1

Feeding Horses

Back to Evolution

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KEY TERMS

- Extinct refers to a species no longer in existence.
- Extant refers to a species still in existence; surviving today.
- Ungulates are even-toed or odd-toed hoofed mammals.
- The perissodactyls (odd-toed ungulates) extant examples are horses, rhinos, and tapirs.
- The artiodactyls (even-toed ungulates) extant examples are pigs, hippos, camels, deer, giraffes, antelope, cattle, and sheep.
- A "hand" is a non-international standard unit of measurement equal to 4 in. commonly used to measure the height of horses from ground level to the top of withers in many English-speaking countries.

KEY POINTS

- A review of equine evolution is essential to understanding their behavioral, nutritional, and dietary requirements.
- Horses evolved over the past 50 million years in response to environmental changes from dense humid forests to open arid grasslands.
- Extant horses adapted a form of cecal fermentation.
- The genus likely originated in North America and migrated to Old World and South America. The North American ancestors became extinct in the last American ice age but were re-introduced in the sixteenth century AD by European settlers.
- All breeds of *Equus ferus caballus* are derived from a 13–14 hand, gregarious, steppe-dwelling animal that thrived on high-fiber/low-protein/low-starch forages.

1.1 Introduction

Charles R. Darwin produced one of the first illustrations of an evolutionary "tree" in his seminal book *The Origin of Species* [1]. An evolutionary (phylogeny or phylogenetic) tree is a branching diagram outlining evolutionary relationships. Over 150 years later, evolutionary biologists still use tree diagrams to depict evolution because such figures effectively convey the concept that speciation occurs through adaptation and splitting of lineages. The tree is a visual representation of the relationship between different organisms, showing the path through evolutionary time from a common ancestor to different descendents. Important to note is that many lineages, or branches of the tree, are not successful when the environment changes and therefore become extinct. Ideally, each true species should have a name different from every other species. Specie classification has become more dynamic and may be automatically generated based on completely sequenced genomes [2]. The scientific classification of Equus, the horse, is outlined in Table 1.1 and Figure 1.1.

Within the family Equidae, Equus is the only recognized living genus with seven living species (Figure 1.1). All domestic horses (miniatures to draft size) are the same subspecies, *Equus ferus caballus*, including the feral horses of Australia, the Western United States, and Canada [4]. A true wild subspecies, *Equus ferus przewalskii*, is native to the steppes of Central Asia. Other extant members of the

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Table 1.1 Taxonomic classification of equids.

Kingdom:	Animalia
Phylum:	Chordata
Class:	Mammalia
Order:	Perissodactyls
Family:	Equidae
Tribe:	Equini
Genus:	Equus

Living species and common names of Equus are:

E. africanus (asses and donkey)

E. ferus (wild, feral and domestic horse [draft, pony, miniature])

E. grevyi (Grévy's zebra)

E. hemionus (onager, kulan)

E. kiang (kiang)

E. quagga (plains zebra)

E. zebra (mountain zebra)

genus are wild asses and zebras. The domesticated donkey is *Equus africanus, subspecie asinus*. The other wild asses, kiang, onager and kulan, and zebras have not been domesticated. Equine species can crossbreed with each other. The most common hybrid is the mule, which is a cross between a male donkey and a female horse. A related hybrid, a hinny, is a cross between a male horse and a female donkey. Most hybrids are sterile and cannot reproduce. Other hybrids include the zorse, a cross between a zebra and a horse, and a zonkey or zedonk, a hybrid of a zebra and a donkey [5].

1.2 The Evolution of Equus

1.2.1 Environmental Changes

It is generally accepted that 66 million years ago (mya), an asteroid hit the earth and changed the atmosphere and vegetation. This ecologically devastating event was responsible for the loss of half of the species of plants and insects on the North American (NA) continent at that time. The subsequent colossal loss of vegetation was responsible for the eventual demise of the dinosaurs. However, small rodent-like mammals survived in part due to their small body size, living underground, and high reproductive rates. In the absence of dinosaurs, mammals thrived, evolved, and diversified to occupy land, sea, and sky in the millions of years following the asteroid. Around 56 mya, a massive volcanic rift opened in the north Atlantic sea increasing atmospheric greenhouse gases (CO_2, CH_4) which resulted in global warming. During this warming period, the NA continent became a lush, dense, rainforest reaching as far north as Alaska providing mammals with ample food and shelter for millions of years.

However as the volcanic rift cooled over 20–30 millions years, global temperatures decreased and the NA environment changed again from a tropical to the temperate climate we know today [6]. For the next several million years, still in the absence of human beings, mammals adapted to this temperate climate and again prospered. It was during this time when NA was changing from rainforest to grassland that Equus evolved from a small fox-size forest-dwelling creature to the large, odd-toed hoofed, prairie-dwelling herbivore we know today. The evolution of the horse during this time has

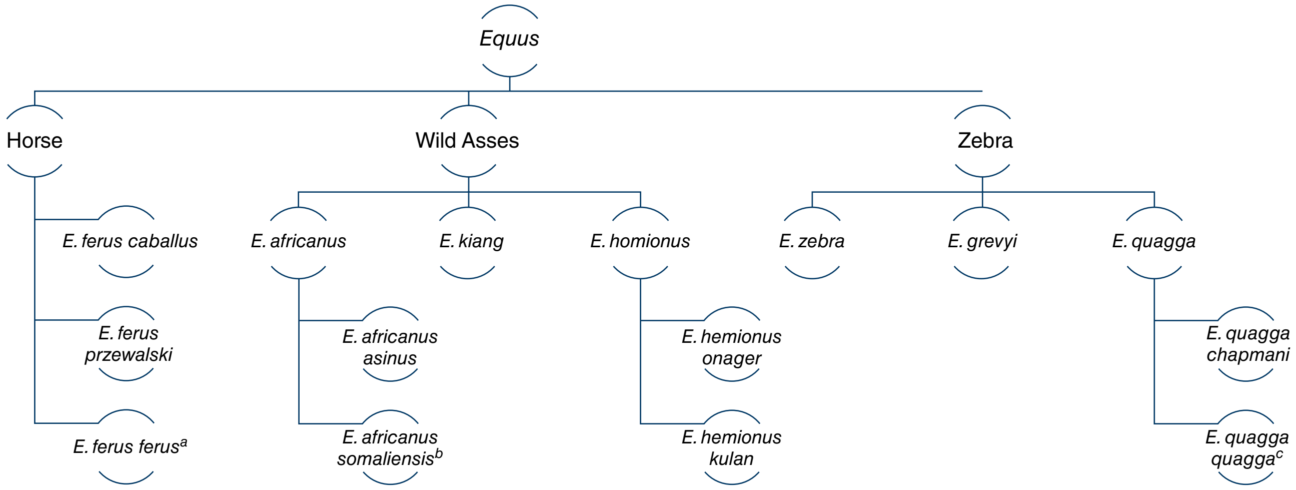

Figure 1.1 Cladogram of genus Equus speciation. *Source:* Based on Vilstrup et al. [3]. [a] Extinct in 1909, [b] Critically Endangered, [c] Extinct in 1883.

been described primarily based on changes occurring to their musculoskeletal and alimentary systems [7].

1.2.2 Musculoskeletal System Changes in Response to Predation on the Open Plains

The evolution of the horse began some 50 mya. See examples at specific points in time in Table 1.2. The common ancestor of the domesticated horse was Hyracotherium (Eohippus or the “Dawn horse”). Hyracotherium was a small mammal about 1 ft tall weighing about 15 kg, the size of a small dog, with large upper and lower canine teeth, four toes on the front limbs, and three on the hind limbs, appropriate for walking in the swamp-like rainforests of NA. See Sidebar 1.1. Eocene ancestors, Orohippus and Mesohippus, were larger and adapted to woodlands and meadow-like environments. Miohippus, Epihippus, and Parahippus

Table 1.2 A simplified version of Equus evolution in North America.

Name	Geological time periods	North American plant environment	Size/notable features
Unknown	Paleocene 56–66 mya[a]	Relatively warm temperatures worldwide gave rise to cacti, palm trees, and thick forests	Mammals only appear in the late Paleocene. Condylarths: ill-defined ancestor to the ungulates
Hyracotherium (Eohippus or Dawn horse)	Eocene 34–56 mya	In forests, while roaming the undergrowth and feeding on succulent leaves, fruits, flowers, and plant shoots, brachydont molars were changing to hypsodont molars	Height: 1 ft Weight: ~25 lb Had four toes on front three toes on rear limbs, had low-crowned teeth termed brachydont
Orohippus	Middle Eocene 45 mya	In forests, woodlands, and meadows, forest dwellers may have been browsing on plant leaves and shoots	Height: 2 ft Weight: ~50 lb Had enlarged middle toes on front and hind feet and low-crowned teeth
Mesohippus	Late Eocene 34–38 mya	In woodlands, meadows, and grasslands, forest dwellers may have been browsing leaves from bushes and small trees	Height: 2 ft Weight: ~75 lb Balanced on enlarged middle toe and had low-crowned teeth
Miohippus	Late Eocene – Early Oligocene	In meadows, grasslands, open plains, eating herbaceous plants bushes, young tree shoots, and grasses	Height: 2 ft Weight: ~100 lb Had a slightly longer skull, a large gap before the chewing teeth, and an increased tooth crown
Epihippus – a direct descendant of Orohippus	Oligocene 23–34 mya	In meadows, grasslands, open plains eating herbaceous plants, bushes, young tree shoots, and grasses	Height: 2 ft Weight: ~100 lb Had enlarged middle toes and a skull with 10 grinding molars
Parahippus – a direct descendant of Miohippus	Miocene 5–23 mya	In meadows, grasslands, open plains, adapting for quick locomotion; morphologically between brachydont and hypsodont grazing [8]	Height: 3–5 ft Weight: ~500 lb Had three visible toes but stood on one with more muscular legs adapted for forward motion, and higher tooth crown but cheek tooth wear indicates no shift to a complete grass diet
Merychippus	Miocene 15 mya	On grasslands grazing exclusively on grass – hypsodont molars	Height: 4–6 ft Weight: ~1 000 lb Had small toes surrounding enlarged middle hoof adapted for running. Incisors were better for cropping grass, and longer necks for grazing
Hipparion	Miocene 10 mya	Open grasslands of North America and Europe, and Steppe of Eurasia and Africa after migrating over the Siberian land bridge	Height: 5 ft Weight: ~500 lb Retained vestigial toes surrounding a hoof with a high-crowned compacted molar surface for grinding
Hippidion[b]	Pilocene 2.59–5.33 mya	Extinct in North America. Open grasslands in South America after the creation of the Isthmus of Panama	Height: 4–5 ft; weight: ~500 lb Direct link to modern horses

[a] Million years ago.

[b] Hippidion became extinct (~10 000 years ago) with the arrival of the first people in South America. European settlers re-introduced the horse into the Americas in the sixteenth century CE [9–12].

Sidebar 1.1: Hyracotherium Curated in Germany

The Welterbe Grube Messel (World Heritage Site Messel Mine) museum, near the village of Messel Germany, systematizes fossil findings from the abandoned Messel pit. The Messel mine contains a large and diverse number of fossils from life on earth 48 mya during the Eocene period. As a World Heritage Site, this museum has the same status as the Grand Canyon in the United States and the Galapagos Islands in South America [13]. And rightfully so as within this museum, there is a 40 million-year-old, near-complete skeletal of Hyracotherium (Eohippus or Dawn horse). The fossil remains are of a small dog-sized mammal with four distinct toes on the forelimb and rather large upper and lower canine teeth. Notably, the stomach contents of the animal's last meal, grapes, have also been well preserved. See Equus "Story of the Horse" [14].

(20–35 mya) were adapting to open grasslands as the forest and woodlands died off, and were, therefore, more vulnerable to predators. Anatomical adaptations for running became a matter of survival. The size of Miocene ancestors approached that of current day horses with an enlarged middle toe but two smaller toes on each foot. See Sidebar 1.2.

Sidebar 1.2: Limb Morphology Perissodactyls vs. Artiodactyls [7]

There are two main groups of hoofed ungulates: perissodactyls (odd-toed) and artiodactyls (even-toed). The two groups evolved independently from a common ungulate prototype (condylarths) and are differentiated today based on foot morphology. The foot evolved as the need for locomotion in search of food and escape from predators changed. The axis of symmetry in artiodactyls (example bovine) passes between the third and fourth metapodials. In perissodactyls (example equine), the axis of symmetry is through the third metacarpal and metatarsal.

Equini, one tribe of tridactyl horses, evolved to the monodactyl condition in the late Miocene. Differences in their foraging behavior and gait preference in Equini may have been a prime reason for the evolution of this monodactyl horse, at a time when tridactyl relatives predominated [9]. The second and fourth visible toes regressed to long thin vestiges (called splint bones today) as the third metacarpal and metatarsal elongated and then became muscular, hoofed, and developed a "spring mechanism" using musculotendons [15]. The spring mechanism adaptation reduces the work of galloping horses by 50% using the stored and returning elastic strain energy in spring-like musculotendons [16, 17]. The ability to cover longer distances at an energy-efficient trot gait in search of food and their rapid response to flee from predators were advantageous while living on the open grass plains of NA. Developing a critical sense of their surroundings (sight and smell) for the early detection of predators, primeval grassland horses banded together evolving a social behavior, i.e. herd mentality. Today, equines are odd-toed with slender legs, large eyes, and an acute sense of their surroundings. The biological need for a herd structure and the ability to flee became intrinsically linked to survival and are still very much present in our domesticated horses.

1.2.3 Alimentary System Changes in Response to a Changing Food Supply

Over time, natural selection leads to the expression of digestive features that approximately match the components and characteristics of the food supply. Jaw and skull musculature, stomach, and intestinal morphologies have all been shown to reflect dietary sources [18]. The morphological and functional features of the gastrointestinal tract (GIT) are unique to a species and can be explained by the interaction between the dietary chemical constituents, i.e. carbohydrates, proteins, fats, and principles of anatomy [19]. In other words, over millions of years of natural selection, GIT anatomy and physiology adapt to the food supply, or the specie dies out.

The expression of digestive enzymes and intestinal nutrient transporters also approximately match the dietary nutrient load consumed by the animal. Many of the nutrient transporters are the same across different animal phyla, though functional details may vary, e.g. glucose and amino acid transporters using K^+ vs. Na^+ exchange [20]. The digestive function also depends on the GIT microbiome. Feedstuffs resistant to endogenous enzyme digestion, e.g. cellulose, are fermented within a specialized chamber of the GIT, hosting a microbial population to digest cell wall polysaccharides. The mammalian bacterial population, as identified by 16S rRNA gene sequence data, is dominated the Bacteroidetes and Firmicutes phyla, each of which includes tens to hundreds of taxa [21]. The taxon richness of the microbiome is strongly influenced by diet.

As the NA environment changed from tropical forests to temperate grasslands, the types of forage changed; therefore, the form of energy changed, and hence, mammals adapted to the changing food supply for survival. Plant forms of carbohydrates contained within the cells are sugars and starch, and those contained in cell walls are cellulose, hemicellulose, and lignin. Plants contain little fat but will seasonally store starch in fruiting bodies (seeds/grain).

Structural parts of the plant contain large quantities of cellulose, hemicellulose, and lignin, primarily in stems, less so in leaves. The more upright fibrous the plant, the greater the proportion of cell wall to the cytoplasm, and the proportion of cellulose to the sugars and starch content. See Sidebar 1.3. Grasses have a higher cell wall to cell content ratio than the plants previously fed upon in tropical-like forests. Hence, as the plants changed due to climate change, the ratio of carbohydrate types changed, and accordingly, early mammals adapted their digestive processes to these new sources of energy.

Sidebar 1.3: Plant Cell Composition

Small herbivorous species eat primarily fruits, seeds, and berries. The **cell contents** of these fruiting bodies contain sugars and starches. Starch is a linear chain of several hundreds to thousands of D-glucose ($C_6H_{10}O_5$) units linked using α(1,4)-glycosidic bonds. The simplest form of starch is the linear polymer amylose; the branched form is amylopectin. Mammals endogenously synthesize intestinal α(1,4)-glycosidases to digest starch.

Large herbivores consume primarily the structural portions of plants, i.e. leaves and stems. The **cell walls** of these structural parts contain primarily the polysaccharide cellulose. Cellulose is a linear chain of several hundreds to thousands of D-glucose units but linked using β(1,4)-glycosidic bonds. Cellulose, hemicellulose, and lignin give rigidity to the cell wall allowing the plants (grasses, browse, and trees) to remain upright from the ground. No mammal synthesizes β(1,4)-glycosidases to digest these cell wall components. Any animal subsisting on a fibrous plant ration must therefore enter into a symbiotic relationship with cellulase-producing bacteria, and provide a fermentation chamber within the digestive tract to house the microbiota.

1.2.3.1 Evolution of the Digestive System in Perissodactyls

Mammals were successful at exploiting different ecological niches because they adapted to changing food supplies and diet composition. Anatomical changes in the Eocene and Miocene horses primarily occurred in the dental arcade and large intestinal tract as the NA food supply changed from fruits, seeds, flowers, leaves, and shoots to abrasive, upright grass forms containing more structural carbohydrates [7] (Table 1.2).

1.2.3.1.1 Dentition

Dental characteristics (tooth size and shape) respond evolutionarily to the physical properties of food because teeth are used in the mechanical processing of food [18, 22, 23]. The earliest mammals had relatively simple cheek teeth made up of three-pointed cusps lying nearly in a line. The highest cusp of the upper tooth occluded the space between adjacent lower teeth cusps, resulting in a vertical guillotine-like action that sliced or sheared food particles. These occlusal surfaces were suitable for holding, tearing, and shredding food pieces. Small mammals that consume primarily young plants and the reproductive parts of forest plants (fruits) eat a low cell wall to cell content ratio diet. These animals have brachydont molars because such plants require minimal mastication, only simple shearing or puncturing, to break open and release the cellular contents of a succulent food particle. See Sidebar 1.4.

Sidebar 1.4: Cheek Teeth Anatomy [10–12]

The primary function of teeth is to break down food without being broken or worn. In mammals, two distinctive types of teeth differ in the pattern of growth, morphology, and purpose:

Brachydont (Greek brachys meaning short) are low-crowned teeth as seen in man, pigs, dogs, and cats. The occlusal surfaces tend to be pointed, well-suited for holding prey and tearing and shredding. This type of tooth consists of a crown above the gingiva, a constricted neck at the gum line, and a root embedded in the jawbone. The crown is encased in enamel and the root in cementum. The earliest mammals had relatively simple cheek teeth made up of three cusps lying nearly in a line or low triangle. These cusps were surrounded by a cingulum on both labial and lingual sides. The highest cusp of the upper tooth occluded with the space between adjacent lower teeth, shearing food particles in a manner like that of pinking shears.

Hypsodont (Greek hypso meaning height) high-crowned teeth as noted in the permanent teeth of horses and cheek teeth of ruminants are well-suited for feeding on gritty, fibrous material. This type of tooth continues to erupt throughout life. Hypsodont teeth are usually described as having a body, much of which is below the gum line, and root, which is embedded in the alveolus of the jaw bone. Enamel covers the entire body of the tooth, but not the root. Hypsodont molars lack both a crown and a neck. The occlusal surface is rough and mostly flat, adapted for crushing and grinding plant material in a manner like that of millstones.

An estimation of when dietary fiber content impacted mammalian evolution can be made noting changes in molar teeth across geologic time periods. An adaptation by mammals to chewing abrasive and fibrous matter is evidenced by the development of a more millstone type of grinding surface [24]. Abrasive components such as silica and soil (grit) are consumed when grazing on grasses, and more so when grazing on plants lying close to the ground [25]. By the Miocene, these molars had become hypsodont, i.e. durable, robust, large, and flattened appropriate for grazing on high-cellulose plants [26]. Equid molars adapted to the consumption of grass or mature browse by increasing occlusal surfaces using two methods: increased complexity of the enamel pattern on occlusal surfaces, and premolars became molars. Increasing the root to crown length of the tooth is a hypsodontic change that does not directly increase molar surface area but does prolong the life of the tooth. Additionally, the direction of the wear facets on the molars of Eocene horses shows a greater transverse component to their jaw movement than previous specimens, which suggests consumption of a diet requiring a grinding motion [24].

1.2.3.1.2 Fiber Digestion

All members of perissodactyls had adapted to some form of primitive cecal fermentation in the late Paleocene (56–59 mya), that is, before Hyracotherium, before becoming a monodactyl, and before artiodactyls developed rumination [24]. However, the biochemistry of fermentation among ungulates is similar regardless of forage type or GIT site of fermentation, and the taxonomic composition of the GIT micro-organisms is broadly similar [24]. The volatile fatty acid products of cellulose fermentation (acetic, propionic, and butyric acid) are absorbed through the rumen wall of artiodactyls. Similarly, the same short-chain fatty acids are produced in the cecum and absorbed through the cecal and colonic epithelium of perissodactyls using a method of transcellular nonionic diffusion [20, 27].

Though the processes of fermentation appear to be similar within the cecum of horses and the rumen of ruminants, the site of fermentation with respect to the small intestine has important nutritional consequences with respect to protein and carbohydrate metabolism. In horses, available dietary protein and soluble carbohydrates (sugar, starch) are absorbed from the small intestine before reaching the cecum [28]. In ruminants, the rumen lies before the small intestine, and therefore dietary carbohydrates and protein are altered by microbes before the digesta reaches the small intestine. There are nutritional advantages and disadvantages to both systems.

The rate of digesta passing through the GIT of horses is not limited by particle size as in ruminants, hence when energy needs increase or forage quality decreases, food intake and the digesta rate of passage can be increased to meet the nutritional needs of horses [29]. However, for equines, the diet must contain all essential amino acids as the large quantity of microbial protein generated in the cecum is excreted in the feces and, therefore, not available to the host. Perissodactyls have not adopted a dependency on coprophagy most likely because they had very large home ranges (250–12 000 ac) and were cursorial, covering 12–50 miles daily while grazing or moving to water [15].

1.2.3.1.3 Feed Intake

The daily energy requirement for all mammals is based on metabolic body weight ($BW^{0.75}$), which is a function of body mass relative to the body surface area. Therefore, less energy is needed per kilogram of BW as animal size increases (Figure 1.2) [30]. For herbivores, as body size increased through the geologic time periods, less energy per kilogram of BW was required, and therefore surviving on a high-fiber/low-protein, fat, and starch diet became possible. Additionally, gut capacity increases linearly with body size and larger herbivores were able to accommodate a GIT fermentation chamber required to derive energy from fibrous feedstuffs, thereby not competing with carnivorous mammals. In summary, as herbivores evolved to larger body sizes, their energy requirement per kilogram of BW decreased and they were able to accommodate a GIT fermentation site, both of which allowed for the utilization of high-cellulose feedstuffs [24, 31].

As BW size increased in perissodactyls and food supplies increased in fiber content, hindgut cecal digestion was a significant adaptation that occurred about 28 million years ahead of rumen development in artiodactyls [24]. Ruminants adapted to a high-fiber diet in a later time period when they were of sufficient body size to physiologically accommodate a large foregut rumen for fermentation. The family Equidae continued to be successful even when ruminants dominated the landscape during the Miocene, Pliocene, and Pleistocene [24]. Today, Equus species are highly successful herbivores living on a diet with the highest fiber, and lowest protein content within a grazing community. Zebras have been reported to select the most fibrous part of the plant (tallest and oldest strands) [32]. Wild asses, onagers, zebras, Przewalski's horses, and feral horses (Mustangs, Assateague Ponies) in NA continue to live in areas with sparse, relatively low nutritional quality vegetation [33–35].

1.3 Equine Nutrient Requirements vs. Recommendations

The true nutrient requirements for any individual horse are determined by the animal's physiologic state; BW, life stage, physical activity and health. At best, based on equine feeding trials and extrapolations, daily nutrient intake recommendations have been published in the *Nutrient Requirements of Horses* [36]. Given the exact quantity of any nutrient required by an individual horse is not known, these are suggested initial nutrient intakes that would be adequate for most horses in the same category (BW, life stage, activity). This data should not be misinterpreted as setting nutrient minimums, maximums or even an estimate of optimal. Monitoring is

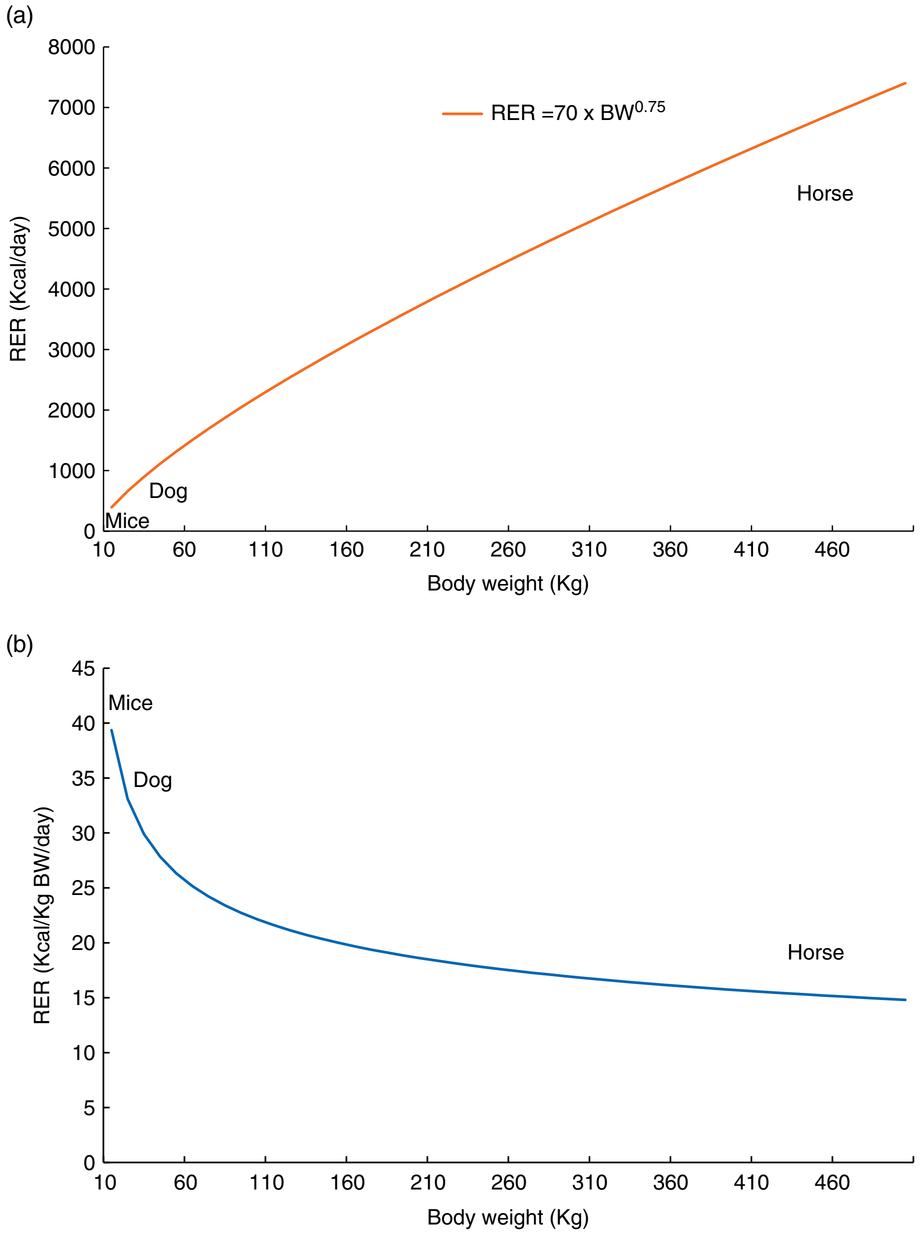

Figure 1.2 Relationship between body mass or weight and daily resting energy requirement (RER). Total RER increases as body mass increases (a) but RER per kilogram of BW decreases as body mass increases (b).

therefore essential as adjustments may be needed for an individual horse.

National Research Council (NRC) publications are the products of a temporary committee of members who have been invited to participate voluntarily. The invitations are extended to individuals considered to be experts in the broad field of equine nutrition and chosen based on their special competencies, and with due regard for an appropriate balance within the committee. The committee members hold advanced degrees (MS, PhD.) in animal nutrition and/or a Doctor of Veterinary Medicine, and additional American Veterinary Medical Association certifications in nutrition. These individuals have been actively involved in research within the field of equine nutrition with numerous scientific peer-reviewed publications to their credit. Collectively, they lend their knowledge and expertise to the NRC publication such that it represents the "best of our knowledge" at that time in the scientific literature. The first edition of NRC *Nutrient Requirements of Horses* was published in 1949. The 1989 fifth and 2007 sixth editions are available from the National Academies (www.nationalacademies.org). The publication is not revised at regular intervals. The next edition will likely be when it has been determined that there is sufficient new information available to warrant an update.

The 2007 NRC *Nutrient Requirements of Horses* is clearly the most frequently referred to source when estimating the nutrient needs for a healthy equine in the United States. This publication suggests the daily intake of 22 nutrients for horses with a healthy mature body weight of 200, 400, 500, 600, and 900 kg across 34 different physiologic states. Although that may appear to be sufficient data, there are gaps in the guidelines as there are no recommendations for horses with medical conditions. For example, how should the NRC nutrient profile recommendations for a healthy horse be adjusted for an obese pony when designing a weight-loss program, or for a 27-year-old horse with increased liver enzymes or chronic respiratory disease? Given the paucity of nutritional recommendations and data for the horse, both healthy and ill, clinical nutritionists then make their "best-educated guess" based on experience and resources when formulating the ration. See Appendix B. After a dietary recommendation has been implemented, the animal must be monitored and future adjustments are made as warranted. See Appendix C. Designing a ration for such cases that fall outside of the NRC recommendations requires expertise in both the science and the art of clinical nutrition.

Additional sources to be consulted include a review of the literature, e.g. scientific articles, abstracts, and proceedings, over the past 15 years as this information would not have been considered in the NRC 2007 publication. Another reasonable source of information on nutritional requirements may be found in the data of closely related species (Figure 1.1). Private research entities are another source as there are several involved in equine research, e.g. Kentucky Equine Research,[1] MARS Equestrian,[2] and Purina Animal Nutrition, LLC.[3] Unfortunately, industries rarely publish in-house nutritional studies in the scientific literature. However, it can be surmised that the nutrient concentrations of long-standing commercial products are safe and effective. By extension, reverse logic would suggest that if the nutrient concentration was found to be effective for one disease, it may be effective for a similar disease process. For example, if the ration concentration of omega-3 fatty acids were found to alter tissue concentrations in the blood of horses with arthritis, it would follow that the same concentration would be a reasonable starting point for a horse with chronic respiratory disease. Hence understanding the evolutionary and comparative aspects of clinical nutrition is an essential component of practice, still today, despite our endless push to specialize.

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[1] https://ker.com

[2] https://www.marsequestrian.com/

[3] https://www.purinamills.com/horse-feed

Case in Point

Patient Assessment

A 10-year-old Anglo-Arabian gelding in training for a 50-mile endurance race was reported by the owner to be exhibiting intermittent abdominal discomfort, not eating well, not always finishing all the feed offered, and had been somewhat resistant during training for the past 10 days or so. The horse is maintained on an unmanaged mixed grass/weed/wooded 10-ac pasture with a small herd of four other horses with an ad libitum water source and run-in shed for shelter. At the start of training about 30 days ago, a textured grain mix and a ration balancer pellet were added to the two meals/d of hay pellets routinely fed to the horse.

Body weight was estimated at 1300 lb using a weight tape, with a body condition score of 5/9, and weight loss had not been noted by the owner. Physical examination, complete blood count, and serum biochemical panel were within normal limits. Gastric ulceration was suggested and a standing gastroscopy procedure using a 2-m endoscope to visualize the stomach mucosa and margo plicatus was performed. There were two gastric lesions in the non-glandular mucosa, both with severity scores of 2/4 [37, 38]. The diagnosis was primary equine squamous gastric disease (ESGD) and treatment options were explained to the owner [38]. In addition to prescribing a proton-pump inhibitor, omeprazole for 28 d, a review of the ration and feeding method was recommended [39].

1) *What aspects of meal feeding pelleted feeds and grain concentrates likely relate to ESGD [42]?*

Assessment of the Ration and Method of Feeding:

The unmanaged pasture was assessed and determined to provide negligible nutrition other than a sparse low-quality fiber source. The owner considered the horse as doing "moderate" work and fed according to feed label instructions. The daily feeding offered consisted of:

Feed	lb fed/d	Mcal/lb	Mcal/d	Crude fiber%	Starch (Kg/d)
	as fed basis				
Hay stretcher pellets	15	1.1	16.5	18	1.43
Performance textured feed	9	1.65	14.85	9	0.92
Vitamin mineral balancer	2	1.7	3.4	5.5	0.05

2) *What are the total daily intakes of feed (lb/d), energy (Mcal/d), and starch (g/kg BW/meal)?*
3) *What would be a sound recommendation to the owner regarding the feeding management of this horse to prevent future ulcers?*
4) *What is the rationale for these feeding recommendations?*

See Appendix A Chapter 1.

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