dutch doors or stall guards are used so that the horse cannot reach light switches, electrical cords, or electrical outlets. Hinged or divided doors should be secured when open to prevent injuries or the blocking of adjacent alleys.

Suitable flooring materials for indoor stalls include rubber mats, artificial turf, packed clay, gravel, stone dust, asphalt, concrete, sand, and wood. Floor material should be selected for ease of cleaning and for sanitation, comfort, and safety of the horse. Slippery floors can lead to injuries and hard surfaces can cause lameness. Harder floorings require deeper bedding, especially for larger horses; the installation of rubber mats over the surface may be the best option. Concrete floors with a rough broom float surface that slope to a floor drain or exterior door are suggested for wash areas, alleys, and feed and equipment storage areas. Pervious concrete is an acceptable floor surface for wash areas as it will allow water to drain through the concrete and does not require an exposed drain. Pervious concrete does require specialized installation.

Table 8-1. Suggested dimensions of housing for horses and ponies used in agricultural research and teaching[1]

Area	m	ft
Indoor facilities		
Box stall: 1.8 m^2/100 kg (9 ft^2/100 lb) of body weight (BW)	3.7 × 3.7	12 × 12
Straight or tie stall, including manger: 0.82 m^2/100 kg (4 ft^2/100 lb) of BW	1.5 × 3.7[2]	5 × 12
Alleys, width		
Between rows of stalls	2.4–4.3	up to 14 ft
Behind rows of tie stalls	1.8	6
In front of rows of tie stalls	1.2	4
Outdoor facilities		
Run-in shed (per 1,000-lb horse; up to 2 horses)	3.3 × 3.3	11 × 11
Fencing height for		
Horses	1.4–1.8	4.5–6.0
Ponies	1.1–1.5	3.5–5.0
Outdoor pen (for single horse)	3.7 × 3.7	12 × 12
Pasture per horse	≥0.4 ha	≥1 acre

[1]Stall and pen sizes should accommodate normal postural adjustments of average-sized light breeds of horses.

[2]Lengths up to 3.7 m (12 ft) are used; length is measured from the manger front to the rear of the stall.

Stall design should allow for proper ventilation, which may assist in decreasing moisture or humidity levels and odors in the stall, and also provide better visual contact between horses and caretakers. An opening above the floor in walls and partitions sufficient in size to allow air movement will aid stall ventilation and can be closed with a removable filler strip. A variety of materials can be used between stalls to aid in ventilation such as steel rods, pipe, welded steel fencing, chain-linked fencing, hardwood slats, or comparable materials. Solid interior stall walls are suggested for housing stallions and for the walls of foaling stalls to prevent aggression by the postpartum mare toward horses in adjacent stalls (aggression that may be redirected toward her foal).

Ceilings, when present, should be made of a moisture-proof material, preferably one that is smooth with a minimum of exposed pipes and fixtures. Commonly, ceiling heights for stalls are 2.4 to 3.1 m (8 to 10 ft) to allow for adequate ventilation and safe confinement for the variety of different-sized horses. However, minimum ceiling height should be at least 0.3 m (1 ft) higher than the horse's ears when the head is held at its highest level and much higher in riding areas.

Windows or unglazed openings are recommended but not essential if adequate lighting and ventilation are supplied by other means. However, windows may provide visual contact between horses and may reduce some stereotypic behaviors associated with frustration of isolated horses such as weaving and head nodding (Cooper et al., 2000). A tip-out or removable window in each box stall aids lighting and natural (i.e., nonmechanical) ventilation in warm weather. The bottom of breakable stable windows should be at a height that is not vulnerable to kicking, and windows should be protected with metal bars or mesh to prevent breakage. Skylights or translucent panels in the roof are useful to let additional light into the barn area. Dutch doors in stalls may be used for windows and ventilation on exterior walls.

An alley should be provided between rows of stalls to allow room for horses to pass, handling feed and bedding, and manage manure; an alley located behind a single row of stalls or in front of a row of stalls allows for feeding horses and allows for people to pass safely. Alleys in horse barns should be wide enough for the horse to turn around, and if narrower, should have exits to larger areas at both ends. Alley doors to the outside may be overhead, swinging, or sliding and should be sized appropriately to the alleyway. A wider alley is suggested where Dutch doors permit horses to extend their heads into the alley and to avoid unnecessary contact with passing horses or people. The width of the alley should accommodate vehicles that deliver feed or remove waste and the movement of horses within the alley.

Horse facilities in tropical and subtropical climates have stall arrangements that are very open to the outside. Commonly used are shed row barns in which the stalls open to the outside under an overhanging roof. Added ventilation is encouraged by stall doors with openings to the floor and slatted or nonsolid stall walls. If barns without these features are used in these environments, these should be constructed to provide proper ventilation. Barns in tropical regions may have large stalls constructed with thick concrete block or well-insulated walls, very high ceilings, and extensive roof venting, unless complete climate control (air-conditioning) is planned.

Bedding. The type of bedding should be consistent with the comfort of the horse and proper sanitation. Acceptable bedding is any material that provides absorption and sound footing including wheat, oat, or rye straw, grass hay, dried pasture clippings, wood shavings or pellets, peat moss, sawdust, paper, shredded cardboard, and sand. Horses fed on the floor of the stall rather than from a feeder should not have sand bedding because they tend to ingest the sand and may suffer from intestinal impaction as a result. Bedding should be free of toxic chemicals or other substances that would injure horses or people. Black walnut shavings (Ralston and Rich, 1983), fresh cedar shavings, cocoa husks, and woods that have been pressure-treated have caused illness. Cocoa and cedar can also result in abnormal blood and urine profiles. Rubber mats alone may be used when the facility design or experimental or instructional protocol does not permit traditional bedding or for horses that are hyperallergic or suffering from respiratory diseases. Otherwise, absorbent bedding should be used over rubber mats.

Temperature and Ventilation. The horse can acclimate to subzero air temperatures, but benefits from the availability of simple structures such as a windbreak or a run-in stall to protect from wind and precipitation during winter months and from the sun during hot summer months. Newborn foals need more protection because of their relatively high lower critical temperature and their inability to regulate body temperature. Any enclosed building that houses horses should have a properly designed and maintained ventilation system. The purpose of ventilation during hot summer months is to aid in dissipating heat. Increasing the ventilation capacity during hot weather may be achieved by increasing the air velocity directly across the horse, usually by utilizing circulating fans and opening windows and doors. During winter months, proper ventilation helps with the control of moisture or condensation in enclosed buildings as well as decreasing the level of air contaminants such as dust, mold, pathogens, or gases (especially ammonia) that accumulate in enclosed buildings housing horses. Poor air quality inside stables may compromise the respiratory health of the horse, especially in the winter months. Supplemental heat may be considered with cold weather ventilation to improve the comfort of the horses and handlers, and insulation is recommended to prevent heat loss. Proper ventilation or the number of air changes per unit of time should be related to environmental temperature, humidity, atmospheric vapor pressure, total weight or stocking density of horses, and heat and water vapor production (from animals, equipment, and bedding) in the building.

Lighting. Lighting should permit adequate inspection of horses and be available during handling, feeding, or other activities involving horses. There is some evidence that total darkness in a horse barn should be avoided (Houpt and Houpt, 1988); it is recommended that windows or another light source be present at night to avoid injury. All lighting fixtures, electrical wiring, and switches should be recessed or otherwise protected against damage by or to the horses.

Noise. Horses are sometimes disturbed by sudden noises, and background white noise or music is often used to mask or habituate horses to unexpected sounds that might otherwise startle them.

Sanitation and Waste Disposal. Stalls should be cleaned as needed, usually daily, to minimize pests, keep horses clean and dry, and maintain the air suitably free of dust and odors, especially ammonia. Sloping floors in stalls and alleys are useful for drainage of urine and water. Gases may be emitted during storage and handling of manure and should be considered for human safety. A 450-kg (1,000-lb) horse produces about 24.5 kg (54 lb) of manure daily, plus spilled water, soiled bedding, and other waste. Although horse manure as deposited is composed of about 75 to 85% water, it is relatively dry to handle (MWPS, 2005). Horses should not have access to manure waste storage areas.

Outdoor Environment

Pastures, Paddocks, and Corrals. In general, horse pastures, paddocks, and corrals should provide a reasonably comfortable environment, including sunshade, windbreak, a firm surface upon which to rest, sufficient area for normal postural adjustments, and an enclosure that confines the horses safely and is free of trash, holes, and other dangerous objects but avoids unnecessary physical restraint. These outdoor accommodations also should provide for the biological needs of the animal (e.g., feed and water, exercise, reproduction if appropriate, and freedom to avoid contact with excreta).

The requirement of the horse for space in paddock and corral areas may vary considerably depending on environmental situations (e.g., soil type, climate, forage availability, and drainage), size and type of animals (ponies, light horses, or draft horses), and, in certain cases, temperament of the individuals in a group. The minimum area per horse in an outdoor pen should be suitable for normal postural changes, but a larger area per horse is suggested, especially for groups of horses. Continuous long-term maintenance of horses in the minimal area should be discouraged because it does not allow for sufficient exercise, especially for young horses. In wet or muddy conditions, dry areas should be available to allow horses to lie down. Tight spaces and sharp corners or projections should be avoided in the pens to reduce injury and the chance of dominant animals trapping subordinates. The pens should be cleaned as needed to ensure proper sanitation and pest control.

In temperate climates, horses may often be confined to paddocks or pastures without shelter other than that provided by terrain, trees, wind fences, or sunshades. However, shelters should be provided in very hot, very cold, or wet environments. The thermoneutral zone of horses has been estimated with the lower critical temperature at 5°C (41°F) and the upper critical temperature between 20 and 30°C (68 to 86°F) (Morgan, 1998). Depending on age, weight, feeding level, acclimatization status, and husbandry system, no additional shelter may be necessary. Still, in certain cases, bedding may be required to enable the horse to keep warm and dry. Sunshades or access to a ventilated stable should be provided in areas where summer temperatures reach 30°C (86°F) or higher if adequate natural shade is not available (Morgan, 1998).

In high traffic areas, there is a tendency for the formation of mud during wet seasons of the year. These areas can include gates, areas around waterers or feeders, and entrances to run-in sheds. To reduce the problems associated with mud, high traffic pads or alternatives are recommended.

Run-In Shed. The minimum sized shelter per horse is approximately the area of a box stall. As a general rule for the size of a run-in shed housing more than one horse, allow for 11.1 m^2 (120 ft^2) each for the first 2 average-sized horses and then 5.6 m^2 (60 ft^2) for each additional horse kept in the pasture or paddock. The

size, design, and number of shelters should allow all animals in the paddock to share the shelter(s) at any given time. Eaves located on the back wall of the shed may be opened to allow for additional ventilation. Drainage systems should direct water away from areas of heavy use (e.g., near feeders, watering troughs, run-in sheds, and shades).

Fencing and Gates. Guides to fencing dimensions and materials are available from the MWPS (2005), and other sources. Fencing may be made of various materials, including wooden posts and rails, solid boards, wire (including high tensile wire), metal pipe, plastic, rubber, and V-mesh or chain-link fencing. It is not necessary to paint or seal fences, except when the protocol requires it. Barbed wire fencing should be avoided particularly where horses are housed in close confinement. Fences should be constructed to avoid features injurious to horses such as sharp, protruding objects (e.g., nails, wires, bolts, and latches), and, if possible, narrow tight corners in which a horse can be trapped by a herd mate and possibly injured.

Fence heights for horses are given in Table 8-1. The bottom of fences and gates should be high enough above the ground or extend to the ground to prevent the horse from catching a leg or hoof under the fence or gate, especially when rolling.

Electric fencing may be used for horses under certain conditions such as pasture rotation. Electric fences may not be adequate under some environmental conditions such as areas with heavy snow accumulation. Electric fence controllers should have been approved by Underwriters Laboratories or other accepted testing organizations. Highly visible, conductive plastic tape of 3/4" to 1 1/4" width is an effective fence material to cross fence pastures or paddocks. Other electric fence materials can also be used but they need to be highly visible in nature.

Gates may be constructed of several different materials, including wooden boards, pipe, sheet metal, and wire. The height of gates should be similar to that of adjoining fences to discourage animals from attempting to jump over at the lower point. The width of gates should span the opening completely and not leave a space where an animal may get caught between the fence and gate. The bottom of gates, like the bottom of fences, should either extend to the ground or be high enough above the ground to prevent injuries. Gates should be hung so they swing into the pasture or paddock.

FEED AND WATER

Horses have evolved over millions of years as grazing animals, spending their days traveling long distances in search of water and feed, primarily highly fibrous forages of widely varying types. The horse's digestive tract is well adapted to this lifestyle, with a stomach and small intestine capable of efficient enzymatic breakdown and absorption of the digestible components of feeds. The large intestine, composed of the cecum and large colon, functions as a fermentation chamber in which microbes reside. These microbes receive their nutrition from the less digestible components of the digesta and anaerobically produce end products that are beneficial to the horse. Nutritional and management practices that allow horses to eat throughout the day, have freedom of movement, and allow socialization with other horses will enhance the horse's well-being (Clarke et al., 1990; Davidson and Harris, 2007).

Horses kept on farms in pasture settings, surrounded by their herd mates, generally thrive in an environment not much different from their evolutionary environment. Provided that feed, water, and shelter are available, horses do an excellent job of utilizing accessible feeds in a natural environment to meet not only their nutritional needs, but also their exercise and social requirements.

Research and teaching facilities as well as modern, urban society usually do not keep horses in natural pastoral settings, but instead keep horses most of the time indoors in individual stalls or small outdoor paddocks. These horses have little opportunity to exercise freely and are often fed a diet that is too nutrient-dense, requiring dietary limitation in feed intake. Equine obesity, laminitis, colic, and associated maladies may result from inappropriate nutritional programs and management practices utilized in the care of horses.

Digestive Physiology

The digestive tract of the horse classifies the horse as a nonruminant herbivore. The horse eats only plant materials but does not possess a rumen, one of the distinguishing features of ruminants such as cattle, sheep, and goats. However, the horse's large intestine (cecum and colon) has a rumen-like function, because it hosts a large population of microbes (primarily bacteria) that can anaerobically digest the components of the horse's diet that are not previously digested by enzymes in the stomach or small intestine. Digestion of these indigestible (sometimes called insoluble) carbohydrates provides nutrition to the microbes resulting in end products called volatile fatty acids, which are absorbed into the circulatory system and utilized by the tissues of the body. In horses maintained on all-forage diets, volatile fatty acids derived from microbial fermentation can provide the majority of the horse's total energy requirement.

The microbes of the large intestine perform optimally in a stable internal environment. Intermittent meals or bolus feeding, when improperly managed, can disrupt the microbial population hindgut of the horse and may result in large fluctuations in nutrients and by-products in the circulation and to the tissues, setting up potentially detrimental physiological conditions such as laminitis or colic. Thus, the daily management of nu-

tritional programs for confined horses is important to their health and welfare.

Horses housed inside or where they cannot graze should be fed and watered at least twice a day. More frequent feeding or ad libitum access to hay and water is preferred. For horses confined in areas where they cannot graze, roughage in the form of hay or other fibrous feedstuffs should be the main component of the diet as a dietary source of nutrients and bulk in the diet. Although a fiber requirement for the horse has not been determined, diets must provide adequate bulk for several reasons: 1) to maintain a more or less "full" digestive tract, 2) as a reservoir of water and to help buffer the chyme, 3) to maintain a constant environment for the microbes of the large intestine, 4) to reduce boredom in the stabled horse, lessening the incidence of stable vices such as cribbing, wood-chewing, tail-chewing, or ingestion of bedding, and 5) to approximate a more natural diet.

Feeding Recommendations

Horses should be fed so that they are neither obese nor too lean (Henneke et al., 1983). Body condition scores of 4 to 6 on a 9-point scale are considered average, although many horses exceed this and are still considered to be in good health. Horses that are not in appropriate body condition should be managed to allow body weight (BW) changes to occur slowly. Changes in energy intake should not exceed 10 to 15% per week in either direction. To increase BW, forage should be increased first before concentrates are added. To decrease BW, concentrate intake should be decreased before forage intake is reduced. A reduction in energy intake of the ration should be accomplished without decreasing total daily dry feed intake below 1.5% of BW.

To maintain normal body condition and health, horses should be fed to meet the current nutrient requirements (NRC, 2007) for their class using feeds that are high quality, palatable, and consistently available. Although nutrient requirements of individual horses may diverge from NRC recommendations, NRC requirements are an excellent starting place for meeting the nutrient needs of horses in different life stages.

Horses in different life stages and exercise regimens have different nutrient requirements. Total daily dry feed (hay and concentrate) consumption usually falls within a range of 1.5 to 3% of BW. The common types of hay for horses are legumes, grasses, cereal grains, or mixtures thereof. Hay is usually fed at the rate of 1% or more of BW for mature horses. However, no minimum amount of forage intake has been set for horses under various conditions with the existing data (NRC, 2007). Legume hays, usually alfalfa or clover, are generally higher in protein, energy, and calcium compared with grass hay. Horses can easily gain weight on free-choice quantities of legume hay, whereas grass hay or cereal grain hay (i.e., oat hay) can sometimes be fed ad libitum because of their lower nutrient content while adding fiber or bulk to the ration.

Concentrates are used to supply energy, protein, vitamins, and minerals to the ration. Concentrates can be fed at different rates, depending on the nutritional need, but care should be taken when total concentrate exceeds 1% of BW. Cereal grains such as oats, corn, barley, wheat, or milo are often supplemented as a source of calories in the diet and tend to be high in starch content. Elevated levels of starch in diets, however, have been implicated as causative for laminitis and other metabolic disorders in horses (Kronfeld et al., 2004). Supplemental fat, usually in the form of vegetable oil, is sometimes used instead of or with cereal grains to increase the caloric density of the diet. Generally, it is recommended that the oil content not exceed 10 to 15% of the total ration. Supplemental protein is often required for growing horses fed grass hay-based rations, and soybean meal is commonly added because of its palatability and high level of digestible protein. Vitamin and mineral supplements are frequently added to concentrate mixes to fortify the nutrient content of concentrates or the entire ration.

Most natural forages and cereal grains are deficient in salt. Because horses can also lose considerable amounts of salt through sweat, sodium chloride (NaCl, common salt) is often added to concentrates at rates of 0.5 to 1.0% or offered as a salt block or free-choice as plain, iodized, cobalt-iodized, or trace-mineralized salt.

Young horses, late-pregnant mares, lactating mares, and hard-working horses have the highest nutrient requirements. While growing, pregnant and lactating mares have greater protein, vitamin, and mineral requirements as well as energy requirements compared with adult horses in maintenance condition. The primary requirement of performance/athletic horses above maintenance is for increased energy. Often, somewhat higher needs for other nutrients are satisfied while the energy requirement is met. Geriatric horses may do better on rations with higher nutrient levels, similar to those for growing horses, perhaps because of diminished digestive or metabolic efficiencies. Details of nutrient requirements are presented in NRC (2007). In all cases, rations should be formulated with good-quality feeds free of contaminants, molds, and toxic weeds.

Rations should be of appropriate physical form. Hay should be relatively fine-stemmed, leafy, soft, and free of dust, mold, and foreign material. Concentrates should be dust free and not too finely ground. Complete pelleted diets are sometimes fed to horses, but at least some long-stem hay or pasture is recommended to increase bulk in the ration and to slow the rate of passage of feed through the digestive tract. Hard, crunchy pellets are consumed more slowly than soft, crumbly pellets (Freeman et al., 1990). However, horses with poor quality teeth and geriatric horses may benefit from softer pellets or the addition of water to pellets to form a mash consistency. Care should be taken to ensure that horses are not accidentally given feed formu-

lated for cattle that is supplemented with ionophores; horses are highly susceptible to illness or death when fed ionophores (NRC, 2007).

Pastures for Horses

Nutrient needs of horses on pasture may be provided from forages available in the pasture or by a combination of pasture forage plus supplemental feeding of roughage or concentrates.

During certain periods of the year, growth of forages may be greatly reduced or the forage may become less palatable and digestible, necessitating supplemental feeding. Also, it is important to consider the effect of the environment on energy requirements, which increase significantly during periods of cold, wet weather (NRC, 2007). At other times, depending on stocking rate, little if any supplemental feeding may be required. If supplemental feeding is required in pasture situations, fenceline mangers, buckets, or boxes may be used to allow feeding from the fence line. Multiple sites (buckets or boxes) are preferable to a single site to decrease the risk of injury during aggressive competition for feed. Salt should be available to horses on pasture, especially if the sodium content in the grasses and legumes of the pasture is insufficient to meet the horse's requirement. When horses are feeding only on pasture, the trace minerals known to be deficient locally may be added to the salt source or fed as palatable supplements.

If horses are expected to meet their nutrient needs solely from pasture, care must be taken to ensure that the pasture can indeed support their requirements. Pasture stocking density varies from 0.4 to 4 ha (1 to 10 acres) or more per horse, depending on the type, concentration, and growth stage of the forage and the season (Hintz, 1983). Good pasture management is required to optimize utilization of improved pastures. Care should include regular fertilization and clipping (mowing) of excess growth to increase the nutrient value and palatability and the control of parasites through manure removal or pasture dragging to break up the manure piles. Pastures should be inspected routinely for growth of unusual or poisonous plants (Kingsbury, 1964; Oehme, 1986), especially when pastures are overgrazed.

Feed Containers

Feed containers may be constructed of metal, plastic, rubber, concrete, wood, or any other material that is safe, sturdy, and cleanable. Hay may be fed from mangers, bags, nets, and racks or directly on the floor. Horses appear to prefer eating from the ground (Sweeting et al., 1985), and, in a properly cleaned environment, relatively little danger exists of parasite transmission although significant forage may be wasted. Eating in the head-down position facilitates drainage of the respiratory tract and minimizes inhalation of dust from feed. However, ground feeding of hay (especially outdoors in group feeding situations) usually results in hay wastage, and concomitant ingestion of sand from sandy soils can lead to impaction colic. Hayracks or feeders may be beneficial in minimizing hay wastage and the ingestion of sand.

Hayracks should be free of sharp edges and corners. The distance between the ground and bottom of the rack should accommodate a comfortable posture of the horses during eating when outdoors. Grain may be fed in buckets in the lower part of many hayracks or from separate troughs or boxes. Feed containers should permit the horse to insert its muzzle easily to the bottom of the container. Examples of acceptable dimensions of hay mangers and boxes have been published (MWPS, 2005). It is important to monitor feed containers daily to ensure that these are clean, free of moldy or wet feed, and not broken or damaged.

Freestanding hayracks may also be used for groups of horses. These racks may be placed away from the fence or adjacent and perpendicular to the fence, allowing them to be filled from the other side of the fence. Drainage away from the feeder should be provided to minimize mud during rainy weather. Alternatively, feeders can be placed on aprons constructed of rubber, concrete, or other all-weather surfaces. Hay also can be placed in a large, stable container placed directly on the ground. The container should be cleaned out and spilled or soiled hay removed regularly.

Creep feeders may be used for foals. These feeders may consist of an enclosure located in the pasture (usually near the hay manger) with openings too small for adult horses to enter, but large enough for foals to enter to allow feeding of rations formulated specifically for growing foals without competition from the adult horses. Creep feeders, like other feeders, should be clean, free of sharp protrusions, and in good repair, and the feed should be kept fresh.

Feeding space for horses has not been well defined and may vary considerably depending on the size, number, and temperament of the individuals that must eat from the same feeder simultaneously. Sufficient bunk space or feeding points should be provided to preclude excessive competition for feed. An extra feeding point (one more than the number of horses) reduces aggression toward and stress upon the lower ranking of horses in the dominance hierarchy. This extra feeding point is particularly important if the feed ration is restricted. Hay racks that provide 1 m (3.3 ft) of eating space per animal and a continuous opportunity for consumption are usually placed down the center or long side of the pen or paddock (MWPS, 2005). The feeding of concentrate should be avoided in large groups, unless the horses are separated into individual feeding slips areas with head dividers or stalls to reduce competition by dominant horses (Holmes et al., 1987). There should be enough space between individual concentrate feeders for group-fed horses to feed but with minimal aggressive behaviors (Motch et al., 2007).

Water

Clean water should be continuously available or made available ad libitum at least twice daily. The requirement for water depends on several factors such as environmental temperature, animal function, and diet composition. In general, mature horses in a moderate environment (20°C) require water in the range of 5 to 7 L/100 kg (5 to 7 quarts per 220 lbs) of body weight per day (NRC, 2007). A horse fed to maintenance in a thermoneutral environment may need 21 to 29 L (4 to 8 gal) daily, but a horse that is working and sweating or a lactating mare may need 50 to 100 L (12 to 25 gal) daily, especially in hot environments. Signs of dehydration are sunken eyes, skin that tents (remains compressed when pinched), and increased capillary refill time at the gums. Also, lack of adequate water may be a cause of colic.

If a natural water source is used, care must be taken to ensure that flow rate is sufficient in dry weather, water is not frozen in cold weather, and supplementary water sources are provided if necessary. Environmental concerns, however, are such that use of natural water sources should be discouraged. Watering devices used in pastures or corrals should be durable and require little maintenance. The water source should be clean and safe; water quality standards and guidelines for horses are provided in the NRC (2007) publication.

Water Containers. Waterers may vary from simple buckets to troughs or automatic drinking devices. Waterers should be free of sharp edges. Automatic waterers must be functional, clean, and able to be operated by the horses. Waterers that operate by a pressure plate pressed by the horse require several days for most horses to learn to operate them. Foals and horses with very small muzzles may not be able to operate these devices. Also, the noise of some waterers refilling may frighten some horses initially. It is wise to provide a water bucket near the waterer until the horses are observed to operate the water device.

Automatic waterers should be inspected daily to be certain that they are operating properly and are free of foreign material. Water troughs should be cleaned as needed to prevent algae or dirt from accumulating. It is recommended that waterers be heated to prevent freezing in cold weather because provision of warm water increases intake in cold weather (Kristula and McDonnell, 1994). Proper installation of heating devices is necessary to prevent electrical shock. A float or stick may be placed in a trough to allow birds and other animals that fall into the trough to escape. Waterers should be positioned in a manner to prevent horses from injuring one another. Several widely spaced waterers or a large water trough may be necessary in enclosures housing a large group of horses.

HUSBANDRY

Social Environment

Horses are social animals that interact based on a dominance hierarchy within a herd structure. Horses develop strong attachments to herd mates; the strongest bond is between a mare and her foal. Horses can adapt to different environments, from free roaming on large areas of pasture to being confined in individual stalls. When separated from a group, horses may display restlessness, pacing, and vocalizations. Chronic social deprivation or isolation is a factor affecting the incidence of some locomotor stereotypies such as weaving, stall-walking, and fence-line pacing (McGreevy et al., 1995; Cooper et al., 2000; Bachmann et al., 2003). Careful selection of the horses' social environment must be considered so as not to interfere with the research and teaching objectives.

Geldings may be housed with mares or broodmares and their foals without causing physical or behavioral indicators of reduced welfare (van Dierendonck et al., 2004). It is not recommended that more than one stallion be kept with a group of mares because aggression and play may result in injuries; often stallions are housed individually. Stallions should be housed and managed to reduce the potential for aggression, although they can be effectively managed in groups under certain circumstances (Christensen et al., 2002).

Social hierarchies remain stable over time, with dominant mares maintaining their status even after reproductive senescence (Feh, 2005). Aggression is common when unfamiliar horses are mixed and dominance relationships are uncertain. Biting and kicking can inflict serious damage during these agonistic interactions; for this reason, horses that are shod should be introduced into new herds with extra caution. In established groups, aggression increases when resources such as feed and space are limited (Heitor et al., 2006). In many facilities, horses are turned out as a group in pastures or paddocks during the day, but are placed in individual stalls when they are fed. This approach accommodates individual feeding and minimizes aggression. Introduction of an unfamiliar horse to a group should take place in daylight, when the horses can see the fences and caretakers can observe the horses to detect injuries or deprivation of feed, water, or shelter of individual horses. Compatibility between neighboring individuals in stalls may depend on temperament in addition to social rank (Morris et al., 2002; Lloyd et al., 2007). Aggression between neighboring stabled horses is often expressed as threats, bar biting, or kicking of the stable walls. These behaviors can result in injury and damage to the stable and are performed more frequently by mares than by geldings (Drissler et al., 2006).

Horses exhibit a wide range of behavior and temperament based on their breeding, training, age, sex, and past experiences. Horses are best managed with predictable routines. Horses respond favorably to positive

handling and can be acclimated to novel environments and procedures. A horse can be quite anxious when approached by an unfamiliar handler or while experiencing a novel environment or research procedure. Because horses have evolved as prey animals, their basic reaction to a threatening, painful, or stressful situation is to flee from the stressor. If a horse is confined or restrained during an unpleasant or novel situation, it is likely to fight using a variety of behaviors such as nipping, biting, kicking, rearing, or striking with a front foot. Visual contact with other horses is recommended to reduce the stress associated with isolation. Totally isolating, even for a few hours, a horse that previously lived in a group causes immune changes that may affect research results (Mal et al., 1991). There is little scientific information about auditory communication by horses and whether vocalizations affect the stress responses of neighboring horses. However, olfactory communication may be important for horses subject to novel environments or procedures.

Management

Observation and Daily Schedule. Horses should be observed carefully for health and well-being at least once daily. This observation can be done during feeding. Lack of appetite or other abnormal feeding behaviors are excellent indications of problems. Horses maintained in large pastures where daily feeding is not routine benefit from daily observation to ensure their health and well-being. It is particularly important to check and monitor water sources for adequacy.

Exercise. With proper husbandry, horses may be kept in an indoor stall for several months at a time if necessary, but those standing for prolonged periods in either box or tie stalls may develop edema of the lower limbs (stocking up) or abdomen, especially if pregnant. The frequency and duration of either controlled exercise or free time (turn out) has not been established by scientific studies for confined horses (McDonnell et al., 1998; Houpt and Houpt, 2000). Horses confined to box stalls should receive 30 min of free time (turn out) or 15 min of controlled exercise per day; horses in tie-stalls should be provided with more time for exercise. Behavioral problems such as stall walking, weaving, and cribbing are commonly thought to occur in confined horses. However, mares confined for up to 2 wk in tie-stalls for continuous urine collection were documented to exhibit fewer stereotypies than observed in the general population (McDonnell et al., 1998).

Grooming. Horses that are maintained in stalls are usually groomed daily. Horses maintained outdoors or in groups that have an opportunity to mutually groom each other and roll in clean dirt or grass do not necessarily require additional grooming. Horses that are maintained in dry lots that become muddy may require additional grooming to remove mud and fecal material.

Hoof Care. Routine hoof care is important to the health and well-being of the horse. Daily hoof care is recommended for horses maintained in stalls or tie stalls. Hooves should be inspected and cleaned using a hoof pick or hoof knife to remove fecal and bedding material to prevent the development of infections. Hoof growth should be monitored and hooves trimmed when the hoof wall becomes excessively long, cracked, or broken. In general, this will occur in about 6 to 12 wk, although the exact timing is highly variable. Trimming of hooves should be done by trained personnel, because improper trimming can result in lameness.

Teeth Floating. The upper and lower arcade of the horse's pre-molars and molars do not match. The upper arcade sets slightly outside the lower arcade. As a result, during the normal wear process, sharp points develop on the outside of the upper molars and the inside of the lowers. These points are extremely sharp and may result in irritation of the cheeks and tongue of the horse. The horse may turn the head sideways while eating in an attempt to relieve the pressure from the affected tissue or may slobber feed while eating. The teeth may be examined by running the index finger along the top of the upper gum line and then carefully lowering onto the outside of the upper molars. If sharp points exist, the teeth should be filed or "floated" with appropriate instruments (floats). The frequency of tooth floating is dependent on age, diet, housing, and environment. No standard recommendation can be made; however, horses that appear unthrifty, slobber feed, or exhibit other abnormal eating behavior should have their teeth examined and treated if needed. In general, very young and old horses require more attention to oral health programs and dental care.

Preventative Health Care. Certain equine diseases are endemic and of concern in protecting the health of horses. The major diseases that horses should be vaccinated against are Eastern equine encephalitis (EEE), Western equine encephalitis (WEE), and tetanus. In certain areas of the United States, Venezuelan equine encephalitis (VEE), West Nile virus, rabies, botulism, and influenza may be significant risks that should be considered in development of a vaccination program. Appropriate vaccination schedules should be developed in consultation with the attending or facility's veterinarian. Additionally, when indicated or through state or federal regulations, disease monitoring and surveillance programs should also be developed and implemented.

Parasite Control. Control of internal and external parasites is extremely important in most horses. Factors that affect internal parasite load include concentration of horses, age of horses, size and type of enclosures, environment, and sanitation and other management procedures. The major internal parasites that can severely affect horse health include, but are not limited to, large strongyles (*Strongulus vulgaris*), small strongyles (40 species), ascarids (*Parascaris equorum*),

bots (*Gastrophilus intestinalis*), and pinworms (*Oxyuris equi*). Regardless of load factors, however, a program of screening, and treatment with an appropriate anthelmintic should be implemented. The class of drug used and timing of treatment varies with type of internal parasite targeted and the exposure load. Consultation with the attending or facility's veterinarian is recommended.

External parasites are generally less important than internal parasites but can affect the horse's health if present in sufficient numbers. Ticks, lice, and mites are the most common external parasites and can be easily detected and controlled with an appropriate drug, in consultation with a veterinarian.

Flying Insect Control. The 2 most common flying pests are flies and mosquitoes. The stable fly and the house fly are the most common species of flies. House flies are primarily a nuisance as these lack biting mouthparts, but they can be present in sufficient numbers to negatively affect the comfort of horses. Stable flies, deer flies, and mosquitoes do present a significant risk of disease transmission because they have biting mouthparts and feed on blood. They can serve as transmission vectors of blood born diseases such as equine infectious anemia (EIA).

Control of flying insects begins with sanitation. Manure, wasted feed, consistently wet areas, and standing water provide excellent breeding areas for flying insects and should be managed accordingly. Elimination of insect breeding areas to the extent possible should be of primary concern. If sanitation does not provide sufficient control, use of other methods may be required. Fly traps, fly baits, use of pyrethroids (synthetic or natural), use of lavacides on standing water, and release of parasitic wasps are all acceptable methods of controlling flying insects. Prolonged use of chemical treatments may result in resistant populations of flying insects. An integrated pest management approach to control is preferred.

Foaling Management. Mares can be managed extensively or intensively during the foaling process. Parturition in mares is normally uneventful. In multiparous mares, the process often occurs in less than 30 min. However, when problems occur, they require immediate attention and action. As a result of an artificially manipulated breeding season, many mares foal in January, February, and March when the weather in many parts of the United States is less than ideal. If extremely cold weather exists, foaling inside is preferable. Indoor foaling stalls should be larger than the normal box stall and easily accommodate the ambulatory movements and lateral recumbent positions of the mare during parturition, and subsequently provide ample space to avoid injuries for the mare and her foal. In more temperate weather, foaling outside is acceptable. An important consideration is that the enclosure used is free from objects that could injure the mare or foal if they lie down or fall. The walls of the stall or fence (in the case of an outdoor paddock) should be constructed such that the mare's legs cannot become entangled when she lies down to foal.

Most mares foal after dark. Mares should be grouped by expected foaling date and observed closely at the evening feeding. The presence of a waxy substance on the end of the teats may be indicative that the mare is within 24 to 36 h of foaling. Maiden mares, however, may not exhibit this classic sign. The onset of parturition is signified by strong abdominal contractions followed by presentation of the water bag. Once the water bag breaks, the foal's front hooves should be visible with the soles of the hooves pointed downward (toward the mare's legs). The foal's nose should be positioned on top of the front legs just above the fetlocks. Any presentation other than described here is an indication of a malpresentation and is cause for concern. If the foaling attendant(s) is(are) not experienced in handling emergency obstetric situations, a qualified veterinarian or his/her designee should be called immediately.

If the presentation of the foal is normal, the mare should be left alone until the foal has been delivered and the umbilical cord has been broken. The umbilical stump should be treated with a tincture of iodine to prevent introduction of pathogenic bacteria into the foal's body. The foal should be allowed to stand and nurse on its own without interference. This process allows the mare and foal to recognize each other and to bond. This process can take an hour or more. If the foal has not stood and nursed within 2 h, assistance may be required. At 8 to 12 h post-foaling, the foal can be tested for the presence of antibodies absorbed from colostrum. There appears to be good correlation between the concentration of antibodies from colostrum and the health of foals during the first 6 wk of life. If the mare does not produce adequate colostrum, frozen colostrum may be available from large breeding farms, but feeding colostrum to the foal more than 12 to 24 h after birth is ineffective. In cases of a failure of transfer of passive immunity from colostrum, transfusion of plasma from hyperimmunized donors may be advisable.

Mares should be observed for the passing of the placenta, which should occur within the first couple of hours post-foaling. Retention of the placenta by the mare more than 3 h post-foaling is considered a medical emergency. A qualified veterinarian should be called to assist in resolving the situation. Endometritis, septicemia, and laminitis are common secondary occurrences when a mare retains the placenta.

Breeding Procedures. Pasture breeding, natural cover, and artificial insemination are all appropriate methods of breeding mares. All can result in acceptable conception rates. Pasture breeding requires the least intensive management. The pasture needs to be of an appropriate size so that submissive mares can retreat from dominant mares or the stallion. Also, there should not be breeding horses in adjacent areas. Natural breeding and artificial insemination require additional management skills and should only be attempted by personnel who

are appropriately trained and understand the behavioral characteristics of both stallions and mares during the breeding season. Although the breeding of mares is not a sterile procedure, proper hygiene should be observed during artificial insemination procedures. All equipment should be kept clean and in good repair, and facilities should be constructed such that risk of injury to horses and personnel are minimized.

Restraint. Proper restraint of horses is an important management skill that is critical to the health and well-being of both the handler and the horse. Restraint can be as simple as putting a horse in a pen to restrict its range of movement to as complex as the use of chemical restraint to perform a surgical procedure. As a general rule, the handler should use the minimal amount of restraint necessary to perform the procedure. Regardless of the restraint used, it should be correctly and appropriately applied. Below is a list of acceptable restraint methods and a description of the proper application of each.

Pens: Pens should be constructed of material that is of sufficient strength to contain the horse. Material should be smooth with no sharp points or edges. Pipe, smooth cable, PVC fencing, wooden planks, and woven wire are all appropriate materials.

Stalls: Stalls should be constructed of material that is of sufficient strength to contain the horse. The lower part (0.9 to 1.1 m; 3 to 4 ft) should be of solid construction such that the horse's legs cannot become entangled. Wood planking, metal sheeting, and concrete are all appropriate materials.

Halters: Halters may be constructed of rope, nylon webbing, synthetic materials, or leather. These should fit tightly enough that the crown piece will not slide down the neck but be loose enough that the horse can chew comfortably. It is not recommended that horses be turned loose in a pasture or stall with a halter on unless the halter is made such that it will break away should the horse become entangled. If a horse is to be tied with a lead rope attached to the halter, there are several factors that must be considered: 1) the horse should be tied at wither height or above; 2) a slip knot that can be untied easily should be used; 3) the horse should be tied to something that will not become detached or move; and 4) there should be no objects in the immediate area that could injure or entangle the horse.

Front Foot Hobbles: Front foot hobbles are a traditional form of restraint used to allow horses to graze on the open range without running off. If used, hobbles should be constructed of leather or soft cotton rope. These are applied to the front feet only and should only be used on horses that have been trained to them. Horses that have not been trained to hobbles may have a violent reaction to them when first applied. Front foot hobbles should not be applied in confined spaces where the horse may be injured by running or falling into a fence, wall, or other object.

Sideline or Breeding Hobbles: Sidelines or breeding hobbles are used to prevent a horse from kicking with the hind legs. As the name implies, they are used to protect a stallion when mounting a mare during breeding or during collection for artificial insemination. These are sometimes used to restrain the horse when trimming feet or when training a horse for riding. Hobbles should be constructed of leather or soft cotton rope to prevent abrasion injuries during application. Horses that have not been trained to sidelines or breeding hobbles may have a violent reaction to them when first applied. These should not be applied in confined spaces where the horse may be injured by running into or falling into a fence, wall, or other object.

Leg Straps: Leg straps are used to hold one front leg off the ground by flexing a front leg and placing the strap around the forearm and cannon bone. Leg straps are applied by trained individuals primarily to keep the horse from moving forward and encourage them to stand still. The strap should be made of leather or soft cotton rope to prevent abrasion injury. Horses that have not been trained to leg straps may have a violent reaction to them when first applied. These should not be applied in confined spaces where the horse may be injured by running into or falling into a fence, wall, or other object.

Twitches: Twitches are used to immobilize horses for procedures where movement of the horse prevents the accomplishment of the task. Twitches are generally applied to the upper lip of the horse and then tightened. This usually results in the horse standing immobile despite even moderately uncomfortable procedures such as rectal palpation or insertion of nasogastric tubes. Twitches come in many types from the so-called humane twitch constructed like a large pair of smooth pliers to wooden handles with rope or chain attached to the end. Regardless of the type, the upper lip is grasped and placed in the loop of the twitch, which is then tightened by clamping or twisting. When used correctly, twitches are a safe and effective method of restraint that often can be used in lieu of chemical restraint. When used incorrectly, twitches are dangerous to both the horse and the handler. Horses often have a violent reaction to twitches when they are improperly used.

Chemical Restraint: Surgical or other procedures that require chemical restraint should be performed only under the advice or supervision of a veterinarian. Improper application of chemical restraint can result in injury or death of the horse and presents a safety hazard to the handler.

STANDARD AGRICULTURAL PRACTICES

Identification

Permanent identification of individual horses may be done by hot or freeze branding, insertion of microchips, or lip tattoos. Proper restraint, physical and/or chemical, should be used to ensure proper application of the brand and to safeguard the handler and horse during the process. The resultant wounds should be monitored for infection (Lindegaard et al., 2009). For microchip insertion, tranquilization is usually not necessary but numbing the insertion site with lidocaine may be indicated. The insertion site midway between the poll and withers in the nuchal ligament should be clipped and surgically scrubbed before insertion to prevent infections. Lip tattoos are traditionally done on the inside surface of the upper lip and do not require chemical restraint.

Castration

Castration may be performed on horses at any age from a few weeks to many years of age. Surgical castration is performed with the horse standing or in recumbency. Anesthesia, provided by a licensed veterinarian, is essential at all ages. Horses should be carefully monitored post-surgery for infection or herniation of bowel through the castration site. Appropriate analgesia may be provided by a licensed veterinarian for use following castration surgery.

Exercise and Equipment

Harnesses, saddles, or other equipment necessary for research and teaching purposes should be properly fitted for each individual horse, such that the equipment does not cause uneven pressure or injury, or rub sores. Horses being exercised should be offered water at regular intervals, and the duration of actual work should take into account climatic condition, fitness of the horse, and physical demands.

Pain and Distress

Chronic signs of pain or distress in horses include lameness, weight loss, hair loss or open sores, loss of appetite, repeated flight attempts or aggression, and depression. Acutely painful or stressed horses may show elevated heart and respiratory rates, inappropriate sweating (not heat or exercise induced), repetitive rolling on the ground, groaning, teeth grinding, pinned ears, clenched jaw, restlessness, tucked-up posture, and other signs of abdominal pain (Kaiser et al., 2006; Mills et al., 2007). Common causes of pain and distress in horses include social isolation, lack of adequate feed or water, improperly fitting harness or equipment causing pressure or friction, improper handling or restraint, prolonged transportation (Stull et al., 2004), and repeated invasive research procedures such as venipuncture, intravenous catheterization, and muscle biopsies.

ENVIRONMENTAL ENRICHMENT

Refer to Chapter 4: Environmental Enrichment for information on enrichment of horse environments.

HANDLING AND TRANSPORT

Refer to Chapter 5: Animal Handling and Transport for information on handling and transportation of horses.

EUTHANASIA

Personnel who perform euthanasia of horses must be trained in the appropriate protocols, humane handling and restraint techniques, and knowledgeable about safety concerns associated with each euthanasia method. Euthanasia of horses can be performed using the intravenous administration of pentobarbital or a pentobarbital combination, gunshot, or captive bolt gun. Pentobarbital is a substance controlled by the US Food and Drug Administration; thus, a veterinarian must be registered through the US Drug Enforcement Agency for its use. Usually a catheter is placed in the jugular vein to facilitate the large volume of solution that must be used. Barbiturates administered too slowly or in insufficient amounts may cause sudden or violent falling and thrashing of the horse. Thus, the use of sedatives or tranquilizers (e.g., xylazine, detomidine, or acetylpromazine) before the intravenous administration of pentobarbital can provide a more controlled recumbency process, which also may be safer for the personnel handling the horse. However, the use of sedatives and tranquilizers before administration of pentobarbital may prolong the time to unconsciousness because of their effect (i.e., bradycardia, hypotension) on the circulatory system (AVMA, 2007).

In emergency situations, or if the use of drugs is contraindicated for any reason, a gun or a penetrating captive bolt gun may be used by trained personnel. For gunshot, a 0.22-caliber long rifle is recommended, but a 9-mm or 0.38-caliber handgun will be effective for most horses. The optimal site for penetration of the skull is one-half inch above the intersection of a diagonal line from the base of the ear to the inside corner of the opposite eye. Personnel must comply with laws and regulations governing the possession and discharge of firearms; local ordinances may prohibit the discharge of firearms in certain areas. A penetrating captive bolt gun fires a blank cartridge that propels a steel bolt into the brain, producing immediate brain destruction.

Proper selection of the cartridge strength should be appropriate for the size of the horse and varies between manufacturers. The site of entry for the projectile is the same as for gunshot. Because the captive bolt device must be held firmly against the area of penetration on the head, horses must be adequately restrained. The advantage of a captive bolt procedure is that is does not fire a free bullet, and therefore may be safer for personnel.

Confirmation of death is essential using any euthanasia method. The horse should be checked for at least 5 min to confirm death by monitoring its vital signs. Death is confirmed by the lack of breathing, heartbeat, and corneal reflex. Additional euthanasia procedures should be initiated if there is any evidence of responsive vital signs.

Carcass Disposal

When practical, choose a location for euthanasia procedures where the carcass can be removed easily by equipment. Animal carcasses should be disposed of promptly, usually by a commercial rendering company or other appropriate means (burial, land fill, incineration, or possibly composting or biodigestion) in accordance with all federal, state, and local regulations. Some local regulations may not allow burial, and rendering services may not accept carcasses containing pentobarbital or other medications. Limit the access of carcasses to scavenging animals, because residues of pentobarbital may remain in the carcass.

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