

Dietary allowances for horses

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The horse industry in the U.S. has encountered numerous challenges since the publication of the very optimistic 2005 American Horse Council (AHC) study, "The Economic Impact of the Horse Industry in the United States." According to that study, the horse industry in the U.S. contributed nearly \$40 billion in direct economic impact to the U.S. economy and supported 1.4 million full-time jobs. When both indirect and induced spending was included, the industry's economic impact reached \$102 billion. The study also estimated that the horse population in this country had increased from 6.9 million in 1996 to 9.2 million in 2005 — an increase of one-third. The AHC study found that the horse industry was not only large and economically important but also diverse and had well-balanced segments that contributed to a solid economic base for the future. The survey evaluated the contributions of recreational, showing and racing segments of the U.S. horse industry. It found that approximately \$32 billion is generated from the recreational segment, \$28.8 billion from the showing segment and \$26.1 billion from the racing segment.

Since the publication of these data, however, the horse industry has been challenged by a general downturn in the economy, severe feed shortages, especially hay, due to poor harvesting conditions in the recent years, increased use of forage crop land for ethanol corn production, increased feed and fuel costs and loss of the bottom-end market support due to the loss of equine slaughter in the U.S. Many horse owners have found that the combination of these economic variables has resulted in nearly complete loss of value of their unwanted horses. These, and other economic forces, have resulted in many horses that traditionally had a residual value of a few hundred dollars at auction to now have a negative value. In other words, since U.S. equine slaughter has been outlawed and feed and fuel prices have skyrocketed, it is not uncommon for horse owners to owe additional consignment and commission fees well above the sale price of their horses, whereas such cases were extremely rare just two to three years ago. Such punishing economic conditions in the equine economy, plus the general downturn of the U.S. economy, will undoubtedly result in an ongoing "correction" for the horse industry. This is especially true at the top levels of the horse market, with the highly speculative, multimillion dollar Thoroughbred yearlings becoming nearly a thing of the past, with a few exceptions. Some of this correction, although painful, may be of long-term benefit to the horse industry, since unbridled optimism and overproduction of poor-quality animals has contributed to the horse industry's current predicament. What the new level of horse populations, uses and values may be in coming years is difficult to predict, with so many variables currently in flux. Of course, certain segments of the horse industry remain quite vibrant and healthy, including regional equine economies that are subsidized by state incentive funds, or that have strong bases of support through busy show facilities, trails, tourism, racing purses enhanced by integrated gaming, etc.

Horse industry organizations, including the AHC sponsored Unwanted Horse Coalition (UHC), have stepped forward to attempt to address some of the difficult challenges to the horse industry. According to UHC, "The Unwanted Horse Coalition, a broad alliance of equine organizations

that have joined together under AHC, is concerned that some horses may slip through the various safety nets within the equine industry. Too many owners are unaware of, or do not give enough thought to, the available options, services and assistance available in the industry to help them ensure that their horse has caring and humane support throughout its life. UHC will help educate the horse industry about this issue and help people learn to own responsibly." The proliferation of unwanted horses, partly as a result of state and federal legislation, will be an ongoing problem that will require continued attention from many organizations within the U.S. horse industry.

Horse owner considerations

The adequacy of dietary energy, protein, vitamins and minerals in a horse's diet may receive considerably less conscious thought from the horse owner than the de facto expression of sufficiency in a glossy hair coat, vigorous attitude, hearty appetite and soundness of limb and wind.

Today's horse owner's desire for the horse to be not merely healthy, but also fully contented, can be a great motivating force that drives feed-buying decisions. This general mindset of many modern horse owners tends to drive the demand for horse feeds that are both high in nutritional quality and in sensory satisfaction to the horse owner. The appearance, texture, aroma, ease of handling and palatability (from the standpoint of the horse's apparent enjoyment) are major considerations when buying feed.

The value of a commercial horse feed has equally as much to do with serving the horse owner's emotional needs as providing adequate nutrient content in a cost-effective manner. Successful feed companies have developed highly profitable new product lines based upon identification of factors that motivate the buying decisions of horse owners. Horse owners have often been willing to pay premium prices for high-quality products that directly acknowledge those motivations.

Purina Mills' clear recognition of the strong emotional bond between the horse owner and a valued geriatric equine companion led to the development of the highly successful "Equine Senior," which takes into account the unique problems of dentition and potential malabsorption in the aged horse. Other manufacturers also produce similar senior feeds, and the availability of such senior horse feeds may be a factor in the gradual increase in life expectancy of domestic horses today.

Other feed companies have discovered niches for new feed products that address fundamental concerns that were not addressed only a few years ago. The development of low-potassium feeds designed for Quarter horses with the genetic defect manifested as hyperkalemic periodic paralysis (HYPP) is an example, as well as numerous high fat and fiber feeds for horses with "equine metabolic syndrome" or "insulin insensitivity" marked by horses that require extremely high insulin concentrations to maintain normal blood glucose levels. The problems of very high insulin concentrations, excess bodyweight, poor hair coat and susceptibility to laminitis in these horses is exacerbated by traditional high starch and sugar diets such as texturized sweet feeds.

Feeding horses

Forage. The horse is fundamentally a grazing herbivore that spends as much as 12 hours per day eating forage when on pasture or rangeland. It is a hind-gut fermenter with substantial cellulolytic microbial populations in the cecum and colon. Both B-vitamin and volatile fatty acid synthesis occurs

in the equine hind gut. The horse tends to be less well suited for utilizing poor-quality roughages than the fore-gut fermenters, the ruminants.

It is therefore important that a logical consideration of feeding horses begins with a focus on the quality of the forage component of the diet. Forage may be supplied by clean, mold-free grass or legume hay, pasture, haylage or cubed or pelleted forage. Ensiled forages tend to be more dangerous than other forms of roughage for horses due to the potential for botulism in improperly produced haylage. Leafy, green, fine-stemmed, dust-free forages grown on fertile soils can meet all of the energy needs for mature, relatively sedentary horses. Early harvested legume hay, such as alfalfa, may meet the protein needs for nearly all classes of horses, depending upon the level of low-protein concentrates simultaneously fed. As demands for growth, work, gestation or lactation are imposed, grain-based concentrates are generally required to maintain adequate body condition.

Table 1 shows expected ranges of forage and concentrate consumption by various classes of horses based on age, work level and stage of production. Exceptions to the values in Table 1 are not uncommon, as horse-breeders with access to excellent-quality alfalfa hay routinely maintain mares in excellent flesh throughout gestation on hay alone. Likewise, it is not uncommon for race horses in heavy training to consume greater than 3% of bodyweight in total daily feed. It is generally recommended that all classes of horses be fed at least 1% of bodyweight each day as some form of forage in order to maintain normal hind-gut function and reduce the potential for colic or laminitis. Some experts recommend that forage should comprise at least 50% of the horse's diet, although some high-performance horses may have difficulty maintaining adequate body condition with this restriction on grain.

Hay cubes and total mixed rations (TMRs), including complete hay/grain cubes and completely pelleted diets, are alternate methods for providing forage for horses. The primary motivation for using these forms of feed is the extreme ease of storage and handling under confinement situations or when frequent hauling of animals precludes transport of bulky-type feeds. Reduced feed wastage and reduced dust under less than optimally ventilated horse housing conditions are also considerations. Because nutrient levels in complete feeds can be precisely defined while still providing adequate roughage, they are gaining favor as creep rations for rapidly growing foals and even as high-performance race horse diets. Hay supplies tend to be unpredictable at the race track, which makes ration-balancing difficult. The potential for increased wood chewing, boredom, colic or founder of horses on complete feeds has been cited as being of concern. However, trainers using complete hay-grain feeds have reported that horses eat the complete pellets slower than grain alone, and that boredom and health problems have not increased. Research on a complete cubed feed also tends to support these observations (Younglove et al., 1994). One study of weanling horses found improved weight gain and a trend for improved feed efficiency when horses consumed a completely pelleted diet of identical dietary composition to a more traditional diet of hay and grain fed separately (Andrew et al., 2006). Another study of weanling horses consuming complete pellets of 50% forage and 50% grain products found improved growth when compared to the same feeds offered as hay cubes and grain fed separately, but also found increased rates of gastric ulcers (Flores et al., 2011). A follow-up study of gastric ulceration in horses on TMR cubes (Next Generation Feeds, Cokato, Minn.) comprised of alfalfa hay cubes with 25% oats incorporated into the cubes found no gastric ulceration due to the diet processed in this way while still maintaining a growth advantage over forage and grain fed separately (Warren et al., 2011).

Nutrition/environmental interactions. Horses are frequently housed in facilities that are often designed more for the comfort of the horse owner than for the horse. Horse

housing is notoriously poorly ventilated to the point of being air-tight in some cases, and the horses are subjected to breathing poor-quality air. Hence, an emphasis should be placed on high-quality, dust-free, mold-free hay, or cubed or pelleted forage or forage/grain combinations. Fear of fecal contamination of hay and/or grain with the causative organism for equine protozoal myelitis has prompted some horse farm managers to feed all forages and concentrates entirely as bagged cubes, pellets or texturized feeds. The fear of feeding hay and grains from bulk storage may decrease as an effective vaccine is developed for this disease.

Nutrient requirements of horses

The sixth revision of the National Research Council (NRC) *Nutrient Requirements of Horses* was published in late 2007. A new feature available to horse owners in an on-line nutrient requirement calculator for feed intake, digestible energy (DE), crude protein (CP), lysine, and the minerals calcium, phosphorus, sodium, chloride and potassium based upon animal specifications for weight, growth and stage of production. According to the National Academies Press, "A great deal of new information has been accumulated since the publication 17 years ago of the last edition of *Nutrient Requirements of Horses*. This new edition features a detailed review of scientific literature, summarizing all the latest information, and provides a new set of requirements based on revised data. Also included is updated information on the composition of feeds, feed additives and other compounds routinely fed to horses. The effects of physiological factors, such as exercise, and environmental factors, such as temperature and humidity, are covered, as well. *Nutrient Requirements of Horses* also contains information on several nutritional and metabolic diseases that horses often have". One significant change to be found in the most recent edition of *Nutrient Requirements of Horses* is that tables expressing nutrient requirements as percent concentrations in diets are no longer included. Instead, all nutrient requirements are expressed in units of metric mass, which allows for consideration of different rates of feed intake. An example of this presentation of nutrient requirements is found here in Table 16-3, reprinted directly, with permission, from the sixth edition of *Nutrient Requirements of Horses*. This table is only meant to represent nutrient requirements of the "average" light horse with mature bodyweight of approximately 500 kg, whereas several additional companion tables are published in the sixth edition for horses and ponies of both lesser and greater expected mature body mass.

Energy. Daily DE requirements expressed in megacalories (Mcal) for mature and growing horses of different stages of production are shown in Table 16-3. Monitoring body condition and weight changes of individual horses is generally the preferred method to assess energy balance, since differences in horse breeds, types and temperaments tend to produce more variation among equines than with other livestock species. Carbohydrates, proteins and fats are all useful sources of energy. Horses should not be fed significantly more protein than required to meet energy requirements due to excess nitrogen excretion and the higher feed cost of protein. Horses can utilize fats and oils effectively, and inclusion rates of up to 15% of the concentrate ration may be well accepted by the horse. One study found that jejunal microflora of ponies were not affected by the addition of up to 20% coconut oil in the diet (Kollarczik et al., 1995). However, the potential for very high levels of dietary fat to suppress cecal fermentation (Jansen et al., 2000) is of some concern, so levels of dietary fat exceeding 15% of the concentrate should be fed to horses with caution. Adding fat to equine diets is an effective method of increasing energy density for horses that have difficulty meeting energy needs due to old-age related maladies such as poor teeth or malabsorption, or for horses with high energy demands due to intense work schedules.

Research suggesting that added dietary fat may reduce the heat production of performance horses working under hot and humid conditions (Kronfeld, 1996), and enhance the oxidative capacity of muscle (Orme et al., 1997) continues to stimulate interest in this dietary supplement for horses.

Protein. Limited data are available regarding the protein digestibility of specific feed ingredients in horses. Amino acid absorption occurs mainly in the small intestine of the horse, but some ammonia absorption also occurs in the hind gut. Therefore, protein requirements in the horse are expressed as CP. Non-protein nitrogen feed ingredients are not efficiently utilized by the horse due to the location of fermentative digestion sites near the end of the gastrointestinal tract. The CP requirement for mature, sedentary horses under maintenance conditions is quite low, possibly as low as 540 grams per day (Table 16-3). Horses at maintenance can meet CP requirements on moderate-quality forages and grains, but growing horses and lactating mares especially require protein supplementation unless a high-CP forage containing legumes is a major component of the diet. Amino acid requirements for horses are not well defined, but recent work has suggested that threonine is the second-limiting amino acid (lysine is first-limiting) in a yearling horse diet of corn, oats, soybean meal and coastal bermuda grass/hay (Graham et al., 1994). There is little question that protein quality is of concern for growing horses and lactating mares, and for the horse in general, as compared to ruminant species. Adequate lysine concentrations should be present in diets high in soybean meal. Diets supplemented with cottonseed, peanut or flax meal could require additional lysine when fed to growing horses or lactating mares.

Vitamins. Fresh green forages and exposure to sunlight is all that is necessary to meet the vitamin needs of most horses. Horses under confinement conditions may lack one or both of these factors, however. Forages preserved with propionic acid or stored for extended periods of time may lose much of their vitamin A activity. It is not unusual for show horses or for horses being prepared for sale to be housed indoors for extended periods of time during summer daylight hours in order to avoid dulling of the hair coat from the sun. These horses may lack vitamin D if good-quality, sun-cured forage is not available. Vitamin E could also potentially be deficient if poor-quality forages are fed for extended periods. B-complex vitamins are synthesized in the horse's hind gut and usually do not require supplementation. Although no dietary biotin requirement has been established beyond what is synthesized in the gut, research continues into the possible use of supplemental biotin for improving poor-quality hooves. Two studies have found improved hoof quality in horses with initially poor hoof quality when fed 5-10 mg of supplemental biotin per 100 kg bodyweight per day for periods ranging from one to six years (Josseck et al., 1995; Geyer and Schulze, 1994). Another study found a 15% increase in the rate of hoof growth in ponies with 0.12 mg/kg bodyweight of biotin as compared to ponies on a control diet without supplemental biotin (Reilly et al., 1998). The positive effects of biotin supplementation on reduction of

hoof-related lameness have been found in a large study of dairy cattle as well (Hedges et al., 2001). This study found a nearly 50% reduction in the risk of lameness due to white line separation in cattle fed 20 mg of biotin per day.

Minerals. The recommended daily allowances for 14 minerals are shown for

1. Expected feed consumption by horses (% bodyweight)¹

	Forage	Concentrate	Total
Mature horses			
Maintenance	1.5-2.0	0-0.5	1.5-2.0
Mares, late gestation	1.0-1.5	0.5-1.0	1.5-2.0
Mares, early gestation	1.0-2.0	1.0-2.0	2.0-3.0
Mares, late lactation	1.0-2.0	0.5-1.5	2.0-2.5
Working			
Light	1.0-2.0	0.5-1.0	1.5-2.5
Moderate	1.0-2.0	0.75-1.5	1.75-2.5
Intense	0.75-1.5	1.0-2.0	2.0-2.5
Young horses			
Nursing foal, 3 months	0	1.0-2.0	2.5-3.5
Weaning foal, 6 months	0.5-1.0	1.5-3.0	2.0-3.5
Yearling foal, 12 months	1.0-1.5	1.0-2.0	2.0-3.0
Long yearling, 18 months	1.0-1.5	1.0-1.5	2.0-2.5
Two years old (24 months)	1.0-1.5	1.0-1.5	2.0-2.5

¹Air-dry feed (about 90% dry matter).

various classes of horses in Table 16-3. Salt (sodium chloride) is routinely included in concentrate mixes at a rate of 0.5-1.0%. Salt requirements vary widely among horses according to work intensity and ambient temperature. Free-choice offering of trace-mineralized salt in addition to free-choice water is an effective method of providing additional minerals, which may be deficient in certain geographic regions. Mineral levels of feedstuffs may vary significantly with soil mineral concentrations, soil fertilization, plant species, harvest conditions and stage of plant maturity. Special attention should be paid to providing trace-mineralized salt for horses that is not designed for another species. For instance, trace-mineralized salt for sheep is typically devoid of a bioavailable copper source for horses, since copper oxide is usually the only source of copper. Copper sulfate or another bioavailable source should be provided instead. Information on trace mineral bioavailability in the horse is not as extensive as data collected in other species (Ammerman et al., 1995).

Adequate dietary calcium and phosphorus is critical in the growing horse and lactating mare. Calcium and phosphorus requirements for these classes of horses may be more than double the maintenance requirement for a non-productive mature horse. In growing horses, it is recommended that the dietary calcium:phosphorus ratio be between 1:1 and 2:1. The most important consideration in calcium:phosphorus balance for horses is that the phosphorus concentration should not exceed the calcium concentration, while both minerals are at or above requirement levels.

References

Andrew, J.E., K.H. Kline, and J. L. Smith. 2006. *J. Equine Vet Sci* 26: 349-355.

Ammerman, C.B., D.H. Baker and A.J. Lewis, Editors. 1995. Academic Press.

Flores, R.S., C.R. Byron and K.H. Kline. 2011. *J. Equine Vet Sci* 31: 124-128.

Geyer, H., and J. Schulze. 1994. *Schweizer Archiv Fur Tierheilhunde* 136:137-149.

Graham, P.M., E.A. Ott, J.H. Brendemuhl and S.H. Tenbroeck. 1994. *J. Anim. Sci.* 72:380-386.

Hedges, J., R.W. Blowey, A.J. Packington, C.J. O'Callaghan and L.E. Green. 2001. *J. Dairy Sci.* 84:1969-1975.

Jasen, W.L., J. van der Kuilen, S.N. Geelen and A.C. Beynen. 2000. *Equine Vet. J.* 32:27-30.

Josseck, H., W. Zenker and H. Geyer. 1995. *Equine Vet. J.* 27:175-182.

Kollaraczki, B., C. Flothrow, C. Radicke and O.R. Kaaden. 1995. *T.J. Anim. Physiol. Anim. Nutr.* 73:225-232.

Kronfeld, D.S. 1996. *Equine Vet. J. Suppl.* 22:24-34.

National Research Council. 2007. *Nutrient Requirements of Horses, Sixth Revised Edition.* The National Academies Press,



500 Fifth St. N.W., Washington, D.C.
 Orme, C.E., R.C. Harris, D.J. Marlin and J. Hurley. 1997. Br. J. Nutr. 78:443-458.
 Reilly, J.D., D.F. Cottrell, R.J. Martin and D.J. Cuddleford. 1998. Equine Vet. J. Suppl. 26:51-57.

Warren, S.N., P. DePedro Gonzales and K.H. Kline. 2011. J. Equine Vet Sci 31: Proceedings of the 2011 Equine Science Society Symposium. 330.
 Younglove, G.A., P.G. Gibbs, G.D. Potter, M. Murraygerzik and D.J. Dorsett. 1994. J. Equine Vet. Sci. 14:598-602. ■

16-3 Daily nutrient requirements of horses (mature bodyweight of 500 kg)^a

Type	ADG/ Milk kg	DE Mcal	CP g	LVS g	Ca g	P g	Mg g	K g	Na g	Cl g	S g	Co mg	Cu mg	I mg	Fe mg	Mn mg	Se mg	Zn mg	A kIU	D IU	E IU	Tiamin mg	Riboflavin mg	
Adult - no work ^b																								
Minimum	500	15.2	540	23.2	20.0	14.0	7.5	25.0	10.0	40.0	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	15.0	3300	500	30.0	20.0	
Average	500	16.7	630	27.1	20.0	14.0	7.5	25.0	10.0	40.0	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	15.0	3300	500	30.0	20.0	
Elevated	500	18.2	720	31.0	20.0	14.0	7.5	25.0	10.0	40.0	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	15.0	3300	500	30.0	20.0	
Working ^c																								
Light exercise	500	20.0	699	30.1	30.0	18.0	9.5	28.5	13.9	46.6	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	22.5	3300	800	30.0	20.0	
Moderate exercise	500	23.3	768	33.0	35.0	21.0	11.5	32.0	17.8	53.3	16.9	0.6	112.5	4.0	450.0	450.0	1.13	450.0	22.5	3300	900	46.3	22.5	
Heavy exercise	500	26.6	862	37.1	40.0	29.0	15.0	39.0	25.5	66.5	18.8	0.6	125.0	4.4	500.0	500.0	1.25	500.0	22.5	3300	1000	62.5	25.0	
Very heavy exercise	500	34.5	1004	43.2	40.0	29.0	15.0	53.0	41.0	93.0	18.8	0.6	125.0	4.4	500.0	500.0	1.25	500.0	22.5	3300	1000	62.5	25.0	
Stallions																								
non-Breeding	500	18.2	720	31.0	20.0	14.0	7.5	25.0	10.0	40.0	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	15.0	3300	500	30.0	20.0	
Breeding	500	21.8	789	33.9	30.0	18.0	9.5	28.5	13.9	46.6	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	22.5	3300	800	30.0	20.0	
Pregnant Mares																								
Early (<5 months)	500	16.7	630	27.1	20.0	14.0	7.5	25.0	10.0	40.0	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
5 months	504	0.14	17.1	685	29.5	20.0	14.0	7.5	25.0	10.0	40.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
6 months	508	0.18	17.4	704	30.3	20.0	14.0	7.5	25.0	10.0	40.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
7 months	515	0.24	17.9	729	31.3	28.0	7.6	25.0	10.0	40.0	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
8 months	523	0.32	18.5	759	32.7	28.0	7.6	25.0	10.0	40.0	15.0	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
9 months	534	0.41	19.2	797	34.3	36.0	26.3	7.7	25.9	11.0	41.0	0.5	125.0	4.0	500.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
10 months	548	0.52	20.2	841	36.2	36.0	26.3	7.7	25.9	11.0	41.0	0.5	125.0	4.0	500.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
11 months	566	0.65	21.4	893	38.4	36.0	26.3	7.7	25.9	11.0	41.0	0.5	125.0	4.0	500.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0	
Lactating Mares																								
1 months	500	16.30	31.7	1555	84.8	59.1	38.3	11.2	47.8	12.8	45.5	18.8	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	
2 months	500	16.20	31.7	1530	84.4	58.9	38.1	11.1	47.7	12.8	45.5	18.8	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	
3 months	500	14.95	30.6	1468	80.3	55.9	36.0	10.9	45.9	12.5	45.5	18.8	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	
4 months	500	13.55	29.4	1398	75.7	41.7	26.2	10.5	35.8	11.9	45.5	18.8	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	
5 months	500	12.20	28.3	1330	71.2	39.5	24.7	10.2	34.8	11.7	45.5	18.8	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	
6 months	500	10.90	27.2	1265	66.9	37.4	23.2	8.7	33.7	11.5	45.5	18.8	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	
Growing animals																								
4 months	168	0.84	13.3	669	28.8	39.1	21.7	3.6	10.9	4.2	15.7	6.3	0.2	42.1	1.5	210.6	168.5	0.42	168.5	7.6	3740	337	12.6	
6 months	216	0.72	15.5	676	29.1	38.6	21.5	4.1	13.0	5.0	20.1	8.1	0.3	54.0	1.9	269.9	215.9	0.54	215.9	9.7	4793	432	16.2	
12 months	321	0.45	18.8	846	36.4	37.7	20.9	5.4	17.4	6.9	26.5	12.0	0.4	80.3	2.8	401.5	321.2	0.80	321.2	14.5	5589	642	24.1	
18 months	387	0.29	19.2	799	34.4	37.0	20.6	6.2	20.2	8.0	32.0	14.5	0.5	96.9	3.4	484.4	387.5	0.97	387.5	17.4	6161	775	29.1	
18 light exercise	387	0.29	22.1	853	36.7	37.0	20.6	11.6	22.9	11.0	37.1	14.5	0.5	96.9	3.4	484.4	387.5	0.97	387.5	17.4	6161	775	29.1	
18 moderate exercise	387	0.29	25.0	906	39.0	37.0	20.6	11.6	25.7	14.0	42.2	14.5	0.5	96.9	3.4	484.4	387.5	0.97	387.5	17.4	6161	775	29.1	
24 months	429	0.18	18.7	770	33.1	36.7	20.4	6.7	22.0	8.8	35.4	16.1	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	
24 light exercise	429	0.18	21.8	829	35.7	36.7	20.4	12.9	25.0	12.1	41.1	16.1	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	
24 moderate exercise	429	0.18	24.8	888	38.2	36.7	20.4	12.9	28.0	15.4	46.8	16.1	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	
24 heavy exercise	429	0.18	27.9	969	41.7	36.7	20.4	12.9	34.0	22.1	58.2	16.1	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	
24 very heavy exercise	429	0.18	32.5	1091	46.9	36.7	20.4	12.9	46.0	35.4	80.9	16.1	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	

^aThe daily requirements listed in this table for S, Co, I, Fe, Mn, Se, and Zn are calculated using assumed feed intakes of 2.5% of BW for heavy and very heavy exercise, lactating mares, and growing horses; 2.25% of BW for moderate exercise; and 2% of BW for all other classes. Daily requirements for Cu are also calculated from assumed feed intakes for adult horses (no work) and exercising horses. ^bMinimum maintenance applies to adult horses with a sedentary lifestyle, due either to confinement or to a docile temperament. Average maintenance applies to adult horses with alert temperaments and moderate voluntary activity. Elevated maintenance applies to adult horses with nervous temperaments or high levels of voluntary activity. ^cExamples of the type of regular exercise performed by horse in each category are described in Chapter 1. These categories are based on average weekly exercise. Four categories are given but users should recognize that the nutrient requirements are more accurately described by a continuous function than by discrete groups.