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NUTRITIONAL ASSESSMENT OF WEANLINGS AND YEARLINGS

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Introduction

Height or long bone growth is the developmental priority for young horses. Energy, protein, minerals, and vitamins are first directed to maintenance requirements, and any additional nutrients are used for skeletal growth, specifically long bones (limbs for locomotion) and flat bones (skull, ribs, etc. for protection). Additional nutrients above those needed for optimal bone development are used to fuel more rapid growth, first developing muscle and then producing a heavier and more well-developed young horse. Optimal growth rates may vary somewhat between breeds, but all young horses have several critical considerations for bone growth and development. Extremely rapid growth caused by overfeeding (particularly energy) has been implicated in developmental orthopedic disease (DOD) and unsoundness. Periods of slow followed by rapid growth are of particular concern for developmental disorders.

Optimal bone development is greatly influenced by nutrition. During the first two months of life, the mare's milk contains enough energy, protein, and other essential nutrients to meet the needs for growth. Work in Australia (Kohnke et al., 1999) has shown that a horse maturing to 450-500 kg requires approximately nine kg of milk for each kg of gain at seven days of age, 13 kg at one month of age, and 15 kg at two months of age. Thoroughbred foals may consume up to 18 kg of milk per day. The foals require around 16.4 kg of milk per kg of gain, so they should be gaining just over 1 kg per day. Beyond two months of age, there is a decrease in milk production, and additional nutrients must be supplied by creep feeding until weaning.

Foals begin to nibble grass soon after birth, but they do not develop a functional hindgut that will allow them to extract significant nutrients from forages for months. In contrast, their efficiency of grain utilization is high at three weeks of age.

Contributions of Pasture

Researchers in Australia, New Zealand, and the United States have recently focused on the contribution of pastures to the nutrition of growing horses. Variability in pastures is considerable across regions and seasons of the year. When pastures were analyzed across seasons, researchers at Virginia Tech found that the amount of hydrolyzable and rapidly fermentable carbohydrates could be as much as five times higher during the spring and fall as opposed to winter and summer for cool season forages. While many professional horsemen recognize the importance of pastures to growth and development, pasture care is not often given the attention it requires.

Pastures generally fall into the categories of cool season or warm season and grass or legume. What species are found in a particular area is dependent on the annual rainfall and seasonal variations in temperature. For example, a common pasture for a temperate climate might include bluegrass, orchard grass, and white clover. Pastures subjected to adequate fertilization and rainfall during early spring and fall may produce forage that can support gains in weanlings of up to two pounds per day, although vitamin and mineral supplementation would be necessary. Studies at Virginia Tech have confirmed that even under the best conditions pasture will fall short of some key mineral and vitamin requirements and may vary depending on the location of the farm (Greiwe-Crandell et al., 1997). However, these same pastures during typically hot and dry July and August weather will not provide enough nutrients to support maintenance needs. To avoid the deleterious effects of these drastic swings in available nutrients, producers supply nutrition through carefully fortified rations.

Pasture is one variable of feeding young horses that is constantly changing and must be accounted for to control growth. Changes in weather patterns, for example, may cause a flush of pasture growth and subsequent weight gain, or a drought may leave pastures barren and unable to fulfill nutritional requirements for growth. Researchers at Cornell University illustrated the effects of undernutrition followed by overnutrition. Hintz (1983) fed one group of Standardbred weanlings free-choice feed for eight months, and a second group was given restricted feed for four months and then free-choice feed for four months. Two-thirds of the foals in the restricted-feed group developed contracted tendons within one to four months of being switched to free-access feed.

Several studies of young horses on pasture demonstrate the effects of undernutrition followed by overnutrition. In one project, six-month-old Danish Warmblood colts were fed to gain either 787 or 433 g/head/day until they were 12 months old (McMeniman, 1995). Then, all foals were put in the same pasture to graze. During the first six months of grazing, the colts fed for slow growth rebounded by gaining 138 kg, and colts fed for fast growth gained an average of only 75 kg. This divergence in growth rates describes the compensatory growth expected to increase the incidence of DOD. Researchers also noted that the horses fed for higher gains were significantly heavier and taller with greater cannon bone circumference, even after compensatory growth. The researchers continued the project for two more years. While all the horses were essentially the same height as three-year-olds, the horses fed for more consistent and steady gains were reported to be more vigorous and aggressive.

In a study at the University of Queensland Veterinary Science School, 15 Australian Stock Horse weanlings were divided into three groups (McMeniman, 2000). One group was fed a nutritionally complete pellet diet, a second group was rotationally grazed through three paddocks with the horses being moved every three weeks, and the third group grazed the same paddock throughout the 60-week study. The mean body weight gains of the completely hand-fed group, the rotationally grazed group, and the group that remained on the same pasture were 0.51, 0.37 and 0.34 kg/day, respectively. At the end of the experiment, the horses in the hand-fed group were significantly heavier and had higher body condition scores (system of evaluating the level of fatness of horses) than the horses in the other two groups. The authors indicate height and muscle mass were similar; however, the hand-fed group had more compact (harder or denser) bone between six and 12 months of age. Chemical analysis of the pastures revealed that some had mean crude protein concentrations below those recommended for growing horses, and a high proportion of the pastures were deficient in calcium, copper, and zinc. The pastures with low calcium concentrations also had inverted calcium to phosphorus ratios (below 1:1). Diets containing inverted calcium to phosphorus ratios and low zinc and copper concentrations are associated with the development of DOD.

Energy

The results of pasture studies indicate that foals are eating enough to satisfy energy needs for rapid growth. Foals consuming traditional high-concentrate diets spend less time grazing than similar horses on high-forage diets. It is generally observed that high grain intake reduces forage consumption. This explains how widely dissimilar management systems, some relying heavily on forages and others feeding much more grain, can lead to success in raising horses. The 1989 NRC recommends specific ratios of concentrate to hay for growing horses. The recommended ratio for weanlings is 70% concentrate and 30% hay, while the recommended ratio for yearlings is 60% concentrate and 40% hay.

Gibbs and Cohen (2001) reported the results of a survey of race-bred weanlings and yearlings. They noted that 99% of the farms contacted fed weanlings diets containing less than 70% concentrate, and 62% of the farms fed less concentrate than forage. Turcott and coworkers (2003) placed 24 weanlings on one of three diets with varying concentrate to hay ratios: 70:30, 50:50, and 30:70. The forage fed was 50% alfalfa and 50% timothy grass hay. Diets were balanced to meet all NRC requirements. The weanlings were fed the experimental diets from five to eight months of age. The low-concentrate diet resulted in greater fecal output. The high-concentrate diet had higher protein and ADF digestibilities. The authors state that the study demonstrates weanlings are more efficient at digesting high-concentrate diets and supports the NRC ratio of 70:30 (concentrate:roughage by percent of diet).

Ott and Kivipelto (2003) assigned weanlings to a diet of either 65% concentrate and 35% Bermuda grass hay or 50% concentrate and 50% Bermuda grass hay. The latter diet (50:50) had 3% added fat. The 65:35 group received 1.7 kg/100 kg body weight daily, and the 50:50 group received 1.35 kg/100 kg body weight daily. There were no differences in weight gain, with mean weight gain 0.76 kg/day. The 50:50 group was higher in the withers, had greater heart-girth circumference, and was higher in the hips. Bone mineral deposition was not different; however, weanlings fed the 50:50 diet had the highest values. The authors state the diet containing equal parts concentrate and forage was as effective in promoting growth as the diet that contained more concentrate.

Stephens and coworkers (2003) maintained yearlings in a drylot or on Bermuda grass pasture. Grain was fed to appetite over two 1.5-hour periods per day. There was no difference in intake between the groups. The drylot group received 1.5 kg/100 kg body weight in hay per day. Yearlings housed on pasture were heavier and had greater heart-girth circumference and bone mineral content at 56 and 112 days.

Energy Requirements

All cellular processes require energy. There is an absolute requirement for energy for maintenance, exercise, lactation, and growth. However, there is no single nutrient identified as energy. Energy is derived from nonstructural carbohydrates (starches), structural carbohydrates (cellulose, hemicellulose, etc.), fatty acids, and carbon chains of proteins. Meeting the energy requirements of horses is complicated by the variable contributions of fermentation in the hindgut. Some of the factors affecting fermentation are concentrate to roughage percentages, amount of structural and nonstructural carbohydrates included in the diet, and efficiency of the hindgut in suckling and weanling horses.

Ott (2001) reviewed the energy requirements for growing horses. The energy requirement for growing horses is determined by adding the maintenance requirement to the requirement for tissue energy deposition and efficiency of the conversion of dietary energy to tissue energy. The digestible energy (DE) requirement for maintenance is DE (Mcal) = 1.4 + .03 BW (body weight, kg). When the maintenance formula is combined with the tissue energy deposition and efficiency predictive equation, the daily DE requirement can be predicted by the following equation: DE (Mcal) = [1.4 + 0.03 BW (kg)] + (4.81 + 11.17x - 0.023 x 2) [ADG (kg)].

The desired average daily gain (ADG) drives the energy requirements up or down. The NRC provides a range of growth rates from moderate to rapid. Selecting the appropriate rate of growth is based on the commercial end point and management system. However, the long-range management of the foal must be planned in advance. Growth must be maintained along a moderately steady course.

The NRC suggests that a six-month-old foal with an adult weight of 560 kg gains 0.65 kg/day for moderate growth and 0.85 kg/day for rapid growth. The NRC estimates that the six-month-old weanling would weigh 230 kg.

Pagan (1998) reported growth data collected on Thoroughbred farms in central Kentucky. He found that the foals averaged 0.8 kg ADG, but they weighed 246 kg on average. The NRC DE requirement for a six-month-old foal gaining 0.8 kg/day is 16.2 Mcal. Kentucky Equine Research (KER) estimates the requirement for the same rate of gain to be 16.8 Mcal. The NRC recommends a yearling (12 months old) that will have an adult weight of 560 kg should weigh 350 kg and be gaining 0.5 kg/day for moderate growth and 0.65 kg/day for rapid growth. Pagan (1998) found Kentucky Thoroughbred yearlings weighed 354 kg and were gaining 0.6 kg/day (Tables1-4). The NRC requirement for this yearling would be 21.3 Mcal, while KER would suggest a requirement of 21.6 Mcal.

Table 1. Nutrient requirements for a six-month-old weanling (246 kg) gaining 0.65 kg/day with an estimated mature weight of 560 kg.

	DE (Mcal)	*CP (g/day)*	*Ca (g)*	*P (g)*	*Cu (g)*	*Zn (g)*
KER	15.3	764	38.0	25.3	168	504
NRC	15.9	796.6	30.6	16.5	54.9	219.7

Table 2. Nutrient requirements for a six-month-old weanling (246 kg) gaining 0.85 kg/day with an estimated mature weight of 560 kg.

	DE (Mcal)	*CP (g/day)*	*Ca (g)*	*P (g)*	*Cu (g)*	*Zn (g)*
KER	17.3	864	44	29.3	168	504
NRC	18.1	906.6	37	20.1	62.5	250.1

Table 3. Nutrient requirements for a twelve-month-old weanling (354 kg) gaining 0.5 kg/day with an estimated mature weight of 560 kg.

	DE (Mcal)	*CP (g/day)*	*Ca (g)*	*P (g)*	*Cu (g)*	*Zn (g)*
KER	20	901	47.5	31.7	168	504
NRC	19.8	890	30.2	16	70.7	282.7

Table 4. Nutrient requirements for a twelve-month-old weanling (354 kg) gaining 0.65 kg/day with an estimated mature weight of 560 kg.

	DE (Mcal)	*CP (g/day)*	*Ca (g)*	*P (g)*	*Cu (g)*	*Zn (g)*
KER	22.4	1008	52.6	35.1	168	504
NRC	22.1	995	35	18.7	79	316

Dietary energy fed at excessive levels has been implicated as a contributing factor in the onset of DOD (Glade, 1986). Savage et al. (1993) fed a control diet that contained DE at the NRC recommended level and a diet containing 129% of the recommended level to foals 2.5-6.5 months of age for 16-18 weeks. The diets were rice-based pellets. The high-DE diet had approximately 5% added corn oil. Eleven of the 12 foals on the high-DE diet developed multiple dyschondroplasia (DCP) lesions. Only one of the foals on the control diet developed DCP lesions. There were no differences in growth rates between the treatments. The authors indicate there may be an association between high DE and a high incidence of DCP.

Pagan et al. (2001) conducted a field study with 218 Thoroughbred weanlings. A glycemic index was created for each diet fed to horses on six different farms. The incidence of osteochondritis dissecans (OCD) was followed for 6 or 8 months or until the yearlings were sold at auction. Twenty-five of the 218 weanlings (11.5%) had OCD lesions that were treated surgically. The incidence of OCD was significantly higher in foals whose glucose and insulin values were greater than one standard deviation above the entire population when the body weights were compared with the Kentucky average (Pagan, 1998). One farm, which experienced a 32% incidence of OCD, averaged 115% of the reference weight. A second farm, which had no incidence of OCD, averaged 97% of the Kentucky average body weight. The authors suggest that feeding foals a concentrate that produces a low glycemic response may decrease the incidence of OCD.

Protein Requirements

Protein accounts for 80% of the fat-free, moisture-free composition of the body. Amino acids are the building blocks of proteins. The concentration of protein needed in a diet is dependent on how well the amino acid profile matches the needs of the animal. A young growing horse, for example, has a higher requirement for the amino acids needed to build muscle and bone. The amino acid profile varies among different protein sources. Milk protein is superior to soybean meal; soybean meal has been shown to grow weanlings faster than zein, cottonseed meal, and brewers dried grains. When each of these protein sources was supplemented with the amino acid lysine, growth rates improved and were comparable (NRC, 1989). Lysine is the most limiting amino acid and specific requirements have been developed. Threonine is the second most limiting amino acid in the diet.

Ott and Asquith (1986) developed the protein requirements of growing horses based on digestible energy requirements, stating both energy and protein restrictions will reduce the growth of the animal. The crude protein (CP) energy relationship for weanlings is CP (g/day) = 50 g/Mcal DE, and for yearlings it is CP (g/day) = 45 g/Mcal DE. Lysine requirements are also provided on an energy basis. The lysine requirement for weanlings is 2.1 g/Mcal DE per day, and the yearling requirement is 1.9 g/Mcal DE per day.

There have been anecdotal reports of high-protein diets causing DOD. Weanling foals fed 126% of the NRC protein requirement had no greater incidence than foals fed at NRC recommended levels (Savage et al., 1993).

Calcium and Phosphorus Requirements

The importance of calcium and phosphorus to bone mineralization is well known. The ratio of calcium to phosphorus in the bone is 2:1. Horses should be fed diets containing calcium and phosphorus ratios between 3:1 and 1:1. Jordan et al. (1975) fed ratios of 6:1 to pony mares over a four-year period and found narrowing of the cortical area and less bone per unit area of bone. Inverted calcium to phosphorus ratios are not uncommon when high-grain diets are fed with little or poor-quality forages. Nutritional secondary hyperparathyroidism can result from excessive phosphorus intakes in the presence of low calcium. This disease can cause shifting lameness and, in advanced cases, enlargement of the upper and lower jaws (NRC, 1989).

The NRC estimates that a growing horse requires 16 g of calcium/kg of body weight gain. Tables 1-4 compare NRC recommendations for calcium and phosphorus with recommendations developed by KER. The NRC recommends a minimum of 30.6 g/day of calcium for a 246-kg weanling gaining 0.5 kg/day. KER recommends 38 g/day for the same weanling. The NRC minimum phosphorus recommendation for a 246-kg weanling gaining 0.5 kg/day is 16.5 g; the KER optimum recommendation is 25.3 g. For a 246-kg weanling gaining 0.65 kg/day, the NRC recommendation for calcium is 37 g, while the KER recommendation is 44 g. For the same weanling, the NRC recommendation for phosphorus is 20.1, while the KER recommendation is 29.3.

Copper and Zinc

Copper requirements in growing horses have been debated for almost 15 years. Gable et al. (1987) published survey data that they felt indicated an association between copper and DOD. Burton and Hurtig (1991) reported a significant increase in DOD lesions in foals that were fed 8 mg of copper versus foals fed 25 mg/kg. Cymbaluk and Smart (1993) reviewed the literature on copper and its relationship to equine bone disease. They suggested that copper requirement may vary among breeds. They recommended that ponies and draft horses be fed 10 mg/kg and that horses prone to copper deficiency be fed a total of 20-25 mg/kg diet. They also reported a high tolerance to high copper supplementation in the horse. The authors warned against a complicated copper deficiency caused by excessive zinc in the diet competing for the same transportation mechanism as copper. The key to proper copper and zinc nutrition seems to be an optimum ratio of 1:4-5 (copper to zinc). Tables 1-4 indicate copper and zinc requirements for minimum and optimum growth.

Growing horses seem to be able to adapt to a variety of nutritional management systems if adequate nutrients are provided in the correct balance and a moderate rate of growth is maintained throughout the growth phase.

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