Equine Session

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Estimation of Pasture Dry Matter Intake and its Practical Application in Grazing Management for Horses

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Take-Home Message

Pasture is a valuable source of nutrients for grazing horses. Pasture can provide some or all of the horse's digestible energy, crude protein, vitamin A and E requirements; although pasture's ability to provide minerals is limited in most cases. In order to fully realize the value of pasture, dry matter intake must be accurately estimated to account for intake of pasture-derived nutrients. Several methods exist to estimate pasture dry matter intake and have yielded published estimates for horses grazing periods ranging from 3 to 24 h. A pasture dry matter intake prediction equation was developed using these data. The equation has application in accounting for pasture nutrient intake relative to requirements, as well as determining pasture access time necessary for a horse to consume a target intake (e.g., time necessary to consume daily maintenance digestible energy requirements).

Introduction

Pasture is an excellent source of nutrients for grazing horses. In fact there are many situations where horses graze continuously and consume far more nutrients than required. The excess nutrient consumption has negative economic and horse-health consequences. Therefore, strategies aimed at measuring and controlling pasture nutrient intake are valuable tools in managing grazing horses. One approach to controlling pasture nutrient intake is to restrict the amount of time a horse grazes based on estimates of pasture dry matter intake (DMI), pasture nutrient concentrations and the horse's nutrient requirements. These three factors (pasture DMI, pasture nutrient concentration and horse nutrient requirements) can be used to calculate the amount of time at pasture that is necessary for the horse to consume only the required nutrients. However, this approach is not without challenges.

This paper will discuss the nutritional value of pasture in feeding horses, the value of controlling pasture nutrient intake, challenges associated with estimating pasture nutrient intake, and its practical application.

Nutritional Value of Pasture for Horses

Well managed pasture can make a significant contribution to a horse's daily nutrient requirements. Pasture's greatest contributions are made toward digestible energy (DE) and crude protein requirements. Digestible energy values for grass pasture have been reported to range from 1.78 to 2.74 Mcal/kg DM (mean ± S.D. 2.26 ± 0.48 Mcals/kg DM; n = 6,959; Dairy One, 2013). This range includes most of the range of DE requirements for horses, expressed on a dietary concentration basis (i.e., 1.67 to 3 Mcals/kg DM; NRC, 2007). The lower values of this range correspond to mature idle horses with maintenance only requirements, while the upper values correspond to a five-month-old weanling. A similar situation exists when crude protein concentrations of grass pasture are compared with the range of crude protein requirements for horses in various physiological states. Crude protein values for grass pasture can range from 7.5 to 22.7% (mean ± S.D. 15.2 ± 7.6%, n = 9,335; Dairy One, 2013) compared to requirements ranging from 6.3% (mature idle) to 13.9% (5-month old weanling). These findings demonstrate clearly that grass pasture can provide some or all of a horses DE and crude protein requirements, depending upon the horse's physiological status and forage quality.

Pasture is a more variable source of minerals. In some cases, pasture can contain adequate amounts of minerals relative to requirements; whereas in others it tends to be deficient. The concentrations of Ca and P reported for 9,432 samples ranged from 0.27 to 0.82 % (mean ± S.D. 0.55 ± 0.28%) and 0 to 0.78% (mean ± S.D. 0.29 ± 0.49%), respectively (Dairy One, 2013). The range of Ca and P requirements for horses is 0.2 (mature idle) to 0.8% (5-month old weanling), and 0.14 to 0.45%, respectively (NRC, 2007). Therefore pasture is not viewed as a consistent source of Ca and P in many cases, especially for lactating mares and growing horses. Pasture also generally lacks the ability to provide Na, Cl, Cu and Zn. Selenium may or may not be deficient depending upon the region geographical location. Most of the Great Plains and Rocky Mountain regions in the US have Se-rich soils whereas other areas are extremely deficient (e.g., Great Lakes regions, Pacific NW and most of the Eastern half of the US).

Pasture can be an excellent source of some required fat soluble vitamins (e.g., pro-vitamin A and vitamin E). An unpublished study conducted at North Carolina State University that evaluated seasonal changes in vitamin E and beta-carotene (pro-vitamin A) over a 12-month period reported mean pasture vitamin E concentrations of 195 $\pm$ 59 IU/kg DM (range = 100 to 300 IU/kg), which is well above the requirement range of 80 to 100 mg/kg DM (NRC, 2007). The lowest concentrations were reported during the months of December through February; while the greatest concentrations occurred from May through August. These results suggest pasture is an excellent source of vitamin E, even during seasons of the year when concentrations are lowest. Beta-carotene is metabolized by the horse to retinol providing vitamin A equivalents. Each milligram of beta-carotene is assumed to provide the horse with 400 IU of vitamin A (NRC, 2007). The mean beta-carotene concentration reported in the aforementioned study was 34 $\pm$ 25 mg/kg DM, which equates to 13,600 IU/kg DM of vitamin A. Horses require between 3,000 to 4,800 IU/kg DM (NRC, 2007). Although the beta-carotene concentration provides vitamin A equivalents well above the requirement; there is no likelihood of vitamin A toxicity in that the conversion of beta-carotene to vitamin A is significantly reduced at high concentrations (i.e., the horse received considerably less than 400 IU/mg beta-carotene).

In summary, pasture can provide some or all of a horse's DE, CP, vitamin A and E requirements. Pasture's ability to provide minerals is variable. Nonetheless, it is clear to see from the above examples that pasture is an excellent source of many important nutrients for horses.

The Value of Controlling Pasture Nutrient Intake

Because pasture can be a plentiful source of nutrients for horses, often having the potential to provide more nutrients than required, the ability to control intake is sometimes desirable. The following example demonstrates the value of controlling pasture nutrient intake with regard to feed costs and horse health. Consider a small acreage operation with two 500 kg mature idle horses grazing 5 acres of pasture containing an average annual herbage mass of 1,300 kg DM/acre and having an average DE concentration of 2.26 Mcals/kg DM. If the horses grazed pasture at a rate of 2.5% of body weight per day they would each consume 28.85 Mcals/d which is 11.58 Mcals greater than required (16.67 Mcals/d). A DE intake of 20 Mcal above maintenance DE is required per kg of BW gain, and an increase in 1 body condition score unit requires approximately 18 kg of body weight gain (NRC, 2007). Given these assumptions, the two horses would gain just under 1 body condition score unit per month while pasture lasts. In order for the horses to consume maintenance only requirements and maintain body weight and condition, the horses' pasture DMI would have to be decreased to approximately 1.5% of body weight. Decreasing the pasture DMI rate to 1.5% of body weight would allow the horses to graze the 5 acres of pasture for 220 days as compare to 130 days for a pasture DMI rate of 2.5% of body weight (assuming a grazing efficiency of .5, or 50% of the forage present is available for grazing). The additional 90 days of grazing resulting from restricting pasture DMI rate to 1.5% of body weight saves $445 in hay costs assuming that two horses would require 18.5 kg hay/d containing an average of 2 Mcals/kg DM and 90% DM (16.67 Mcals/2 Mcals/kg DM x 2 horses / 0.9) costing $0.267/kg as fed ($4.85/40 lb bale; ~$243/ton). This example demonstrates the value of controlling pasture nutrient intake in cases where nutrient intake exceeds nutrient requirements in order to minimize feeding costs and prevent negative health consequences such as obesity.

In the example above, the maximum DE intake for a single horse weighing 500 kg, assuming 2.5% of body weight in DM, is 28.85 Mcals/d, which not only exceeds the DE requirement for a mature idle horse, but also for several feeding classes of horses (e.g., gestating mares, breeding stallions, light through heavy work) (NRC, 2007). Therefore, the efficient use of pasture nutrients, especially DE, requires strategies to regulate pasture intake. The two primary methods used to regulate pasture intake are the use of dry-lots (Glunk et al., 2013a) and grazing muzzles (Dowler et al., 2012); however, the effectiveness of grazing muzzles is dependent upon plant morphology (upright vs prostrate) and horse preference for different plants (Glunk et al., 2013b).

Estimates of Pasture DMI Rate

Methods used to predict pasture intake of horses include: herbage mass difference before and after a grazing (Duren et al., 1987; Dowler et al., 2012; Glunk et al., 2013), body weight difference pre- and post-grazing (Ince et al., 2011), and inert marker methods (e.g., alkanes, chromic oxide) (Mayes and Dove, 2000).

Pasture DMI rates for a 24-h period have been reported to range from 1.4 to 3% of BW (Glunk et al., 2013a; Grace et al., 2002b; Grace et al., 2002a; Longland et al., 2011a). Several additional studies report pasture DMI over a period shorter than 24 h (Chavez et al., 2011a; Chavez et al., 2011b; Dowler et al., 2012; Duren et al., 1989; Glunk et al., 2013a; Ince et al., 2005; Ince et al., 2011; Longland et al., 2011b). Values associated with shorter grazing bouts are useful for managing horses having limited pasture access. There is evidence to suggest that DMI rate is not constant over a 24-h period and is accelerated as time allowed for grazing is restricted. Dowler et al. (2012) reported pasture DMI rate during the first four hours of grazing was 1.6 times greater (1.47 g DM kg $\cdot$ BW^{-1} $\cdot$ h^{-1}) than that (0.9 g DM $\cdot$ kg BW^{-1} $\cdot$ h^{-1}) in the 4-h period that followed. Glunk et al. (2013a) reported that DMI rate, expressed as g DM $\cdot$ kg BW^{-1} $\cdot$ h^{-1} for 6, 9, and 24 h grazing periods were 78, 57 and 29% of that for a 3-h period. The lack of a constant DMI rate over a 24 h period makes prediction of pasture DMI difficult when grazing occurs for only a fraction of the day. Extrapolation of 24-h DMI to shorter periods may underestimate the actual intake due to increased DMI rate associated with restricted grazing time. Therefore, data (23 means) from 12 studies measuring pasture DMI of horses (including yearlings, mature idle, and lactating mares) and ponies over periods ranging from 3 to 24 h were used to develop a prediction equation for pasture DMI (g DM/kg BW) as a function of hours of pasture access. The PROC REG function of SAS was used according to Walker (2002). The model was $y = \sqrt{x}$, where y = pasture DMI (g DM/kg BW) and x = pasture access (h). The square root of pasture access was used as a means of fitting non-linear data using linear methodology. The final equation was $y = 5.12\sqrt{x} - 2.86$ ($R^2 = 0.7$; $P < 0.001$). The model predicts a pasture DMI of 11.11 kg/d or 2.2% of BW for a 500 kg BW horse, which is a reasonable pasture DMI for a 24-h period (NRC, 2007).

The DMI rate (DMIR) prediction equation above is far from perfect and should be used with caution as it does not consider all factors. Other factors that influence pasture DMIR include herbage mass available for grazing (Dowler et al., 2012), physiological status of the horse (Grace et al., 2002b), environmental temperature (Glunk et al., 2013a), forage chemical composition, plant maturity and plant species (Dowler et al., 2012; Fleurance et al., 2010; Fleurance et al., 2009). The effect of these factors on pasture DMI rate requires further study in horses. However, the prediction equation above can serve as a starting point to build upon in the future.

Practical Applications of Pasture Intake Estimates

The DMI rate prediction equation above can be used to evaluate nutrient intake from pasture and more effectively balance rations for grazing horses. Additionally, the equation can be rearranged to calculate the hours of pasture access required for horses to obtain a target DE intake. For example: a 500 kg mature idle horse requiring 16.67 Mcals DE/d would need to consume 7.4 kg of pasture containing 2.26 Mcals DE/kg DM (value reflects an average grass pasture DE concentration as stated previously). When DMI is expressed per unit of BW, the 500 kg horse requires 14.8 g DM/kg BW. This value can be entered into the prediction equation, which can then be solved for x (i.e., hours of pasture access). The horse in this example would require approximately 12 h (11.9 h) of pasture access to consume 7.4 kg DM and 16.67 Mcals DE and meet its maintenance energy requirement. This approach conserves pasture and reduces feeding costs as well as preventing unnecessary weight gain, as was illustrated in the preceding section.

The pasture DMI prediction equation can be used also to calculate the amount of supplemental hay required for grazing horses having access to pasture for less than 24 h/d that do not fully meet their DE requirement from pasture. For example: if a 500 kg BW mature idle horse grazed for 4 h/d it would consume 7.38 g DM/kg BW or 3.69 kg DM, as calculated using the DMI prediction equation. The supplemental amount of hay necessary to meet the horse's daily energy requirement is calculated using the respective pasture and hay DE concentrations. Assuming a pasture DE of 2.26 Mcals DE/kg DM (staying consistent with previous examples) the pasture would provide 8.34 Mcals (3.69 kgDM x 2.26 Mcals/kg DM). Therefore, the remaining DE required (16.67 Mcals/d required – 8.34 Mcals supplied by pasture) is 8.33 Mcals, which can be supplied by feeding 4.17 kgDM hay (~9 lbs DM or 10 lbs as-fed), assuming hay contains 2 Mcals/kg DM and 90% DM (again, staying consistent with previous examples). Alternatively, the amount of hay replaced by pasture can be calculated by estimating the caloric intake from pasture and then calculating the amount of hay that provides an equivalent amount of calories. Table 1 shows some general pasture/hay equivalencies for horses having a variety of differing body weights and hours of pasture access. Keep in mind that these values are average estimates with some degree of variation. Nonetheless, by comparing values in the table one should appreciate the value of pasture in terms of hay replacement. When considering current hay prices near $250/ton ($0.125/lb) the table shows that horses having pasture access from 2 to 16 h/d can save owners approximately 0.5 to 3.2 $/hd/d (15 to 96 $/mo), which is significant when multiplied across several horses.

Table 1. Amount of hay replaced by grazing variable amounts of time for horses of varying body weight (BW).[a]

	BW, kg				
	200	300	400	500	600
Pasture Access, h	Grass Hay, kg As-Fed				
2	0.70	1.05	1.40	1.75	2.10
4	1.58	2.37	3.16	3.96	4.75
8	2.83	4.25	5.66	7.08	8.49
12	3.79	5.68	7.58	9.47	11.36
16	4.60	6.89	9.19	11.49	13.79

[a] *Estimates assume well managed pasture approximately 6 to 8 inches high at the start of grazing and no less than 3 to 4 inches high at the completion of grazing. Pasture should contain less than 10% bare-spots and weeds. Pasture and grass-hay DE was assumed to be 2.26 and 2 Mcals/kg DM, respectively. DE requirements are for "maintenance only".*

Conclusion

Pasture is an excellent source of calories, protein, pro-vitamin A and vitamin E. The full value of pasture can only be realized when DMI is accounted for. The prediction equation reported in this manuscript can be used to predict pasture DMI in horses grazing from 3 to 24 hr. However, it is important to remember that the equation is based on a limited data set and experimental conditions. Therefore, the DMI values generated from the equation should be used as a starting point and the horse's body weight and condition should be used as the final determinant of the rations adequacy in terms of energy intake. Future research in this area should aim to generate pasture DMI over a range of physiological states, pasture characteristics and environmental conditions in order to develop more accurate equations for specific feeding classes of horses.

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