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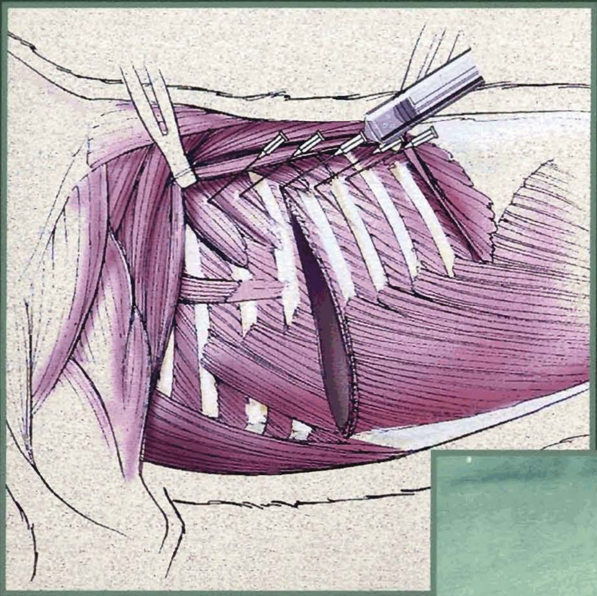

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Feeding Equine Athletes*

FOCAL POINT

A visual and palpable estimation of stores of body fat, indicating the body condition score of a horse, is more pertinent than body weight in maintaining proper nutrition of performance horses.

KEY FACTS

- Hay or grass should not be restricted before long rides; forage may provide a major source for energy, water, and electrolyte reserves for prolonged exercise or endurance events, p. 176.
- Increasing the energy density of feeds by adding dietary fat may decrease the chance of fermentation-related digestion disorders and myositis, p. 177.
- Utilizing fat as a substrate spares the muscle and liver glycogen stores, which delays the onset of fatigue in exercising horses, p. 177.
- Horses fed excessive protein sweat more and have higher heart and respiratory rates during endurance work than do horses fed appropriate amounts of protein, p. 178.

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Physiologically, horses are apparently adapted to eating throughout the day. They may spend as many as 12 hours a day grazing if unattended. In the process, they satisfy a psychologic need to feel satiated and facilitate the efficient functioning of the digestive system. A diet of high-quality pasture and/or hay fulfills the daily nutritional requirements of most athletic horses. As the intensity or duration of exercise increases, however, more feed or feed with a higher energy density is required. An increase in the frequency of feeding with improved hay or forage quality will satisfy an increased energy demand.

There are considerable differences in the types of athletic events that horses are required to perform. Racehorses sprint from approximately 0.25 mile to more than 1.25 miles. In a single event, an endurance horse may travel 35 to 100 miles. Horses also perform in dressage, driving or pleasure shows, and other events. Because of this wide variation in activities, it is difficult to make specific dietary management recommendations that apply to all performance horses. This article thus provides an overview of the nutrition and feeding of adult equine athletes.

DETERMINATION OF BODY CONDITION

A visual and palpable estimation of body fat stores, indicating the body condition score,[1–4] is more pertinent than body weight in determining proper nutrition of performance horses. Energy recommendations for performance based on body weight are extremely variable, as are estimates of body weight. In estimating the weight of horses, 91% of 62 veterinarians (with an average of 21 years in equine practice) underestimated body weight by an average of 192 pounds (18%).[1] Similarly, 81% of 191 owners underestimated the weights of their horses. Even years of experience with horses apparently does not ensure the accuracy of weight estimation.[1]

Body condition score, not body weight, should be the basis for assessing long-term nutrition in recommending a feeding regimen. For maximum athletic or reproductive performance and health, the goal of a feeding program should be to attain and maintain the ideal body condition of the horse.

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FEEDING TO MEET ENERGY REQUIREMENTS

The first step toward determining whether the energy demands of a horse are being met is to examine the horse. The level of nutrition is probably adequate if the horse is sleek but not skinny, the coat shines, and the horse works with vigor and eagerness. If, however, the haircoat and attitude are dull, it may be necessary to adjust the diet to suit the nutritional needs of the horse.

Table I presents the energy requirements of a mature, 500-kg horse for maintenance and for performance at various exercise levels.[5] As a practical rule, 1.5 to 2.0 pounds of high-quality hay per 100 pounds of body weight will meet the basic daily maintenance needs.[4–6] This amount varies slightly according to the energy content of the hay; the basal metabolic rate of the horse; and the amount of restless energy expended in stall walking, pawing, or other anxiety-related behaviors.

Energy requirements increase with the level of exercise. A performance horse that is underfed is unlikely to perform to its full potential. The energy content of the diet is of primary importance in feeding an equine athlete because the energy expenditure per minute of aerobic exercise in horses is exponentially related to speed (possibly as a result of the higher speeds and greater range of speeds measured).[6,7]

Forage

Forage is essential for proper function of the equine digestive tract.[6–8] Cellulose (a major fiber component of most forages) is not digested in the small intestine but is broken down in the cecum and colon by microbial digestion. The end products of microbial cellulose digestion are volatile fatty acids.[8] During low-intensity (aerobic) exercise, volatile fatty acids are readily utilized energy substrates. Light exercise may improve the digestibility of feedstuffs, including forages.[7] Because forage can provide a major source for energy for prolonged exercise or endurance events, access to hay or grass should not be restricted before long rides.[9] In addition, endurance horses should be fed large amounts of forage (6 to 8 kg/day) to increase intestinal contents and thus provide water and electrolyte reserves to replace those lost by sweating.[10]

The amount of intestinal contents depends on the type and amount of feed ingested. Horses that completed a 160-km endurance ride consumed more hay and less grain than horses that were unable to complete the ride due to fatigue and dehydration. With every kilogram of dry matter ingested, approximately 10 kilograms of water (8 to 14 kg, depending on fiber content)—containing approximately 135 mmol/L of sodium and 10 mmol/L of potassium—flow into the cecum.[10] Horses that are fed more forage thus have a reserve of water and electrolytes in addition to a source of volatile fatty acids.

Forage is essential for proper function of the digestive tract and to satisfy the need to chew. Low-forage diets decrease the weight of ingesta in the digestive tract but also increase the risk of digestive upset and behavioral abnormalities (e.g., wood chewing, cribbing, stall weaving, and digging).[11]

Grain

As the intensity or duration of exercise increases, more feed or feed of higher energy density must be fed. Grains usually provide more energy substrate per volume than does hay; the energy density of most feedstuffs is related to the weight of the feed per unit of volume. Because the weight per unit is related to fiber content, bulky high-fiber feeds weigh less. For example, sweet feed is lighter in weight and has a lower energy density than corn per unit of volume[5] (Figure 1). Table II compares the volume and weight of several common feeds.[12]

Some of the increased energy demands of exercise can be met by an increase in the frequency of feeding with improved hay or forage quality.[7] Moderate exercise usually causes horses to increase voluntary feed intake.[7] When high-intensity, anaerobic work (e.g., sprinting or pulling) is performed, grain should be added to the diet to prevent a decrease in body condition. Feeds with increased energy density should be added to the diet gradually.[13] The energy needs of a horse can usually be met by adding corn or other energy-dense grains and reducing or eliminating low-energy feed (e.g., oats).[8]

As a rule, most grains should be fed at a daily rate of 0.23 to

TABLE I
Daily Nutrient Requirement for a Mature (500-kg) Horse

Purpose	Digestible Energy (mcal/day)	Crude Protein (g/day)	Calcium (g/day)	Phosphorus (g/day)
Maintenance	16.4	656	20	14
Light work	20.5	820	25	18
Moderate work	24.6	984	30	21
Intense work	32.8	1312	40	29

0.68 kilograms (0.5 to 1.5 pounds) for each hour a horse is used for light pleasure riding.[12] For each hour of moderate exercise (e.g., jumping or barrel racing), we suggest feeding 0.9 to 1.4 kilograms (2 to 3 pounds) of grain mix daily. The energy required for strenuous work may be as much as 70 times greater per unit of time than that required for walking.[12] If horses are intensely exercised (e.g., polo or racing), we recommend feeding 1.4 to 2.3 kilograms (3 to 5 pounds) of grain mix daily for each hour of activity.[12] Because these estimates may result in overfeeding or underfeeding in certain horses, common sense and changes in body condition scores should dictate feeding regimens. Overfeeding of grain may stimulate changes in the intestinal microflora; a reduction of pH in the large intestine can result in microbial death and subsequent endotoxemia.[7]

Figure 1—A balance scale depicts the volume difference between equal weights of whole corn and sweet feed. This demonstrates the energy difference between the feeds as well as the importance of administering the ration by weight rather than volume.

Muscle glycogen concentrations can be altered by exercise and manipulation of the diet.[14] Training or conditioning increases the amount of glycogen stored in skeletal muscle and the glycogen available during exercise.[15,16] Because glycogen can be rapidly utilized anaerobically to produce energy, increasing glycogen in muscle theoretically delays the onset of fatigue during anaerobic exercise.[16] Adequate repletion of glycogen stores after exercise is an important goal in dietary management because performance may be impaired if horses exercise in a glycogen-depleted state.[17]

Glycogen loading of muscles is a controversial method of increasing muscle energy stores. Maximum loading is attempted by taking the horse through an initial depletion phase, which consists of 3 to 5 days of high-intensity exercise and low-carbohydrate, high-protein, high-fat meals. The glycogen repletion phase of reduced exercise and increased carbohydrate feeding then lasts for 2 to 3 days.[11] This phase must be undertaken with care—the increased carbohydrate intake may alter the bacterial balance in the cecum and colon, causing an increase in lactic acid–producing bacteria (primarily *Lactobacillus* and *Streptococcus*); acute laminitis may result.[18]

Because the glycogen depletion–repletion cycle is effective only in horses with muscle fibers that are trained to store and metabolize glucose rapidly and efficiently, there is a risk of triggering exertional myopathy during the high-carbohydrate feeding–resting phase. The results of studies performed to date indicate that glycogen loading has no positive effect on the threshold for anaerobic fatigue or performance in horses.[11,16,19,20] Because of the lack of a clear benefit of glycogen loading and the increased potential for exertional myopathy and laminitis, we do not recommend glycogen loading.

Fat

Fat can be utilized as a fuel source during low-intensity, aerobic exercise.[8,13] Fat in the diet raises the caloric density of feed without appreciably increasing feed volume.[16,21] Increasing the energy density of feed by adding dietary fat may allow reduction of the total feed intake required to meet energy demands. This approach decreases the chance of fermentation-related digestion disorders and reduces the weight of ingesta in the digestive tract. A combination of high fat and roughage intake can prevent the daily dry-matter intake from exceeding 2.5% of body weight. This reduction in feed intake can benefit an exercising horse by reducing the amount of weight being

TABLE II
Weights of Commonly Used Feedstuffs

	Weight	
Feed	*Pounds/quart*	*Kilograms/liter*
Alfalfa meal	0.60	0.29
Corn		
Whole	1.75	0.83
Cracked	1.60	0.72
Linseed meal	0.90	0.48
Whole oats		
Regular	0.85	0.41
Heavy	1.0	0.48
Soybean meal	1.80	0.85
Whole wheat	1.90	0.86
Wheat bran	0.50	0.24

carried and by minimizing the potential for carbohydrate overloading of the intestinal tract.

Muscle and liver glycogen stores are spared when fat is used as an energy source.[8,11,15,21] This sparing delays the onset of fatigue in exercising horses by priming the enzymes responsible for the metabolism of fatty acids, the main source of energy during aerobic work.[21] A horse conditioned to utilize fat in the diet can reserve the muscle glycogen stores until a state of oxygen deficiency has been reached. These stores then can be used as a source of energy for the muscles.[8,11,15,21] The delay in fatigue onset might allow the horse to maintain speeds for longer periods or improve competition times.[22]

Horses can consume diets that contain as much as 30% fat without apparent ill effects and can utilize approximately 85% of the metabolizable energy in corn oil.[16,23,24] One pint of oil per 5 pounds of grain mix results in 20% added fat in the mix. If 50% of the total diet by weight is the grain mix, adding this amount to the grain will result in 10% added fat in the diet. If grain makes up 33% of the total diet, as much as 30% fat or 1.5 pints of oil can be added to each 5 pounds of grain mix. Horses that have reached peak racing performance may benefit from the addition of 5% to 10% fat to the diet.[8] Horses fed these concentrations of dietary fat have lower heart rates and blood lactate concentrations during and after exercise.[8,22] Arabian horses ridden for 60 kilometers had a 15% reduction in feed intake when fed a ration that contained 8% added fat.[25] Compared with controls, horses fed 5% or 10% added-fat rations had a decrease of 21% or 25% of concentrate intake, respectively.[22]

If there are no problems with the manufacture and storage of these oils, fat can be mixed with the feedstuff. Plant oils, especially corn oil, have a high rate of palatability and acceptance. Fat must be top dressed in the grain diet; fats that are added to a diet and not consumed for a period may become rancid, which destroys many nutrients and decreases the palatability of the diet. Because fiber digestibility and fat utilization are reduced when an excessive amount of fat enters the large intestine, fat should be introduced into the diet slowly and divided into several meals per day.[22]

Effects of Excessive Protein on Exercising Horses

- Increased sweating
- High heart rate
- High respiratory rate
- Increased urine volume
- Increased urinary nitrogen
- Increased water requirements
- Slower racing times in Thoroughbreds

FEEDING TO MEET PROTEIN REQUIREMENTS

Table I presents the protein requirements of a mature, 500-kg horse undergoing various degrees of exercise. If the energy requirements of a working horse are met, protein requirements beyond those for maintenance are slight. The protein requirements of a mature working horse are usually met if the total feed has 8% to 10% crude protein and the horse eats 2% to 3% of its body weight in dry matter daily.[3,10] Exceeding this concentration of dietary protein is apparently not beneficial.[26] Although the requirements for protein increase with exercise, these needs are usually met as total feed intake increases to meet energy demands.

Because most feedstuffs prepared for horses contain more protein per unit of digestible energy than is recommended, exercising horses often are fed excessive amounts of protein. If fats are added to the diet, however, the resultant reduced feed intake may necessitate increasing the percentage of dietary protein to meet the protein requirements of the horse.[12]

The effects of excessive protein in the diets of exercising horses have been investigated.[6,20,27–31] Horses that are fed excessive protein sweat more and have higher heart and respiratory rates during endurance work than do horses fed appropriate amounts of protein.[28] Excessive intake of protein is associated with increased urine volume and urinary nitrogen and thus produces increased water requirements.[6,29] If water is limited, an increased water requirement can be detrimental to the horse.[6] Urinary nitrogen losses tend to increase with work and exacerbate water loss.[28,30]

Increased crude protein intake has been correlated with slower racing times in Thoroughbreds, and excessive dietary protein apparently provides no beneficial effect in the performance of sprinting or endurance horses[27,29,31] (see the box). Feeding adequate (but not excessive) amounts of protein thus should result in lower feed costs and increased performance.[20]

Minerals

Calcium and Phosphorus

The calcium and phosphorus requirements for horses are listed in Table I. The mineral requirements for most exercising horses are met by most diets, and mature horses normally maintain large reserves of calcium in the bones.[32] Because some bone remodeling may occur during intense training, the calcium requirement of an exercising horse is slightly higher than that of an idle horse.[33]

If a diet meets calcium and phosphorus requirements, a high ratio of calcium to phosphorus is not harmful to an adult horse. Some horses receive only alfalfa or other legumes (with a calcium-to-phosphorus ratio that exceeds 6:1) throughout their adult lives and yet display no detrimental effects. By contrast, special attention should be paid to the calcium-to-phosphorus ratio of diets fed to 2-year-old (or younger) horses beginning training. Because excessive phosphorus intake can interfere with calcium absorption, diets that contain large amounts of oats and corn (which are low in calcium and contain moderate amounts of phosphorus) should be avoided.[33]

Most forages provide enough calcium and phosphorus to meet the needs of a mature, nonpregnant, nonlactating horse. Although many grass pastures or hays have a calcium-to-phosphorus ratio of approximately 1:1, mountain grass hays and hays harvested along the eastern coast of the United States more often have calcium-to-phosphorus ratios of 2:1 or 3:1.[33]

Legumes (e.g., alfalfa and clover) are excellent sources of calcium but, like other forages, are fair to poor sources of phosphorus. In contrast, cereal grains contain less than 50% of the calcium required by even a mature, nonpregnant, nonlactating horse. Unlike grass forages, alfalfa and other legumes contain enough calcium to offset the low amount in a diet that is high in cereal grains. If a diet has a high ratio of cereal grain to grass forages (more than 33% to 50% grain), trace mineral salt mixed with dicalcium phosphate or steamed bonemeal at a ratio of 1:1 should be available ad libitum as the only salt.

To ensure adequate intake of calcium and phosphorus, the entire diet should be analyzed and balanced. As a rule, the diet of an adult working horse should contain 0.27% to 0.32% calcium and 0.20% to 0.25% phosphorus. Although an exercising horse loses calcium in sweat, the increase in feed intake associated with exercise usually offsets this loss.[12] Furthermore, exercise increases bone weight and the retention of calcium in bone.[34]

Sodium, Potassium, and Chloride

Sodium, potassium, and chloride are essential for fluid balance, nerve and muscle function, and acid–base balance. Sodium, potassium, chloride, magnesium, calcium, and phosphorus are components of sweat and are lost in increasing quantities with intense exercise.[6,7] Because equine sweat is approximately 0.7% sodium chloride,[12] the requirement for salt increases with excessive sweating; performance can be impaired if electrolytes that are lost in sweat are not replaced.[33]

The increased feed intake associated with increasing levels of exercise does not always allow this requirement to be met.[6] This is especially true in events in which there is prolonged or frequent sweating. Because horses normally have a desire for salt, free access to loose trace mineral salt will suffice unless excessive and prolonged sweating occurs.[6,7,32] Maintenance sodium requirements are approximately 20 mg/kg/day but may reach 250 mg/kg/day during heavy work.[34,35] The potassium requirement of a resting horse is 30 mg/kg/day; the requirement may increase to 130 mg/kg/day in a horse that sweats profusely.[7,8]

Rhabdomyolysis and synchronous diaphragmatic flutter have been associated with dehydration and electrolyte depletion after intense exercise. Because of the large losses of most electrolytes during intense exercise, competing horses are commonly provided with supplemental electrolytes. Although giving electrolytes before competition has not minimized exercise-induced losses of these electrolytes, providing concentrated electrolyte mixtures to horses during or after periods of exercise may help to replenish body stores.[7,8,11,36] Supplements used to replace electrolyte losses should contain potassium, sodium, and chloride; the amount given is more important than the ratio of the three electrolytes. Light salt (which consists of equal parts of sodium chloride and potassium chloride) may be used. Adding one part ground limestone to three parts light salt may increase its palatability.

Supplementation of potassium is especially important in horses that are fed coastal grass hays and given scant grain. Commercially available electrolyte supplements can be administered as a paste or in the feed.[6] If electrolyte mixtures are added to water, some horses refuse to drink or drink less; untreated fresh water therefore should be readily available. If glucose is a component of the electrolyte mixture, excessive bacterial growth and contamination of water may occur in hot weather. Excessive use of electrolyte supplements can result in increased urinary output and thus should be avoided.[11]

Selenium

Selenium acts as a coenzyme for glutathione peroxidase in the cellular antioxidant defense system. Selenium requirements are increased proportionally by exercise.[7,8] Selenium deficiencies have been associated with reproductive diseases in mares, muscular dystrophy in growing foals, and poor racing performance in training Thoroughbreds.[15] Supplementation of selenium-deficient diets increases low blood selenium concentrations, but excessive amounts of selenium in the diet do not improve performance and may result in toxicity.[5,37,38] Equine diets should contain 0.1 to 0.3 milligram of selenium per kilogram of feed; as little as 10 times this amount may be harmful.[5,39]

Iron

Iron is important for synthesis of hemoglobin and is a component of sweat. The total iron requirement of exercising horses is determined by endogenous losses, excretion by sweat, and the absorption rate in the gastrointestinal tract. At the beginning of the training period, the iron requirement may be higher because of increased red blood cell synthesis.[10]

Because the amount of iron is adequate in most equine rations,[34] exercising horses do not need supplemental iron.[32] Nevertheless, iron (in the form of hematinics) is commonly added to the feed of athletic horses in hopes of stimulating performance.[10] Chelated iron supplements are apparently not better utilized by horses than nonchelated or inorganic iron.[10]

Vitamins

Vitamin E

Vitamin E (α-tocopherol) functions as a biologic antioxidant that protects membranes from damage by superoxide anions (0_2^-). These anions are free radicals formed by the loss of one electron from oxygen; like other free radicals, they are highly reactive chemically. Membrane protection may be particularly important during exercise, when the formation of these compounds, peroxides, and hydroxyl radicals may be increased.[40] Studies in many species have demonstrated a positive effect of vitamin E supplementation on immune function.[41] Any improvement in immune function may benefit performance horses that have an increased risk of respiratory disease.[41,42]

Most common equine feeds contain less than 50 IU of vitamin E per kilogram of dry matter. The vitamin thus must be added to many rations to meet the current National Research Council recommendation of 80 IU/kg of dry matter. Vitamin E is available as a dietary supplement in various forms, which may have different biologic properties. There is scant knowledge concerning the potency of the various forms of the vitamin.[41,42]

Vitamins A and D

Because of their relatively low cost, vitamins A and D (the major components of vitamin supplements) are commonly added to many commercial grain products. Horses primarily obtain vitamin D from three sources: vitamin D_2 synthesized from hay, vitamin D_3 produced by the effect of ultraviolet irradiation on skin, and synthetic vitamin D in the diet. Although vitamin D is not involved in energy turnover in muscles, the vitamin may be slightly deficient in some training horses because of inadequate sunlight and reduced vitamin D activity in stored feed.[43] Supplementation of vitamin D at 500 IU/kg of feed thus may be beneficial.

Because the precursor of vitamin A (β-carotene) is reduced when hay is stored, it may be beneficial to add vitamin A to the ration if fresh hay or pasture grasses are unavailable.[44] Low or marginal blood vitamin A concentrations have been reported in horses in training in the United Kingdom.[43] Supplementation of these horses with vitamin A was apparently associated with a reduction in training-related injuries. Consequently, it has been recommended that 6,000 to 7,000 IU of vitamin A be added to each kilogram of feed.[43] Because a moderate excess of vitamins A and D might diminish performance, intake of more than five times the maintenance requirement of each vitamin (i.e., greater than 16,000 IU of vitamin A and 2,200 IU of vitamin D per kilogram of dietary dry matter) should be avoided.[10]

B Vitamins

The B vitamins can be obtained directly from the diet or from microbial synthesis in the large intestine. These vitamins play an important role in red blood cell physiology and energy metabolism and thus are key nutrients for exercising horses. Whether horses are capable of synthesizing enough B vitamins to meet the needs of high performance has been questioned.[15]

Thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin, pyridoxine (vitamin B_6), pantothenic acid, and biotin are involved in energy metabolism, usually as cofactors in enzymatic reactions. Because exercise increases energy expenditure, the requirements for these vitamins may be increased. The current recommendations of the National Research Council (per kilogram of dietary dry matter) are: 2 milligrams of riboflavin, 3 milligrams of thiamine for horses at rest, and 5 milligrams of thiamine for working horses.[10] There are no recommendations concerning other B vitamins or vitamin C. More research is needed to determine the effect of exercise on vitamin requirements in horses.[42]

CONCLUSION

The use of body condition scoring is helpful in evaluating energy balance in all horses, including performance horses. As the intensity of exercise increases, energy and nutrient demands also increase. The additional requirements can be met by increased feed intake or the inclusion of more grain and less forage in the diet. Care should be taken to avoid overfeeding of grain. As a rule, grain should not make up more than 50% of the total diet weight.

Fat at a level of 10% to 15% of the total diet is an excellent energy source and can be safely included in most equine rations. The high protein requirements associated with exercise are usually met by increased dietary intake. Trace mineral salt should always be available, and attention must be paid to the mineral requirements of horses that sweat excessively.

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ARTICLE #7 REVIEW QUESTIONS

The article you have read qualifies for ½ hour of Continuing Education Credit from the Louisiana State University School of Veterinary Medicine. *Choose only the one best answer* to each of the following questions; then mark your answers on the test form inserted in *The Compendium*.

1. Energy requirements for body maintenance of an adult horse can be met by feeding high-quality hay at what percentage of body weight daily?
   a. 3.5 to 4
   b. 2.5 to 3
   c. 1.5 to 2
   d. 0.5 to 1

2. Cellulose is digested in the
   a. stomach.
   b. small intestine.
   c. large intestine and cecum.
   d. none of the above

3. For each hour that a 500-kg horse is used for light pleasure riding, grain should be fed at a rate of how many kg/day?
   a. 0.23 to 0.68
   b. 0.15 to 1.0
   c. 0.5 to 1.0
   d. 1.0 to 1.38

4. Decreased heart rates and blood lactate concentrations during and after exercise are evident in fit horses with what percentage of fat added to the diet?
   a. less than 5
   b. 5 to 10
   c. 15 to 20
   d. 20 to 30

5. A horse can consume what percentage of added fat in the diet without ill effects?
   a. 10
   b. 20
   c. 30
   d. 40

6. In a mature horse, the calcium-to-phosphorus ratio should be maintained at
   a. 3:1 to 2:1.
   b. 6:1 to 1:1.
   c. 4:1 to 3:1.
   d. 1:1 to 0.5:1.

7. Equine sweat is approximately what percentage salt?
   a. 0.2
   b. 0.4
   c. 0.5
   d. 0.7

8. In growing horses, normal calcium absorption can be disrupted by excessive
   a. selenium
   b. phosphorus.
   c. iron.
   d. chloride.

9. When hay is stored, the availability of which of the following vitamin precursors is reduced?
   a. A
   b. B
   c. C
   d. D

10. Which of the following vitamins is synthesized and absorbed in the intestinal tract of a normal horse?
   a. A
   b. B
   c. C
   d. D