

HORSE NUTRITION AND FEEDING

- *References: NRC (1989, 2007), Lawrence (1998) in Kellems and Church (1998), Pagan (1998), Kline [2001. Horse feeds and feeding. Feedstuffs 73(29): 66-69], and Jurgens (2002).*

INTRODUCTION

1. Horse Industry

- A. The horse industry has become a very important part of the agricultural scene in many areas of the States - An increase in horse research in recent years because of the popularity and the economic impact of the horse industry.
- B. After several years of declining horse populations, which began in the mid 1980s, the status of the horse industry has improved in recent years:
 - 1) High feed sales by most major horse feed manufacturers - A reflection of not only the number of horses, but also the demand for high-quality feeds to keep horses "fully content" rather than merely satisfying the needs or maintaining the health.
 - 2) High sale prices at a public auction [e.g., the avg. for selected yearlings at one sale (2000) in Kentucky was more than \$620,000, the highest since the mid 1980s].

2. Feeding Horses?

- A. Some examples of "myths and wives' tales?" [Jackson (1998) in Pagan (1998)]
 - 1) "*Beet pulp must be soaked prior to feeding!*"
 - 2) "*When I feed my horse high protein feed, it goes DITZO!*"
 - 3) "*Molasses causes colic!*"
 - 4) "*Pellets cause horses to choke!*"
 - 5) "*If horses are getting pot bellies, reduce their grain intake!*"
 - 6) "*I feed corn oil to prevent impaction!*"
 - 7) "*High protein causes development of orthopedic disease!*"
 - 8) "*New hay must go through a sweat before being fed!*"
 - 9) "*Alfalfa causes kidney damage in horses!*"
- B. Feeding horses for show or performance purposes? - Perhaps, more complicated than feeding other farm animals!?
- C. Limited experimental information on the nutritional need of horses: 1) large gaps on the published information on many issues, 2) "unresolved" and conflicting reports on many issues, and 3) some difficulty in actual application of information obtained under diverse conditions.
- D. Some considerations?

- 1) Digestive and metabolic differences among horses - Should make appropriate adjustments to compensate the possible differences!?
- 2) Variations in the production/performance capability and the expectation of the owner?
- 3) Others? Health status of the animal, variations in the nutrient availability in feed ingredients, interrelationships among nutrients, previous nutritional status, and weather/environmental conditions.

NUTRIENT REQUIREMENTS

1. Water

Expected daily water consumption (Gal; Lawrence, 1998)	
Maintenance, 500 kg (Thermoneutral)	6-8
Maintenance, 500 kg (Warm environ)	8-15
Lactating mare, 500 kg	10-15
Working (moderate), 500 kg	10-12
Working (moderate), 500 kg (Warm environ)	12-18
Weanling, 300 kg (Thermoneutral)	6-8

- A. Like other species, an adequate supply of clean water is important for horses - Should have water available all the time via buckets, troughs, ponds, or streams (Table).
- B. The water content of the body is relatively constant (68 to 72% of the total weight on a fat-free basis) and cannot change appreciably . . . without severe consequences.
- C. A minimum requirement? Sum of the water lost from the body (via urine, feces, sweat, and secretions) plus a component of growth in young animals.
- D. Some factors influencing the water consumption/needs:
 - 1) Dry matter intake - Horses may need 2 to 3 L of water/kg of dry matter intake.
 - 2) High salt or excess protein contents - Increase water intake.
 - 3) Environmental temperatures - e.g., need 2 L of water/kg dry feed at -18°C, but need 8 L of water/kg dry feed at 38°C.
 - 4) Work/exercising - May increase water needs by 20 to 300%.
 - 5) Lactation.
- E. Dehydration and electrolyte balance
 - 1) Dehydration through sweating can result in the loss of water and electrolytes (mostly, Na & Cl with some K).
 - 2) Preventive electrolyte therapy by oral or i.v. administration of 1-3 L of electrolyte solution - Beneficial? No conclusive evidence, but, oral supplementation may be helpful for a heavily sweating endurance horse in a hot or humid environment!
 - 3) An adequate water supply, a balanced diet, and a trace mineralized salt on a free-choice should be sufficient in most racing situations!

2. Energy

- A. The energy requirements are expressed in megacalories (Mcal) of DE.
- B. Differences among individuals:

- 1) "Easy keeper" - Often used to describe a horse that can maintain body weight on less than the average dietary energy supply.
- 2) "Hard keeper" - One requires more than the average dietary energy to maintain body weight.

C. Energy status? Can be determined by weighing regularly! If not, can use subjective condition scoring system to monitor body condition - See the table:

- 1) Based on body fatness using 1 (very thin) to 9 (very fat).
- 2) Most horses should be maintained at a score of at least 4 and not exceeding 7.

D. Environmental temperatures:

- 1) Have a large impact on energy requirements for maintenance, especially if they don't have a shelter.
- 2) See "Effect of cold stress on DE requirements of mature horses (LCT = lower critical temperature; Lawrence, 1998)."

E. The maintenance requirement has been estimated to be: $DE \text{ (Mcal/d)} = 1.4 + 0.03BW$, where BW = body weight of the horse (kg).

F. Energy requirements for growth? - Can be estimated by:

- | | |
|-------------------|---------------------------------------|
| 1) Weanlings | $1.4 + 0.03 BW + 9 \text{ ADG (kg)}$ |
| 2) Yearlings | $1.4 + 0.03 BW + 16 \text{ ADG (kg)}$ |
| 3) Long yearlings | $1.4 + 0.03 BW + 18 \text{ ADG (kg)}$ |
| 4) 2-yr-olds | $1.4 + 0.03 BW + 20 \text{ ADG (kg)}$ |

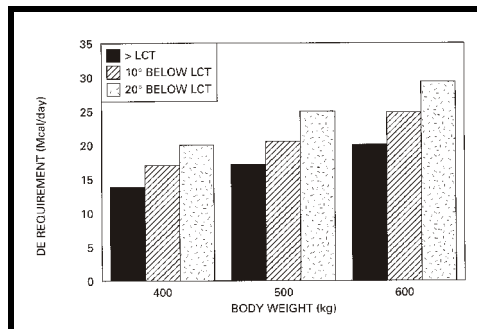
☞ NRC (1989): 9.1, 11.0, 15.5, 18.4, and 19.6 Mcal DE/kg gain for 4-mo. weanling, 6-mo. weanling, yearling, long yearling, and 2-yr-old horses, respectively.

G. Energy requirements for work?

- 1) Depend not only on the type of work but the speed and the terrain over which the work is done.

Body Condition Scoring System (1 - 9)	
Description	
1	No fat covering on ribs, spine, pelvis, etc. All bony structures in trunk extremely apparent. Bones in neck may be visible.
2	Ribs, shoulder, spine, and pelvis structures are prominent. Neck is very thin.
3	Ribs, shoulder, spine, and pelvis are clearly discernable but some fat cover can be felt. Neck is thin.
4	Ribs are slightly visible. Some fat cover can be felt on ribs, spine, tailhead. Neck is not thin.
5	Some fat covering over ribs, spine, shoulder, and pelvis. Ribs not visible; back (loin) may be flat. Body parts are distinct but blend together smoothly.
6	More fat accumulation on ribs and at tailhead. Back (loin) may be flat or have a slight crease. Neck starting to fill out.
7	Fat accumulating on ribs and tailhead feels soft. Definition between body parts (neck to shoulder; shoulder to ribs) is decreased. Neck is filled in over crest.
8	Ribs are difficult to feel. Back (loin) has noticeable crease. Neck is thick. Tailhead is very fat and soft.
9	Soft, thick fat accumulated on ribs, shoulder, and tailhead. Neck is very thick and withers have lost definition. Fat accumulated between thighs, in flank area, and behind shoulder.

Henneke et al. (1983). Modified by Lawrence (1998).



- 2) The NRC's DE need above the maintenance? - From 4 Mcal to as high as 16 Mcal DE/hour of work (Jurgens, 2002).

H. Sources of energy:

- 1) At maintenance? - May derive most of the energy need from the digestion of fiber in the large intestine.
- 2) Fiber digestion alone is, usually, not sufficient to satisfy the energy need for lactation, growth, and exercise - May need some supplemental grains or lipids.
- 3) Can satisfy the energy need by using only grains, but should never be done! Diets with a large amount of starch and a low amount of fiber are associated with an increased incidence of colic and laminitis. Should provide, at least, "12 to 15% fiber?!"

3. Protein

A. Protein requirements? - Usually expressed as grams of CP required per day.

B. Mature horses at maintenance:

- 1) Have relatively low protein needs and deficiency is rare with an adequate energy.
- 2) A mature 500-kg horse needs \approx 660 g/CP/d, which can be supplied by 8 kg of a hay containing 8.25% CP.

C. Young horses, lactating mares, and mares in late gestation - Need a diet with higher protein quantity and quality.

D. Protein quality - An important consideration in growing horses, and Lys seems to be the first limiting amino acid in diets for growing horses, with Thr being suggested as the second limiting.

E. Microbial protein/amino acid synthesis:

- 1) Unclear on the rate of amino acid synthesis and absorption at the cecum, thus, should provide an adequate amount of dietary indispensable amino acids, especially for growing horses until more information is available?
- 2) Possible that horses can absorb some N (as ammonia?) from the cecum and(or) large intestine, which can be used for the synthesis of dispensable amino acids.
- 3) Similarly, microbes can synthesize some indispensable amino acids, but their absorption by the hindgut might be limited!?

F. Broodmares - Need protein for the deposition of fetal tissues and milk production.

- 1) If the mare's milk contains about 2.0% protein and a 500-kg mare produces 15 kg of milk/day, about 300 g of protein will be secreted in the milk.
- 2) Conversion is not very efficient, so, perhaps, \approx 1,430 g of dietary CP is needed?

4. Minerals

A. Ca & P - Special importance in horses:

- 1) The development of quality bone is more important in horses than other livestock species simply because some athletic activity may put more stress on bones.
- 2) The horse's bone? - About 35% Ca and 16% P, and deficiencies or imbalances in dietary Ca and P can result in various bone disorders.
- 3) High-P can impair the absorption of Ca, thus, the concentration of P should not exceed the concentration of Ca. Also, must consider availability of Ca and P!
- 4) Obviously, a sufficient amount of vitamin D must be available!

B. Sodium, K, and Cl - Function as electrolytes and essential for all classes of horses.

- 1) Most non-working horses obtain enough Na and Cl to meet their needs with their access to a salt block or a "loose" salt mix.
- 2) Potassium? - Usually met by K found in hay and pasture.
- 3) The needs are greater for working horses, lactating mares, and horses that are exposed to high environmental temperatures.
- 4) Deficiency? - Can reduce a water/feed intake, plus show some unusual oral behavior such as licking of stall surfaces.

C. Others minerals?

- 1) Iodine - Both I deficiency and I toxicity have been reported in horses. The I content of common horse feeds can vary considerably!
- 2) Iron - Usually met by the typical feed ingredients, even though the availability of Fe in grains and forages may be low. Fe deficiency signs are rarely reported.
- 3) Copper - The level and availability of Cu is very low in many forages, and it is a common practice to formulate grain mixes to contain 20 to 30 mg Cu/kg DM.
- 4) Zinc - Forages may also be low in Zn. Zinc deficiency can reduce growth of young horses.
- 5) Selenium - Low in soils of many regions of North America, thus, feeds are also low in Se. Selenium supplementation is often necessary but should be done carefully because of its toxicity.

5. Vitamins

A. Fat-soluble vitamins:

- 1) Vitamin A and E are of the most practical importance in horse diets:
 - a) One of the richest sources of β -carotene (precursor of vitamin A) is "green" pasture.
 - b) Vitamin E activity? - High in forages with an early stage of maturity, but once a plant is harvested for hay, the vitamin E activity can decrease.

- 2) Vitamin D - Usually, supplementation of horses kept outside is not necessary.
- 3) Vitamin K - The requirement has not been established. Microbes can synthesize compounds with vitamin K activity, and also can get substances with vitamin K activity from hay and pasture.

B. Water-soluble vitamins - Little information is available on the horse's dietary need!

- 1) A dietary requirement for vitamin C has not been determined.
- 2) Microbes in the hind gut seem to be capable of synthesizing several B vitamins.

FEED INGREDIENTS AND FEEDS

1. Forages

A. Forages are the basis for any horse feeding program - Should receive 1.0 to 2.5 kg of good quality hay (or "pasture equivalent")/10 0 kg of body weight/day:

Type of Horse	Hay, kg/d*	Comments
Maintenance, early gestation, very light work	9.5-12	More hay may be needed in cold temperatures; if alfalfa hay is fed, concentrate is usually not necessary
Late gestation, light work	7.5-11	Most horses require a small amount of concentrate (1.5 to 3 kg) in addition to hay
Lactation	9.5-13	Most lactating mares require at least 3 to 4 kg of concentrate grain in addition to hay
Yearling	7-11.5	Amount of concentrate varies (2 to 6 kg) depending on age, type of hay, and situation (sale preparation, breaking, etc.)
Weanling	3.5-7	Amount of concentrate varies (2 to 4 kg) depending on age of horse and type of hay
Performance horse	7-12	Amount of hay and grain varies depending on level of work; most will receive 3 to 6 kg of grain per day

*Assumes that horses have no access to pasture. When pasture is available, the amount of hay needed will be reduced.

- 1) Forages can provide many of the essential nutrients required by the horse.
- 2) The fiber in forages assists the horse in maintaining gastrointestinal health.

B. Pasture should be utilized whenever possible:

- 1) Can reduce labor costs and provide a high-quality source of nutrients.
- 2) During most part of the growing season, about 2.5 to 3.0 kg of fresh pasture is equivalent to about 1 kg of good hay.
- 3) Most grasses can be grazed by the horse, and legume-grass mixtures make excellent high quality pastures.
- 4) Rotational grazing and(or) clipping are important management practices because horses are selective and tend to graze the youngest and most tender grasses.
- 5) With plenty of high-quality pasture or hay, only rapidly developing weanling and yearling horses, mares that are lactating and to be bred back, and show and performance horses may need supplemental grains.

C. Hay for horses

- 1) Undoubtedly, obtaining good hay, storing, and feeding can be a major management problem.
- 2) Some factors associated with feeding hay:
 - a) Moldy or dusty hay may cause colic and heaves in horses.
 - b) Large amounts of very poor quality hay can be poorly digested and may not pass the digestive tract, and can cause "impaction and colic?"
 - c) Very high quality clover or small grain hay can be readily digested, and when fed with a high-grain feed, may result in a "loose" feces or colic.
 - d) When a very high-quality hay is fed with grain, perhaps, necessary to feed a poorer quality grass hay?
- 3) Bromegrass, orchardgrass, timothy, and Bermudagrass make excellent hay for horses:
 - a) Palatable and usually less dusty and less likely to become moldy than legume hays.
 - b) Legumes:
 - (1) Higher in the nutrient content than grasses and may be fed by themselves or in combination with grass hays.
 - (2) Heavier and more difficult to cure properly, and are, thus, more prone to mold and become dusty. Alfalfa hay is more laxative than grass hays and may cause "loose" feces.

2. Concentrates

- A. When a horse cannot meet its energy and protein needs through forage alone, must provide additional nutrients via concentrated feedstuffs.
- B. Grains
 - 1) Oats:
 - a) Still the most widely used and the most popular grain for horses - Some believe that oats can cause fewer digestive problems than corn, possibly because of its fiber content?
 - b) Heavy (> 32 lb/bu.), bright, or clean oats, which contain a small percentage of hull, are preferred - Best to roll or crush oats for horses with poor teeth or young foals.
 - c) Lower in the energy content than other grains but will cause less trouble with stomach compaction. Dusty oats should be avoided because they may cause colic.
 - 2) Corn:

- a) Like oats, widely used for horses - Should be cracked, coarsely ground, or preferably rolled.
 - b) Higher in energy vs. oats - Usually mix it with oats, and include less corn than oats in the mixture.
- 3) Barley - Used some in the States (west), but popular in some other countries. Should be coarsely ground or preferably rolled, and usually mix it with oats in about equal parts.
 - 4) Wheat, rye, and milo - Not used much because they become rather doughy and tend to ball up with moisture when ground. If used, should be rolled and mixed at a low level with bulky feed such as oats or wheat bran. (Milo has a very hard seed coat!)
 - 5) Grain by-products:
 - a) Wheat bran - Very valuable for its mild laxative effect and for its bulky nature. Generally used at 5 to 15% of the diet.
 - b) Wheat middlings - Used in pelleted feeds and an economical source of energy.

C. Protein supplements

- 1) Linseed meal:
 - a) A popular protein supplement for horse feeding - May contain something that produces bloom and luster in the hair coat?
 - b) Often, pelleted meal is used because of its dustiness - Perhaps, too low in fat after extraction?
 - c) Usually more costly and inferior amino acid composition vs. soybean meal.
- 2) Soybean meal - Also, used quite extensively for horses and may be substituted on an equal protein basis for linseed meal. Contains high-quality protein and is generally more economical.
- 3) Cottonseed meal - Lower in protein quantity and quality vs. soybean meal. May contain gossypol, which may not be toxic to horses, but a maximum of 0,03% for young horses.
- 4) Milk protein - Dried whey or commercial supplements with milk products are often used in a starter diet for foals. Rarely used for mature horses because of the cost.

D. Other miscellaneous feed ingredients

- 1) Beet pulp - High in fiber, but the fiber is well-digested and has fairly high energy value. Often, used to replace hay in the diet for horses with heaves (or broken wind, an asthmatic disease of horses).
- 2) Molasses - Including 5 to 10% sweetens the feed and makes it more palatable. Also, tends to condition feeds, prevent separation, and reduce dustiness.

- 3) Dehydrated alfalfa meal - Include 5 to 10%. A good source of vitamins, minerals, protein, and "unidentified factors."
- 4) Also, rice bran, rice hulls, citrus pulp, or soybean hulls are being used depending on the cost and availability.

3. Other Ingredients

A. Minerals:

- 1) Sodium, Cl, and K - Na and Cl needs can be met easily by the addition of salt to a horse diet via plain, iodized, or trace mineralized salt. Forages are a good source of K.
- 2) Calcium and P - When diets are low, may be supplemented with limestone, dicalcium phosphate, steamed bone meal, or defluorinated rock phosphate.
- 3) Trace minerals - Usually via commercial trace mineral premixes or trace mineralized salt.

B. Fats and oils - Animal fats and vegetable oils (5 to 10%) can be used as a highly concentrated energy source for horses.

- 1) Vegetable oils are generally more palatable than animal fats.
- 2) Can be used as a source of linoleic acid, to reduce feed dustiness, and to put a bloom on the animal hair coat.

4. Antibiotics

- A. No information available on the value of antibiotics for horses, but addition of an antibiotic may be helpful for young foals? - Infections, digestive troubles, lack of milk, poor weather, or other stress factors.
- B. Presently, the Food and Drug Administration allows the use of 85 mg chlortetracycline per head daily for horses up to one year of age for stimulating growth and improving feed efficiency (Jurgen, 2002).

5. Pelleting Feeds?

- A. Pellets may be especially useful in creep feeds and diets for weanlings where there is a tendency for horses to separate out the fine particles.
- B. Pelleted diets containing hay, as well as grain, should contain 60 to 70% coarsely ground hay to decrease problems with colic.
- C. May be necessary to feed a small amount of unprocessed hay to prevent wood chewing and mane and tail chewing when groups of animals are penned together?

6. Manufactured Feeds

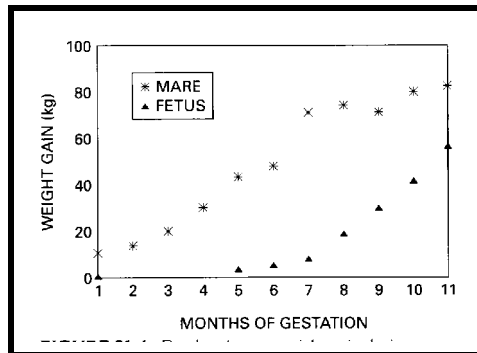
- A. Fortified grain mixes - Used widely in the horse industry:

- 1) Include a combination of grain or grain by-products, protein supplement, Ca and P, trace minerals, vitamins, and salt, and others. Formulated/designed to meet the nutrient needs when fed with forage alone.
 - 2) Most manufactures offer at least three separate formulations:
 - a) For maintenance or light work horses - Contains about 10 to 12% CP.
 - b) For performance horses, broodmares, and yearlings - Contains about 13 to 14% CP.
 - c) For lactating mares, weanlings, and yearlings - Contains 15 to 16% CP.
 - 3) Also available in several physical forms, i.e., a coarse mix (aka, sweet feed or textured feed?), pelleted, or extruded.
- B. Supplements - Designed to satisfy the need for protein, vitamins, and minerals by feeding a small amount every day to horses on lush pastures to satisfy their energy needs.
- C. Complete feeds:
- 1) Useful? - a) When good quality hay or pasture is not available, and b) in older horses with poor teeth or ones with respiratory allergies to hay.
 - 2) Contain a roughage source (alfalfa dehy and beet pulp are common) and designed to be fed without any forage - Ones with alfalfa are often pelleted.
 - 3) Fiber - Usually at least 12 to 15%, and may be > 20%.

FEEDING HORSES

1. Breeding, Gestation & Lactation

- A. Breeding? Most mares are not bred until 3 to 4 yr of age, whereas successful performance horses may not be bred until 8 yr of age.
- B. Desirable for mares to have a foal every year, and most mares can be rebred within a few weeks of foaling (no lactational anestrus?) - Thus often, gestation & lactation overlap in horses.
- C. Just like other species, mares will use body reserves to meet the nutrient needs for fetal growth and milk production if they do not consume a sufficient amount of nutrients during gestation and lactation.
- D. Breeding/gestation:
 - 1) The recommended maintenance needs for energy and protein should be sufficient during the breeding and early gestation periods, but need additional nutrients during the last 90 d because about 60% of the



weight of the fetus develops during that time. See the figure on "Fetal and mare weight gains during gestation (Lawrence, 1998)."

- 2) But, if mares are lactating, they obviously need more nutrients.
- 3) Loss of weight or body condition - Obviously, a clear indication of the inadequate nutritional status.
- 4) Ca - An inadequate Ca intake during lactation may lead to mobilization of Ca from the bone to meet the demands, thus, could have a significant impact on the long-term soundness if continued over several cycles.
- 5) Increase a nutrient intake by 10 to 20% above the maintenance if mares lost the weight during lactation and enters the second trimester of gestation in sub-optimal body condition.
- 6) During a 340-d gestation, a 500-kg mare may gain 50 to 70 kg (foal weighs about 40 to 55 kg at birth) - Regular weighing/assessing body condition scores would be helpful.
- 7) Can meet the mare's requirements for late gestation by increasing feed, but they may eat less feed in late gestation, thus necessary to change the composition of the diet, i.e., to increase concentrate?

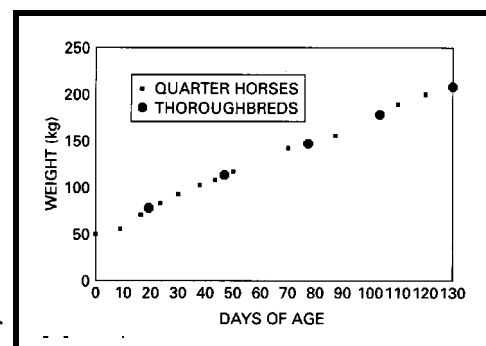
E. Lactation

- 1) A mare has just foaled, lactating, and being prepared for breeding? - Obviously a period of critical nutritional stress and they must be well nourished!
- 2) Mares should be in a good condition prior to foaling so that they can use their "build-up" reserves in the time of need.
- 3) A few days before foaling, provide a bulky diet to reduce potential constipation problems, and allow 7 to 10 d after foaling to bring mares to full feed.
- 4) Mares peak lactation at 3 mo. post-foaling, and a 500-kg mare may produce over 35 lb of milk/d?

2. Growing Horses

A. Foals:

- 1) Nutrients from the mare (assuming well-fed) would be adequate during the first 3 to 4 mo.
- 2) But, they begin to eat solid food within a few days and will consume significant amounts of hay, pasture, or grain by 2 mo. of age.

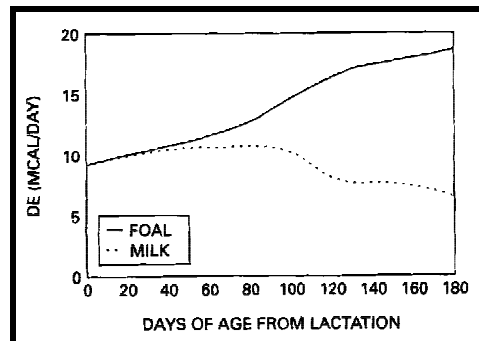


B. Weight gain and creep feed:

- 1) Weight gain - 1.2 to 1.6 kg/day in the first mo. and gradually declines to about 1.0 kg/d at 4 mo. of age. See the figure on "Representative growth curves for foals (Lawrence, 1998)."

- 2) May want to provide an appropriate creep feed (e.g., 16% CP, 0.9% Ca, and 0.6% P) at about 2 mo. of age, and can be fed about 0.5 kg/mo. of age/day?

☛ Foals should not be given unlimited access to a creep feed!



C. Weaning:

- 1) Most foals are weaned at 4 to 6 mo. of age
- 2) By 4 mo. of age, the contribution of milk to the total nutrient needs starts to decline, and additional feed is necessary even if the foal is not weaned.
- 3) By 6 mo. of age, milk provides less than 50% of the daily nutrient intake. See the figure on "DE needs of a growing horse & DE contributed by mare's milk (Lawrence, 1998)."
- 4) The foals should be consuming 6 to 8 lb (2.7 to 3.6 kg) of feed at weaning time or 5 to 6 mo. of age - Weaning can be stressful for many foals, and the reduction in weight gain may be as brief as a week if foals are accustomed to eating substantial amounts of pasture, hay, or grain prior to weaning.

D. Yearling and 2-yr-old:

- 1) Weight gain during the first 2 yr of life will not affect the final mature size, but may affect the age at which the animal reaches maturity.
- 2) Very rapid rates of growth - Associated with an increased incidence of bone and joint problems (osteochondrosis, physitis, cervical vertebral malformation, and angular limb deformities):
 - a) Feed diets that have an adequate amount of all required nutrients, not just energy.
 - b) Some additional nutritional factors? Low dietary Ca, low or high dietary P, an unbalanced Ca:P ratio, low dietary Cu, and very high dietary Zn.
- 3) At 1 yr of age or about 800 lb, change to a yearling diet. Possible to start relying on hay and pasture more extensively, but still very important to assure adequate protein, vitamin, and mineral intakes.
- 4) Feed based on the requirements for maintenance and growth that is desired, and feeding practice should be based on maintaining the desired condition and development and growth of the horse as the horse goes into training.

3. Working/Performance Horses

- A. Include horses being trained for various performance events or horses used for roping, cutting, jumping, etc.
- B. Generally, ridden every day, and thus have a relatively high energy expenditure, but perhaps, no greater demands for protein, Ca, P, most trace minerals, and most fat-soluble vitamins?
- C. Nutrient requirements - Vary with the type and degree of activity, e.g., racing Quarter Horse running at maximal speed for 400 yd or less vs. Arabian endurance horse competing over distances of 50 to 100 miles.

Ingredient (kg)	Trainer					
	A	B	C	D	E	F
Oats	5.4	1.3	6.0	5.2	5.9	4.2
R Oats	-	1.8	-	-	-	-
R Barley	-	0.6	-	-	-	-
Cr Maize	1.55	0.6	2.1	-	0.8	0.9
Lupins	0.3	-	0.33	1.8	-	-
Peas	-	-	0.33	--	0.4	-
Tick Beans	-	0.4	-	-	0.4	0.875
Bran	0.3	0.53	0.2	0.3	-	0.3
Sunflowers	0.25	0.2	0.1	0.1	0.4	0.075
Pellets	-	0.7	-	-	-	-
Oil	-	-	0.2	-	-	0.12
Cereal Chaff	0.4	1.8	0.45	0.8	0.65	1.8
Lucerne Chaff	0.3	0.75	0.7	0.8	0.9	1.2
Lucerne Hay	1.7	-	1.5	2	0.75	1.0
Oaten Hay	1.35	-	1.4	-	-	-
Supplements	5.0	2.0	3.0	1.0	5.0	4.0
Pasture		+			+	+

[See the table on “Examples of racing horse diets used in Australia & New Zealand,”
Huntingdon & Jenkinson (1998) in Pagan (1998).]

- D. Energy required by performance horses:
 - 1) Affected by two primary factors - The intensity of the daily exercise and the duration of the daily exercise.
 - 2) Some recommendations for the DE intake are based on general categories of work effort - Increase DE by 25, 50, and 100% above maintenance for horses involved in light, moderate, and intense exercise, respectively (. . . e.g., light work can be pleasure riding, whereas intense work can include training for races and polo?).
 - 3) Horses performing moderate or intense work? - Cannot consume enough forage to meet their energy needs, thus must increase a concentrate.
 - 4) Addition of fat to a concentrate feed can increase energy density without increasing feed/starch intake, and commercially manufactured feeds nowadays contain 4 to 8% added fat. Also, can be added directly by top dressing.
 - 5) Feeding more than 7 lb (3.2 kg) or more of concentrate/day - Should be fed in two to three meals depending on the amount. No single meal should exceed 3 kg of concentrate!?
 - 6) Feeding programs for Thoroughbred and Standardbred racehorses - Often, restrict forage intake the night or morning before a race to decrease bulk in the gastrointestinal tract.
- E. Protein - Working horses need more dietary protein than sedentary horses?
 - 1) Reasons? - a) Protein is lost in sweat, b) a small amount of protein may be broken down during exercise, and c) horses in training may retain slightly more nitrogen than horses at maintenance.

- 2) The magnitude of the needed increase may be small, and if feed intake is increased to satisfy the energy demand, perhaps, the protein requirement would be almost always satisfied!?

F. Electrolytes & other minerals:

- 1) Horse sweat is very high in Na, K, and Cl, and exercise can result in losses of these minerals.
- 2) Electrolytes cannot be stored in the body, thus the needs must be satisfied on a daily basis. Should give a small amount of a balanced supplement at regular intervals during a long ride.
- 3) Little is known about the effect of exercise on the requirement for other minerals, even though it is known that Ca and P intakes are most critical for young horses.
- 4) A reasonable guideline for mineral requirements in exercising horses? - Perhaps, increase the mineral intake (in grams per day) in proportion to the increase in the energy intake?

G. Vitamins:

- 1) Performance horses may require a higher dietary concentration of some vitamins than sedentary horses.
- 2) Many B vitamins are synthesized by microbes, but it may be better to ensure that by providing, at least, 50% of the need by the diet.
- 3) Important ones? - Thiamin, niacin, riboflavin, pantothenic acid, choline, biotin, folic acid, and B₁₂, and also vitamin E?

- H. Following a heavy exercise, small quantities (a few swallows) of water should be provided at 5- to 10 min intervals until thirst is quenched. By doing that, can prevent digestive disturbances and possibly founder from excessive water intake.

NUTRITION RELATED PROBLEMS AND FEEDING MANAGEMENT

1. Nutritional Related Problems

A. Colic

- 1) Many factors can contribute to colic, but some may be caused by dietary factors.
- 2) Colic?
 - a) Severe abdominal pain.
 - b) Horses with colic may kick at their abdomens, roll, or repeatedly attempt to urinate.
 - c) Sweating and signs of anxiety and discomfort are also common.
 - d) Some cases are mild and resolve quickly, but other cases require surgery. Can result in death.

3) Dietary factors?

- a) Lower incidence in horses with 24-hr access to pasture, but high in horses consuming a high-concentrate diet.
- b) Also, sudden changes in the diet and lack of water availability can cause the problem.
- c) To minimize the potential problem, should provide adequate water and forage, and any diet changes should be made slowly.

B. Laminitis or founder

- 1) May be caused by overconsumption of concentrate or lush-growing pasture.
- 2) Ones with acute laminitis exhibit pain and heat in the hooves and reluctant to move.
- 3) Often results in permanent lameness and may cause death in some cases.
- 4) To reduce a potential problem?
 - a) Should be adjusted to lush pastures gradually, and, whenever possible, the energy need should be met with roughage instead of concentrate.
 - b) If a horse needs a large amount of concentrate, should be adjusted to the diet gradually and should not be given more than 3 kg of concentrate at any meal.
 - c) Once a horse has foundered, she/he may become more susceptible.

C. Plant poisoning

- 1) Thistles, nettles, and burrs - Mechanically injurious to horses and may cause damage to the nose and mouth.
- 2) St. John's wort and buckwheat - May produce photosensitization, most often observed in unpigmented areas, and dermatitis.
- 3) Mountain laurel, azalea, jimson weed, oak, field blind weed, buttercups, and a number of other plants - May cause colic or diarrhea and some of these plants may be fatal with consumption of a sufficient quantity.
- 4) Other plants that may be fatal include serviceberry, elderberry, foxglove, oleander, and yew.

2. Feeding Management

A. Housing:

1) Grazing:

- a) Eating and non-eating periods are interspersed and eating periods are rarely separated by more than 2 or 3 hr, i.e., grazing horses often spend about 50 to 60% of their time or 12 to 14 hr eating.
- b) Mature horses on good-quality pasture should have access to a salt block and a source of clean fresh water.

- c) Supplementation is not necessary unless the pasture is not sufficient to meet the nutrient needs
 - d) If supplementation is needed:
 - (1) Better to bring the horse into stalls for individual feeding once or twice a day.
 - (2) If not possible to feed individually, can avoid over- or underfeeding by grouping horses by their needs.
- 2) Many pleasure and performance horses are housed in box stalls and have little access to pasture:
- a) Easy to provide each horse with a diet that is specific to its needs, but usually fed only two or three times per day, which is, perhaps, too long between meals?
 - b) Horses on a typical hay and concentrate diet may spend less than 6 hr a day "eating."
 - d) To allow stabled horses to have a more natural feeding environment:
 - (1) Hay availability should be maximized - Hay should be offered at least 1 hr before a concentrate to encourage the horse to consume hay first.
 - (2) No more than 3 kg of concentrate should be fed at one time to a mature horse (500 kg).
 - (3) Feeding more than 6 kg of concentrate/day? Then, the concentrate should be divided into at least three meals.

NUTRIENT REQUIREMENT TABLES

[Tables 1 to 5 - NRC (2007); Tables 6 to 8 - NRC (1989); Abbreviations: **Wt** = weight; **ADG** = average daily gain; **DE** = digestible energy; **CP** = crude protein]

1. Table 1. Daily Nutrient Requirements of Horses (Mature Body Wt, 200 kg)^a

Type	Wt, kg	ADG/ Milk, kg/d	DE, Meal	CP, g	Lys, g	Ca, g	P, g	Mg, g	K, g	Na, g	Cl, g	S, g
Adult - no work ^b												
Minimum	200		6.1	216	9.3	8.0	5.6	3.0	10.0	4.0	16.0	6.0
Average	200		6.7	252	10.8	8.0	5.6	3.0	10.0	4.0	16.0	6.0
Elevated	200		7.3	288	12.4	8.0	5.6	3.0	10.0	4.0	16.0	6.0
Working ^c												
Light exercise	200		8.0	280	12.0	12.0	7.2	3.8	11.4	5.6	18.7	6.0
Moderate exercise	200		9.3	307	13.2	14.0	8.4	4.6	12.8	7.1	21.3	6.8
Heavy exercise	200		10.7	345	14.8	16.0	11.6	6.0	15.6	10.2	26.6	7.5
Very heavy exercise	200		13.8	402	17.3	16.0	11.6	6.0	21.2	16.4	37.2	7.5
Stallions												
Nonbreeding	200		7.3	288	12.4	8.0	5.6	3.0	10.0	4.0	16.0	6.0
Breeding	200		8.7	316	13.6	12.0	7.2	3.8	11.4	5.6	18.7	6.0
Pregnant mares												
Early (< 5 months)	200		6.7	252	10.8	8.0	5.6	3.0	10.0	4.0	16.0	6.0
5 months	201	0.05	6.8	274	11.8	8.0	5.6	3.0	10.0	4.0	16.0	6.0
6 months	203	0.07	7.0	282	12.1	8.0	5.6	3.0	10.0	4.0	16.0	6.0
7 months	206	0.10	7.2	291	12.5	11.2	8.0	3.0	10.0	4.0	16.0	6.0
8 months	209	0.13	7.4	304	13.1	11.2	8.0	3.0	10.0	4.0	16.0	6.0
9 months	214	0.16	7.7	319	13.7	14.4	10.5	3.1	10.3	4.4	16.4	6.0
10 months	219	0.21	8.1	336	14.5	14.4	10.5	3.1	10.3	4.4	16.4	6.0
11 months	226	0.26	8.6	357	15.4	14.4	10.5	3.1	10.3	4.4	16.4	6.0
Lactating mares												
1 months	200	6.52	12.7	614	33.9	23.6	15.3	4.5	19.1	5.1	18.2	7.5
2 months	200	6.48	12.7	612	33.8	23.6	15.2	4.5	19.1	5.1	18.2	7.5
3 months	200	5.98	12.2	587	32.1	22.4	14.4	4.3	18.4	5.0	18.2	7.5
4 months	200	5.42	11.8	559	30.3	16.7	10.5	4.2	14.3	4.8	18.2	7.5
5 months	200	4.88	11.3	532	28.5	15.8	9.9	4.1	13.9	4.7	18.2	7.5
6 months	200	4.36	10.9	506	26.8	15.0	9.3	3.5	13.5	4.6	18.2	7.5
Growing animals												
4 months	67	0.34	5.3	268	11.5	15.6	8.7	1.4	4.4	1.7	6.3	2.5
6 months	86	0.29	6.2	270	11.6	15.5	8.6	1.7	5.2	2.0	8.0	3.2
12 months	128	0.18	7.5	338	14.5	15.1	8.4	2.2	7.0	2.8	10.6	4.8
18 months	155	0.11	7.7	320	13.7	14.8	8.2	2.5	8.1	3.2	12.8	5.8
18 light exercise	155	0.11	8.8	341	14.7	14.8	8.2	4.6	9.2	4.4	14.8	5.8
18 moderate exercise	155	0.11	10.0	362	15.6	14.8	8.2	4.6	10.3	5.6	16.9	5.8
24 months	172	0.07	7.5	308	13.2	14.7	8.1	2.7	8.8	3.5	14.2	6.4
24 light exercise	172	0.07	8.7	332	14.3	14.7	8.1	5.2	10.0	4.8	16.4	6.4
24 moderate exercise	172	0.07	9.9	355	15.3	14.7	8.1	5.2	11.2	6.2	18.7	6.4
24 heavy exercise	172	0.07	11.2	387	16.7	14.7	8.1	5.2	13.6	8.8	23.3	6.4
24 very heavy exercise	172	0.07	13.0	436	18.8	14.7	8.1	5.2	18.4	14.1	32.4	6.4

^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 horses 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.

- Cont. - Table 1. Daily Nutrient Requirements of Horses (Mature Body Wt, 200 kg)^a

Type	Co, mg	Cu, mg	I, mg	Fe, mg	Mn, mg	Se, mg	Zn, mg	A, kIU	D, IU	E, IU	Thiamin, mg	Riboflavin, mg
Adult - no work^b												
Minimum	0.2	40.0	1.4	160.0	160.0	0.40	160.0	6.0	1320	200	12.0	8.0
Average	0.2	40.0	1.4	160.0	160.0	0.40	160.0	6.0	1320	200	12.0	8.0
Elevated	0.2	40.0	1.4	160.0	160.0	0.40	160.0	6.0	1320	200	12.0	8.0
Working^c												
Light exercise	0.2	40.0	1.4	160.0	160.0	0.40	160.0	9.0	1320	320	12.0	8.0
Moderate exercise	0.2	45.0	1.6	180.0	180.0	0.45	180.0	9.0	1320	360	22.6	9.0
Heavy exercise	0.3	50.0	1.8	200.0	200.0	0.50	200.0	9.0	1320	400	25.0	10.0
Very heavy exercise	0.3	50.0	1.8	200.0	200.0	0.50	200.0	9.0	1320	400	25.0	10.0
Stallions												
Nonbreeding	0.2	40.0	1.4	160.0	160.0	0.40	160.0	6.0	1320	200	12.0	8.0
Breeding	0.2	40.0	1.4	160.0	160.0	0.40	160.0	9.0	1320	320	12.0	8.0
Pregnant mares												
Early (< 5 months)	0.2	40.0	1.4	160.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
5 months	0.2	40.0	1.4	160.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
6 months	0.2	40.0	1.4	160.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
7 months	0.2	40.0	1.4	160.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
8 months	0.2	40.0	1.4	160.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
9 months	0.2	50.0	1.6	200.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
10 months	0.2	50.0	1.6	200.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
11 months	0.2	50.0	1.6	200.0	160.0	0.40	160.0	12.0	1320	320	12.0	8.0
Lactating mares												
1 months	0.3	50.0	1.8	250.0	200.0	0.50	200.0	12.0	1320	400	15.0	10.0
2 months	0.3	50.0	1.8	250.0	200.0	0.50	200.0	12.0	1320	400	15.0	10.0
3 months	0.3	50.0	1.8	250.0	200.0	0.50	200.0	12.0	1320	400	15.0	10.0
4 months	0.3	50.0	1.8	250.0	200.0	0.50	200.0	12.0	1320	400	15.0	10.0
5 months	0.3	50.0	1.8	250.0	200.0	0.50	200.0	12.0	1320	400	15.0	10.0
6 months	0.3	50.0	1.8	250.0	200.0	0.50	200.0	12.0	1320	400	15.0	10.0
Growing animals												
4 months	0.1	16.8	0.6	84.2	67.4	0.17	67.4	3.0	1496	135	5.1	3.4
6 months	0.1	21.6	0.8	107.9	86.4	0.22	86.4	3.9	1917	173	6.5	4.3
12 months	0.2	32.1	1.1	160.6	128.5	0.32	128.5	5.8	2236	257	9.6	6.4
18 months	0.2	38.7	1.4	193.7	155.0	0.39	155.0	7.0	2464	310	11.6	7.7
18 light exercise	0.2	38.7	1.4	193.7	155.0	0.39	155.0	7.0	2464	310	11.6	7.7
18 moderate exercise	0.2	38.7	1.4	193.7	155.0	0.39	155.0	7.0	2464	310	11.6	7.7
24 months	0.2	42.9	1.5	214.6	171.7	0.43	171.7	7.7	2352	343	12.9	8.6
24 light exercise	0.2	42.9	1.5	214.6	171.7	0.43	171.7	7.7	2352	343	12.9	8.6
24 moderate exercise	0.2	42.9	1.5	214.6	171.7	0.43	171.7	7.7	2352	343	12.9	8.6
24 heavy exercise	0.2	42.9	1.5	214.6	171.7	0.43	171.7	7.7	2352	343	12.9	8.6
24 very heavy exercise	0.2	42.9	1.5	214.6	171.7	0.43	171.7	7.7	2352	343	12.9	8.6

^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 horses 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.

2. Table 2. Daily Nutrient Requirements of Horses (Mature Body Wt, 400 kg)^a

Type	Wt, kg	ADG/ Milk, kg/d	DE, Meal	CP, g	Lys, g	Ca, g	P, g	Mg, g	K, g	Na, g	Cl, g	S, g
Adult-no work^b												
Minimum	400		12.1	432	18.6	16.0	11.2	6.0	20.0	8.0	32.0	12.0
Average	400		13.3	504	21.7	16.0	11.2	6.0	20.0	8.0	32.0	12.0
Elevated	400		14.5	576	24.8	16.0	11.2	6.0	20.0	8.0	32.0	12.0
Working^c												
Light exercise	400		16.0	559	24.1	24.0	14.4	7.6	22.8	11.1	37.3	12.0
Moderate exercise	400		18.6	614	26.4	28.0	16.8	9.2	25.6	14.2	42.6	13.5
Heavy exercise	400		21.3	689	29.6	32.0	23.2	12.0	31.2	20.4	53.2	15.0
Very heavy exercise	400		27.6	804	34.6	32.0	23.2	12.0	42.4	32.8	74.4	15.0
Stallions												
Nonbreeding	400		14.5	576	24.8	16.0	11.2	6.0	20.0	8.0	32.0	12.0
Breeding	400		17.4	631	27.1	24.0	14.4	7.6	22.8	11.1	37.3	12.0
Pregnant mares												
Early (< 5 months)	400		13.3	504	21.7	16.0	11.2	6.0	20.0	8.0	32.0	12.0
5 months	403	0.11	13.7	548	23.6	16.0	11.2	6.0	20.0	8.0	32.0	12.0
6 months	407	0.15	13.9	563	24.2	16.0	11.2	6.0	20.0	8.0	32.0	12.0
7 months	412	0.19	14.3	583	25.1	22.4	16.0	6.1	20.0	8.0	32.0	12.0
8 months	419	0.26	14.8	607	26.1	22.4	16.0	6.1	20.0	8.0	32.0	12.0
9 months	427	0.33	15.4	637	27.4	28.8	21.0	6.1	20.7	8.8	32.8	12.0
10 months	439	0.42	16.2	673	28.9	28.8	21.0	6.1	20.7	8.8	32.8	12.0
11 months	453	0.52	17.1	714	30.7	28.8	21.0	6.1	20.7	8.8	32.8	12.0
Lactating mares												
1 months	400	13.04	25.4	1228	67.8	47.3	30.6	8.9	38.3	10.2	36.4	15.0
2 months	400	12.96	25.3	1224	67.5	47.1	30.5	8.9	38.1	10.2	36.4	15.0
3 months	400	11.96	24.5	1174	64.2	44.7	28.8	8.7	36.7	10.0	36.4	15.0
4 months	400	10.84	23.6	1118	60.5	33.3	20.9	8.4	28.7	9.5	36.4	15.0
5 months	400	9.76	22.7	1064	57.0	31.6	19.7	8.2	27.8	9.4	36.4	15.0
6 months	400	8.72	21.8	1012	53.5	30.0	18.6	7.0	27.0	9.2	36.4	15.0
Growing animals												
4 months	135	0.67	10.6	535	23.0	31.3	17.4	2.9	8.8	3.4	12.5	5.1
6 months	173	0.58	12.4	541	23.3	30.9	17.2	3.3	10.4	4.0	16.1	6.5
12 months	257	0.36	15.0	677	29.1	30.1	16.7	4.3	13.9	5.5	21.2	9.6
18 months	310	0.23	15.4	639	27.5	29.6	16.5	4.9	16.2	6.4	25.6	11.6
18 light exercise	310	0.23	17.7	682	29.3	29.6	16.5	9.3	18.4	8.8	29.7	11.6
18 moderate exercise	310	0.23	20.0	725	31.2	29.6	16.5	9.3	20.5	11.2	33.8	11.6
24 months	343	0.14	15.0	616	26.5	29.3	16.3	5.3	17.6	7.0	28.3	12.9
24 light exercise	343	0.14	17.4	663	28.5	29.3	16.3	10.3	20.0	9.7	32.9	12.9
24 moderate exercise	343	0.14	19.9	710	30.6	29.3	16.3	10.3	22.4	12.3	37.4	12.9
24 heavy exercise	343	0.14	22.3	775	33.3	29.3	16.3	10.3	27.2	17.7	46.5	12.9
24 very heavy exercise	343	0.14	26.0	873	37.5	29.3	16.3	10.3	36.8	28.3	64.7	12.9

^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.

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- Cont. - Table 2. Daily Nutrient Requirements of Horses (Mature Body Wt, 400 kg)^a

Type	Co, mg	Cu, mg	I, mg	Fe, mg	Mn, mg	Se, mg	Zn, mg	A, kIU	D, IU	E, IU	Thiamin, mg	Riboflavin, mg
Adult - no work ^b												
Minimum	0.4	80.0	2.8	320.0	320.0	0.80	320.0	12.0	2640	400	24.0	16.0
Average	0.4	80.0	2.8	320.0	320.0	0.80	320.0	12.0	2640	400	24.0	16.0
Elevated	0.4	80.0	2.8	320.0	320.0	0.80	320.0	12.0	2640	400	24.0	16.0
Working ^c												
Light exercise	0.4	80.0	2.8	320.0	320.0	0.80	320.0	18.0	2640	640	24.0	16.0
Moderate exercise	0.5	90.0	3.2	360.0	360.0	0.90	360.0	18.0	2640	720	45.2	18.0
Heavy exercise	0.5	100.0	3.5	400.0	400.0	1.00	400.0	18.0	2640	800	50.0	20.0
Very heavy exercise	0.5	100.0	3.5	400.0	400.0	1.00	400.0	18.0	2640	800	50.0	20.0
Stallions												
Nonbreeding	0.4	80.0	2.8	320.0	320.0	0.80	320.0	12.0	2640	400	24.0	16.0
Breeding	0.4	80.0	2.8	320.0	320.0	0.80	320.0	18.0	2640	640	24.0	16.0
Pregnant mares												
Early (< 5 months)	0.4	80.0	2.8	320.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
5 months	0.4	80.0	2.8	320.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
6 months	0.4	80.0	2.8	320.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
7 months	0.4	80.0	2.8	320.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
8 months	0.4	80.0	2.8	320.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
9 months	0.4	100.0	3.2	400.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
10 months	0.4	100.0	3.2	400.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
11 months	0.4	100.0	3.2	400.0	320.0	0.80	320.0	24.0	2640	640	24.0	16.0
Lactating mares												
1 months	0.5	100.0	3.5	500.0	400.0	1.00	400.0	24.0	2640	800	30.0	20.0
2 months	0.5	100.0	3.5	500.0	400.0	1.00	400.0	24.0	2640	800	30.0	20.0
3 months	0.5	100.0	3.5	500.0	400.0	1.00	400.0	24.0	2640	800	30.0	20.0
4 months	0.5	100.0	3.5	500.0	400.0	1.00	400.0	24.0	2640	800	30.0	20.0
5 months	0.5	100.0	3.5	500.0	400.0	1.00	400.0	24.0	2640	800	30.0	20.0
6 months	0.5	100.0	3.5	500.0	400.0	1.00	400.0	24.0	2640	800	30.0	20.0
Growing animals												
4 months	0.2	33.7	1.2	168.5	134.8	0.34	134.8	6.1	2992	270	10.1	6.7
6 months	0.2	43.2	1.5	215.9	172.7	0.43	172.7	7.8	3834	345	13.0	8.6
12 months	0.3	64.2	2.3	321.2	257.0	0.64	257.0	11.6	4471	514	19.3	12.8
18 months	0.4	77.5	2.7	387.5	310.0	0.77	310.0	13.9	4929	620	23.2	15.5
18 light exercise	0.4	77.5	2.7	387.5	310.0	0.77	310.0	13.9	4929	620	23.2	15.5
18 moderate exercise	0.4	77.5	2.7	387.5	310.0	0.77	310.0	13.9	4929	620	23.2	15.5
24 months	0.4	85.8	3.0	429.2	343.4	0.86	343.4	15.5	4704	687	25.8	17.2
24 light exercise	0.4	85.8	3.0	429.2	343.4	0.86	343.4	15.5	4704	687	25.8	17.2
24 moderate exercise	0.4	85.8	3.0	429.2	343.4	0.86	343.4	15.5	4704	687	25.8	17.2
24 heavy exercise	0.4	85.8	3.0	429.2	343.4	0.86	343.4	15.5	4704	687	25.8	17.2
24 very heavy exercise	0.4	85.8	3.0	429.2	343.4	0.86	343.4	15.5	4704	687	25.8	17.2

^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 horses in each category are described in Chapter I. 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.

3. Table 3. Daily Nutrient Requirements of Horses (Mature Body Wt, 500 kg)^a

Type	Wt, kg	ADG/ Milk, kg/d	DE, Mcal	CP, g	Lys, g	Ca, g	P, g	Mg, g	K, g	Na, g	Cl, g	S, g
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
Average	500		16.7	630	27.1	20.0	14.0	7.5	25.0	10.0	40.0	15.0
Elevated	500		18.2	720	31.0	20.0	14.0	7.5	25.0	10.0	40.0	15.0
Working ^c												
Light exercise	500		20.0	699	30.1	30.0	18.0	9.5	28.5	13.9	46.6	15.0
Moderate exercise	500		23.3	768	33.0	35.0	21.0	11.5	32.0	17.8	53.3	16.9
Heavy exercise	500		26.6	862	37.1	40.0	29.0	15.0	39.0	25.5	66.5	18.8
Very heavy exercise	500		34.5	1004	43.2	40.0	29.0	15.0	53.0	41.0	93.0	18.8
Stallions												
Nonbreeding	500		18.2	720	31.0	20.0	14.0	7.5	25.0	10.0	40.0	15.0
Breeding	500		21.8	789	33.9	30.0	18.0	9.5	28.5	13.9	46.6	15.0
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
5 months	504	0.14	17.1	685	29.5	20.0	14.0	7.5	25.0	10.0	40.0	15.0
6 months	508	0.18	17.4	704	30.3	20.0	14.0	7.5	25.0	10.0	40.0	15.0
7 months	515	0.24	17.9	729	31.3	28.0	20.0	7.6	25.0	10.0	40.0	15.0
8 months	523	0.32	18.5	759	32.7	28.0	20.0	7.6	25.0	10.0	40.0	15.0
9 months	534	0.41	19.2	797	34.3	36.0	26.3	7.7	25.9	11.0	41.0	15.0
10 months	548	0.52	20.2	841	36.2	36.0	26.3	7.7	25.9	11.0	41.0	15.0
11 months	566	0.65	21.4	893	38.4	36.0	26.3	7.7	25.9	11.0	41.0	15.0
Lactating mares												
1 months	500	16.30	31.7	1535	84.8	59.1	38.3	11.2	47.8	12.8	45.5	18.8
2 months	500	16.20	31.7	1530	84.4	58.9	38.1	11.1	47.7	12.8	45.5	18.8
3 months	500	14.95	30.6	1468	80.3	55.9	36.0	10.9	45.9	12.5	45.5	18.8
4 months	500	13.55	29.4	1398	75.7	41.7	26.2	10.5	35.8	11.9	45.5	18.8
5 months	500	12.20	28.3	1330	71.2	39.5	24.7	10.2	34.8	11.7	45.5	18.8
6 months	500	10.90	27.2	1265	66.9	37.4	23.2	8.7	33.7	11.5	45.5	18.8
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
6 months	216	0.72	15.5	676	29.1	38.6	21.5	4.1	13.0	5.0	20.1	8.1
12 months	321	0.45	18.8	846	36.4	37.7	20.9	5.4	17.4	6.9	26.5	12.0
18 months	387	0.29	19.2	799	34.4	37.0	20.6	6.2	20.2	8.0	32.0	14.5
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
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
24 months	429	0.18	18.7	770	33.1	36.7	20.4	6.7	22.0	8.8	35.4	16.1
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
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
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
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

^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 horses 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.

- Cont. - Table 3. Daily Nutrient Requirements of Horses (Mature Body Wt, 500 kg)^a

Type	Co mg	Cu mg	I mg	Fe mg	Mn mg	Se mg	Zn mg	A kIU	D IU	E IU	Thiamin mg	Riboflavin mg
Adult - no work^b												
Minimum	0.5	100.0	3.5	400.0	400.0	1.00	400.0	15.0	3300	500	30.0	20.0
Average	0.5	100.0	3.5	400.0	400.0	1.00	400.0	15.0	3300	500	30.0	20.0
Elevated	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	0.5	100.0	3.5	400.0	400.0	1.00	400.0	22.5	3300	800	30.0	20.0
Moderate exercise	0.6	112.5	4.0	450.0	450.0	1.13	450.0	22.5	3300	900	56.5	22.5
Heavy exercise	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	0.6	125.0	4.4	500.0	500.0	1.25	500.0	22.5	3300	1000	62.5	25.0
Stallions												
Nonbreeding	0.5	100.0	3.5	400.0	400.0	1.00	400.0	15.0	3300	500	30.0	20.0
Breeding	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)	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0
5 months	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0
6 months	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0
7 months	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0
8 months	0.5	100.0	3.5	400.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0
9 months	0.5	125.0	4.0	500.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0
10 months	0.5	125.0	4.0	500.0	400.0	1.00	400.0	30.0	3300	800	30.0	20.0
11 months	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	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	25.0
2 months	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	25.0
3 months	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	25.0
4 months	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	25.0
5 months	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	25.0
6 months	0.6	125.0	4.4	625.0	500.0	1.25	500.0	30.0	3300	1000	37.5	25.0
Growing animals												
4 months	0.2	42.1	1.5	210.6	168.5	0.42	168.5	7.6	3740	337	12.6	8.4
6 months	0.3	54.0	1.9	269.9	215.9	0.54	215.9	9.7	4793	432	16.2	10.8
12 months	0.4	80.3	2.8	401.5	321.2	0.80	321.2	14.5	5589	642	24.1	16.1
18 months	0.5	96.9	3.4	484.4	387.5	0.97	387.5	17.4	6161	775	29.1	19.4
18 light exercise	0.5	96.9	3.4	484.4	387.5	0.97	387.5	17.4	6161	775	29.1	19.4
18 moderate exercise	0.5	96.9	3.4	484.4	387.5	0.97	387.5	17.4	6161	775	29.1	19.4
24 months	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	21.5
24 light exercise	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	21.5
24 moderate exercise	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	21.5
24 heavy exercise	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	21.5
24 very heavy exercise	0.5	107.3	3.8	536.5	429.2	1.07	429.2	19.3	5880	858	32.2	21.5

^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 horses 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.

4. Table 4. Daily Nutrient Requirements of Horses (Mature Body Wt, 600 kg)^a

Type	Wt, kg	ADG/ Milk, kg/d	DE, Meal	CP, g	Lys, g	Ca, g	P, g	Mg, g	K, g	Na, g	Cl, g	S, g
Adult - no work^b												
Minimum	600		18.2	648	27.9	24.0	16.8	9.0	30.0	12.0	48.0	18.0
Average	600		20.0	756	32.5	24.0	16.8	9.0	30.0	12.0	48.0	18.0
Elevated	600		21.8	864	37.2	24.0	16.8	9.0	30.0	12.0	48.0	18.0
Working^c												
Light exercise	600		24.0	839	36.1	36.0	21.6	11.4	34.2	16.7	56.0	18.0
Moderate exercise	600		28.0	921	39.6	42.0	25.2	13.8	38.4	21.3	63.9	20.3
Heavy exercise	600		32.0	1034	44.5	48.0	34.8	18.0	46.8	30.6	79.8	22.5
Very heavy exercise	600		41.4	1205	51.8	48.0	34.8	18.0	63.6	49.2	111.6	22.5
Stallions												
Nonbreeding	600		21.8	864	37.2	24.0	16.8	9.0	30.0	12.0	48.0	18.0
Breeding	600		26.1	947	40.7	36.0	21.6	11.4	34.2	16.7	56.0	18.0
Pregnant mares												
Early (< 5 months)	600		20.0	756	32.5	24.0	16.8	9.0	30.0	12.0	48.0	18.0
5 months	604	0.16	20.5	822	35.3	24.0	16.8	9.0	30.0	12.0	48.0	18.0
6 months	610	0.22	20.9	845	36.3	24.0	16.8	9.0	30.0	12.0	48.0	18.0
7 months	618	0.29	21.5	874	37.6	33.6	24.0	9.1	30.0	12.0	48.0	18.0
8 months	628	0.38	22.2	911	39.2	33.6	24.0	9.1	30.0	12.0	48.0	18.0
9 months	641	0.49	23.1	956	41.1	43.2	31.5	9.2	31.0	13.2	49.2	18.0
10 months	658	0.63	24.2	1009	43.4	43.2	31.5	9.2	31.0	13.2	49.2	18.0
11 months	679	0.78	25.7	1072	46.1	43.2	31.5	9.2	31.0	13.2	49.2	18.0
Lactating mares												
1 months	600	19.56	38.1	1842	101.7	70.9	45.9	13.4	57.4	15.3	54.6	22.5
2 months	600	19.44	38.0	1836	101.3	70.7	45.7	13.4	57.2	15.3	54.6	22.5
3 months	600	17.94	36.7	1761	96.4	67.1	43.2	13.0	55.1	15.0	54.6	22.5
4 months	600	16.26	35.3	1677	90.8	50.0	31.4	12.7	43.0	14.3	54.6	22.5
5 months	600	14.64	34.0	1596	85.5	47.4	29.6	12.3	41.7	14.0	54.6	22.5
6 months	600	13.08	32.7	1518	80.3	44.9	27.9	10.5	40.5	13.8	54.6	22.5
Growing animals												
4 months	202	1.01	15.9	803	34.5	46.9	26.1	4.3	13.1	5.1	18.8	7.6
6 months	259	0.87	18.6	811	34.9	46.4	25.8	5.0	15.6	6.0	24.1	9.7
12 months	385	0.54	22.5	1015	43.6	45.2	25.1	6.5	20.9	8.3	31.8	14.5
18 months	465	0.34	23.1	959	41.2	44.5	24.7	7.4	24.3	9.6	38.4	17.4
18 light exercise	465	0.34	26.5	1023	44.0	44.5	24.7	13.9	27.5	13.2	44.5	17.4
18 moderate exercise	465	0.34	30.0	1087	46.7	44.5	24.7	13.9	30.8	16.9	50.7	17.4
24 months	515	0.22	22.4	924	39.7	44.0	24.4	8.0	26.4	10.5	42.5	19.3
24 light exercise	515	0.22	26.1	995	42.8	44.0	24.4	15.5	30.0	14.5	49.3	19.3
24 moderate exercise	515	0.22	29.8	1066	45.8	44.0	24.4	15.5	33.6	18.5	56.1	19.3
24 heavy exercise	515	0.22	33.5	1162	50.0	44.0	24.4	15.5	40.8	26.5	69.8	19.3
24 very heavy exercise	515	0.22	39.0	1309	56.3	44.0	24.4	15.5	55.2	42.4	97.1	19.3

^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 horses 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.

- Cont. - Table 4. Daily Nutrient Requirements of Horses (Mature Body Wt, 600 kg)^a

Type	Co, mg	Cu, mg	I, mg	Fe, mg	Mn, mg	Se, mg	Zn, mg	A, kIU	D, IU	E, IU	Thiamin, mg	Riboflavin, mg
Adult - no work ^b												
Minimum	0.6	120.0	4.2	480.0	480.0	1.20	480.0	18.0	3960	600	36.0	24.0
Average	0.6	120.0	4.2	480.0	480.0	1.20	480.0	18.0	3960	600	36.0	24.0
Elevated	0.6	120.0	4.2	480.0	480.0	1.20	480.0	18.0	3960	600	36.0	24.0
Working ^c												
Light exercise	0.6	120.0	4.2	480.0	480.0	1.20	480.0	27.0	3960	960	36.0	24.0
Moderate exercise	0.7	135.0	4.7	540.0	540.0	1.35	540.0	27.0	3960	1080	67.8	27.0
Heavy exercise	0.8	150.0	5.3	600.0	600.0	1.50	600.0	27.0	3960	1200	75.0	30.0
Very heavy exercise	0.8	150.0	5.3	600.0	600.0	1.50	600.0	27.0	3960	1200	75.0	30.0
Stallions												
Nonbreeding	0.6	120.0	4.2	480.0	480.0	1.20	480.0	18.0	3960	600	36.0	24.0
Breeding	0.6	120.0	4.2	480.0	480.0	1.20	480.0	27.0	3960	960	36.0	24.0
Pregnant mares												
Early (< 5 months)	0.6	120.0	4.2	480.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
5 months	0.6	120.0	4.2	480.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
6 months	0.6	120.0	4.2	480.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
7 months	0.6	120.0	4.2	480.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
8 months	0.6	120.0	4.2	480.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
9 months	0.6	150.0	4.8	600.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
10 months	0.6	150.0	4.8	600.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
11 months	0.6	150.0	4.8	600.0	480.0	1.20	480.0	36.0	3960	960	36.0	24.0
Lactating mares												
1 months	0.8	150.0	5.3	750.0	600.0	1.50	600.0	36.0	3960	1200	45.0	30.0
2 months	0.8	150.0	5.3	750.0	600.0	1.50	600.0	36.0	3960	1200	45.0	30.0
3 months	0.8	150.0	5.3	750.0	600.0	1.50	600.0	36.0	3960	1200	45.0	30.0
4 months	0.8	150.0	5.3	750.0	600.0	1.50	600.0	36.0	3960	1200	45.0	30.0
5 months	0.8	150.0	5.3	750.0	600.0	1.50	600.0	36.0	3960	1200	45.0	30.0
6 months	0.8	150.0	5.3	750.0	600.0	1.50	600.0	36.0	3960	1200	45.0	30.0
Growing animals												
4 months	0.3	50.5	1.8	252.7	202.1	0.51	202.1	9.1	4488	404	15.2	10.1
6 months	0.3	64.8	2.3	323.8	259.1	0.65	259.1	11.7	5751	518	19.4	13.0
12 months	0.5	96.4	3.4	481.8	385.5	0.96	385.5	17.3	6707	771	28.9	19.3
18 months	0.6	116.2	4.1	581.2	465.0	1.16	465.0	20.9	7393	930	34.9	23.2
18 light exercise	0.6	116.2	4.1	581.2	465.0	1.16	465.0	20.9	7393	930	34.9	23.2
18 moderate exercise	0.6	116.2	4.1	581.2	465.0	1.16	465.0	20.9	7393	930	34.9	23.2
24 months	0.6	128.8	4.5	643.8	515.0	1.29	515.0	23.2	7056	1030	38.6	25.8
24 light exercise	0.6	128.8	4.5	643.8	515.0	1.29	515.0	23.2	7056	1030	38.6	25.8
24 moderate exercise	0.6	128.8	4.5	643.8	515.0	1.29	515.0	23.2	7056	1030	38.6	25.8
24 heavy exercise	0.6	128.8	4.5	643.8	515.0	1.29	515.0	23.2	7056	1030	38.6	25.8
24 very heavy exercise	0.6	128.8	4.5	643.8	515.0	1.29	515.0	23.2	7056	1030	38.6	25.8

^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 horses 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.

5. Table 5. Daily Nutrient Requirements of Horses (Mature Body Wt, 900 kg)^a

Type	Wt , kg	ADG/ Milk, kg/d	DE, Mcal	CP, g	Lys, g	Ca, g	P, g	Mg , g	K, g	Na, g	Cl, g	S, g
Adult - no work^b												
Minimum	900		27.3	972	41.8	36.0	25.2	13.5	45.0	18.0	72.0	27.0
Average	900		30.0	1134	48.8	36.0	25.2	13.5	45.0	18.0	72.0	27.0
Elevated	900		32.7	1296	55.7	36.0	25.2	13.5	45.0	18.0	72.0	27.0
Working^c												
Light exercise	900		36.0	1259	54.1	54.0	32.4	17.1	51.3	25.0	83.9	27.0
Moderate exercise	900		42.0	1382	59.4	63.0	37.8	20.7	57.6	32.0	95.9	30.4
Heavy exercise	900		48.0	1551	66.7	72.0	52.2	27.0	70.2	45.9	119.7	33.8
Very heavy exercise	900		62.1	1808	77.7	72.0	52.2	27.0	95.4	73.8	167.4	33.8
Stallions												
Nonbreeding	900		32.7	1296	55.7	36.0	25.2	13.5	45.0	18.0	72.0	27.0
Breeding	900		39.2	1421	61.1	54.0	32.4	17.1	51.3	25.0	83.9	27.0
Pregnant mares												
Early (< 5 months)	900		30.0	1134	48.8	36.0	25.2	13.5	45.0	18.0	72.0	27.0
5 months	906	0.24	30.8	1233	53.0	36.0	25.2	13.5	45.0	18.0	72.0	27.0
6 months	915	0.33	31.4	1267	54.5	36.0	25.2	13.5	45.0	18.0	72.0	27.0
7 months	927	0.44	32.2	1311	56.4	50.4	36.0	13.7	45.0	18.0	72.0	27.0
8 months	942	0.57	33.3	1367	58.8	50.4	36.0	13.7	45.0	18.0	72.0	27.0
9 months	962	0.74	34.6	1434	61.7	64.8	47.3	13.8	46.5	19.8	73.8	27.0
10 months	987	0.94	36.4	1514	65.1	64.8	47.3	13.8	46.5	19.8	73.8	27.0
11 months	1019	1.17	38.5	1607	69.1	64.8	47.3	13.8	46.5	19.8	73.8	27.0
Lactating mares												
1 months	900	29.34	54.4	2763	152.6	106.4	68.9	20.1	86.1	23.0	81.9	33.8
2 months	900	29.16	54.3	2754	152.0	106.0	68.6	20.1	85.8	23.0	81.9	33.8
3 months	900	26.91	52.4	2642	144.5	100.6	64.9	19.6	82.7	22.6	81.9	33.8
4 months	900	24.39	50.3	2516	136.2	75.0	47.1	19.0	64.5	21.4	81.9	33.8
5 months	900	21.96	48.3	2394	128.2	71.1	44.4	18.4	62.6	21.1	81.9	33.8
6 months	900	19.62	46.3	2277	120.5	67.4	41.8	15.7	60.7	20.7	81.9	33.8
Growing animals												
4 months	303	1.52	23.9	1204	51.8	70.3	39.1	6.4	19.7	7.6	28.2	11.4
6 months	389	1.30	28.0	1217	52.3	69.5	38.7	7.5	23.3	9.1	36.1	14.6
12 months	578	0.82	33.8	1522	65.5	67.8	37.7	9.7	31.4	12.4	47.7	21.7
18 months	697	0.51	34.6	1438	61.8	66.7	37.1	11.1	36.4	14.5	57.5	26.2
18 light exercise	697	0.51	39.8	1535	66.0	66.7	37.1	20.9	41.3	19.9	66.8	26.2
18 moderate exercise	697	0.51	45.0	1631	70.1	66.7	37.1	20.9	46.2	25.3	76.0	26.2
24 months	773	0.32	33.7	1386	59.6	66.0	36.7	12.0	39.6	15.8	63.7	29.0
24 light exercise	773	0.32	39.2	1492	64.2	66.0	36.7	23.2	45.0	21.8	74.0	29.0
24 moderate exercise	773	0.32	44.7	1599	68.7	66.0	36.7	23.2	50.4	27.7	84.2	29.0
24 heavy exercise	773	0.32	50.2	1744	75.0	66.0	36.7	23.2	61.2	39.7	104.7	29.0
24 very heavy exercise	773	0.32	58.4	1964	84.5	66.0	36.7	23.2	82.9	63.7	145.6	29.0

^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 horses 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.

- Cont. - Table 5. Daily Nutrient Requirements of Horses (Mature Body Wt, 900 kg)^a

Type	Co, mg	Cu, mg	I, mg	Fe, mg	Mn, mg	Se, mg	Zn, mg	A, kIU	D, IU	E, IU	Thiamin, mg	Riboflavin, mg
Adult - no work^b												
Minimum	0.9	180.0	6.3	720.0	720.0	1.80	720.0	27.0	5940	900	54.0	36.0
Average	0.9	180.0	6.3	720.0	720.0	1.80	720.0	27.0	5940	900	54.0	36.0
Elevated	0.9	180.0	6.3	720.0	720.0	1.80	720.0	27.0	5940	900	54.0	36.0
Working^c												
Light exercise	0.9	180.0	6.3	720.0	720.0	1.80	720.0	40.5	5940	1440	54.0	36.0
Moderate exercise	1.0	202.5	7.1	810.0	810.0	2.03	810.0	40.5	5940	1620	101.7	40.5
Heavy exercise	1.1	225.0	7.9	900.0	900.0	2.25	900.0	40.5	5940	1800	112.5	45.0
Very heavy exercise	1.1	225.0	7.9	900.0	900.0	2.25	900.0	40.5	5940	1800	112.5	45.0
Stallions												
Nonbreeding	0.9	180.0	6.3	720.0	720.0	1.80	720.0	27.0	5940	900	54.0	36.0
Breeding	0.9	180.0	6.3	720.0	720.0	1.80	720.0	40.5	5940	1440	54.0	36.0
Pregnant Mares												
Early (< 5 months)	0.9	180.0	6.3	720.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
5 months	0.9	180.0	6.3	720.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
6 months	0.9	180.0	6.3	720.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
7 months	0.9	180.0	6.3	720.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
8 months	0.9	180.0	6.3	720.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
9 months	0.9	225.0	7.2	900.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
10 months	0.9	225.0	7.2	900.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
11 months	0.9	225.0	7.2	900.0	720.0	1.80	720.0	54.0	5940	1440	54.0	36.0
Lactating mares												
1 months	1.1	225.0	7.9	1125.0	900.0	2.25	900.0	54.0	5940	1800	67.5	45.0
2 months	1.1	225.0	7.9	1125.0	900.0	2.25	900.0	54.0	5940	1800	67.5	45.0
3 months	1.1	225.0	7.9	1125.0	900.0	2.25	900.0	54.0	5940	1800	67.5	45.0
4 months	1.1	225.0	7.9	1125.0	900.0	2.25	900.0	54.0	5940	1800	67.5	45.0
5 months	1.1	225.0	7.9	1125.0	900.0	2.25	900.0	54.0	5940	1800	67.5	45.0
6 months	1.1	225.0	7.9	1125.0	900.0	2.25	900.0	54.0	5940	1800	67.5	45.0
Growing animals												
4 months	0.4	75.8	2.7	379.0	303.2	0.76	303.2	13.6	6731	606	22.7	15.2
6 months	0.5	97.1	3.4	485.7	388.6	0.97	388.6	17.5	8627	777	29.1	19.4
12 months	0.7	144.5	5.1	722.7	578.2	1.45	578.2	26.0	10061	1156	43.4	28.9
18 months	0.9	174.4	6.1	871.9	697.5	1.74	697.5	31.4	11090	1395	52.3	34.9
18 light exercise	0.9	174.4	6.1	871.9	697.5	1.74	697.5	31.4	11090	1395	52.3	34.9
18 moderate exercise	0.9	174.4	6.1	871.9	697.5	1.74	697.5	31.4	11090	1395	52.3	34.9
24 months	1.0	193.1	6.8	965.7	772.6	1.93	772.6	34.8	10584	1545	57.9	38.6
24 light exercise	1.0	193.1	6.8	965.7	772.6	1.93	772.6	34.8	10584	1545	57.9	38.6
24 moderate exercise	1.0	193.1	6.8	965.7	772.6	1.93	772.6	34.8	10584	1545	57.9	38.6
24 heavy exercise	1.0	193.1	6.8	965.7	772.6	1.93	772.6	34.8	10584	1545	57.9	38.6
24 very heavy exercise	1.0	193.1	6.8	965.7	772.6	1.93	772.6	34.8	10584	1545	57.9	38.6

^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 horses 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.

6. **Table 6. Nutrient Concentrations in Total Diets for Horses and Ponies (100% DM or 90% DM Basis)^{a,b} [NRC, 1989]**

	Diet Proportions									
	DE, Mcal/kg	Concent- rate, %	Hay, %	CP, %	Lys, %	Ca, %	P, %	Mg, %	K, %	Vitamin A, IU/kg
DM or 100% DM Basis										
Mature horses										
Maintenance	2.00	0	100	8.0	0.28	0.24	0.17	0.09	0.30	1830
Stallions	2.40	30	70	9.6	0.34	0.29	0.21	0.11	0.36	2640
Pregnant mares										
9 months	2.25	20	80	10.0	0.35	0.43	0.32	0.10	0.35	3710
10 months	2.25	20	80	10.0	0.35	0.43	0.32	0.10	0.36	3650
11 months	2.40	30	70	10.6	0.37	0.45	0.34	0.11	0.38	3650
Lactating mares										
Foaling to 3 months	2.60	50	50	13.2	0.46	0.52	0.34	0.10	0.42	2750
3 months to weaning	2.45	35	65	11.0	0.37	0.36	0.22	0.09	0.33	3020
Working horses										
Light work	2.45	35	65	9.8	0.35	0.30	0.22	0.11	0.37	2690
Moderate work	2.65	50	50	10.4	0.37	0.31	0.23	0.12	0.39	2420
Intense work	2.85	65	35	11.4	0.40	0.35	0.25	0.13	0.43	1950
Growing horses										
Weanling, 4 months	2.90	70	30	14.5	0.60	0.68	0.38	0.08	0.30	1580
Weanling, 6 months										
Moderate growth	2.90	70	30	14.5	0.61	0.56	0.31	0.08	0.30	1870
Rapid growth	2.90	70	30	14.5	0.61	0.61	0.34	0.08	0.30	1630
Yearling, 12 months										
Moderate growth	2.80	60	40	12.6	0.53	0.43	0.24	0.08	0.30	2160
Rapid growth	2.80	60	40	12.6	0.53	0.45	0.25	0.08	0.30	1920
Long yearling, 18 months										
Not in training	2.50	45	55	11.3	0.48	0.34	0.19	0.08	0.30	2270
In training	2.65	50	50	12.0	0.50	0.36	0.20	0.09	0.30	1800
Two year old, 24 months										
Not in training	2.45	35	65	10.4	0.42	0.31	0.17	0.09	0.30	2640
In training	2.65	50	50	11.3	0.45	0.34	0.20	0.10	0.32	2040
90% DM Basis										
Mature horses										
Maintenance	1.80	0	100	7.2	0.25	0.21	0.15	0.08	0.27	1650
Stallions	2.15	30	70	8.6	0.30	0.26	0.19	0.10	0.33	2370
Pregnant mares										
9 months	2.00	20	80	8.9	0.31	0.39	0.29	0.10	0.32	3330
10 months	2.00	20	80	9.0	0.32	0.39	0.30	0.10	0.33	3280
11 months	2.15	30	70	9.5	0.33	0.41	0.31	0.10	0.35	3280
Lactating mares										
Foaling to 3 months	2.35	50	50	12.0	0.41	0.47	0.30	0.09	0.38	2480
3 months to weaning	2.20	35	65	10.0	0.34	0.33	0.20	0.08	0.30	2720
Working horses										
Light work	2.20	35	65	8.8	0.32	0.27	0.19	0.10	0.34	2420
Moderate work	2.40	50	50	9.4	0.35	0.28	0.22	0.11	0.36	2140
Intense work	2.55	65	35	10.3	0.36	0.31	0.23	0.12	0.39	1760
Growing horses										
Weanling, 4 months	2.60	70	30	13.1	0.54	0.62	0.34	0.07	0.27	1420
Weanling, 6 months										
Moderate growth	2.60	70	30	13.0	0.55	0.50	0.28	0.07	0.27	1680
Rapid growth	2.60	70	30	13.1	0.55	0.55	0.30	0.07	0.27	1470
Yearling, 12 months										
Moderate growth	2.50	60	40	11.3	0.48	0.39	0.21	0.07	0.27	1950
Rapid growth	2.50	60	40	11.3	0.48	0.40	0.22	0.07	0.27	1730
Long yearling, 18 months										
Not in training	2.30	45	55	10.1	0.43	0.31	0.17	0.07	0.27	2050
In training	2.40	50	50	10.8	0.45	0.32	0.18	0.08	0.27	1620
Two year old, 24 months										
Not in training	2.20	35	65	9.4	0.38	0.28	0.15	0.08	0.27	2380
In training	2.40	50	50	10.1	0.41	0.31	0.17	0.09	0.29	1840

^aDE values assume a concentrate feed containing 3.3 Mcal/kg and hay containing 2.00 Mcal/kg of dry matter.

^bLight work: Examples are horses used in Western and English pleasure, bridle path work, equitation, etc.; Moderate work: Examples are horses used in ranch work, roping, cutting, barrel racing, jumping, etc.; Intense work: Examples are horses in race training, polo, etc.

7. Table 7. Other Minerals and Vitamins for Horses and Ponies (DM Basis)^a [NRC, 1989]

	Adequate Concentrations in Total Diets				
	Maintenance	Pregnant & Lactating Mares	Growing Horses	Working Horses	Maximum Tolerance
Minerals					
Na, %	0.10	0.10	0.10	0.30	3 ^b
S, %	0.15	0.15	0.15	0.15	1.25
Fe, mg/kg	40	50	50	40	1,000
Mn, mg/kg	40	40	40	40	1,000
Cu, mg/kg	10	10	10	10	800
Zn, mg/kg	40	40	40	40	500
Se, mg/kg	0.1	0.1	0.1	0.1	2.0
I, mg/kg	0.1 - 0.6	0.1 - 0.6	0.1 - 0.6	0.1 - 0.6	5.0
Co, mg/kg	0.1	0.1	0.1	0.1	10
Vitamins					
Vitamin A, IU/kg	2,000	3,000	2,000	2,000	16,000
Vitamin D, IU/kg ^c	300	600	800	300	2,200
Vitamin E, IU/kg	50	80	80	80	1,000
Vitamin K, mg/kg	-	-	-	-	-
Thiamin, mg/kg	3	3	3	5	3,000
Riboflavin, mg/kg	2	2	2	2	-
Niacin, mg/kg	-	-	-	-	-
Pantothenic acid, mg/kg	-	-	-	-	-
pyridoxine, mg/kg	-	-	-	-	-
Biotin, mg/kg	-	-	-	-	-
Folacin, mg/kg	-	-	-	-	-
Vitamin B ₁₂ , µg/kg	-	-	-	-	-
Ascorbic acid, mg/kg	-	-	-	-	-
Choline, mg/kg	-	-	-	-	-

^aDash ("-") indicates that data are insufficient to determine a requirement or maximum tolerable concentration.

^bAs sodium chloride.

^cRecommendations for horses not exposed to sunlight or to artificial light with an emission spectrum of 280-315 nm.

8. Table 8. Expected Feed Consumption by Horses (% Body Wt; Air-Dry Feed or About 90% DM) [NRC, 1989]

	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 lactation	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 horses			
Light work	1.0 - 2.0	0.5 - 1.0	1.5 - 2.5
Moderate work	1.0 - 2.0	0.75 - 1.5	1.75 - 2.5
Intense work	0.75 - 1.5	1.0 - 2.0	2.0 - 3.0
Young horses			
Nursing foal, 3 months	0	1.0 - 2.0	2.5 - 3.5
Weanling 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 year old (24 months)	1.0 - 1.5	1.0 - 1.5	1.75 - 2.5