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PASTURE COUNTS: THE CONTRIBUTION OF PASTURE TO THE DIETS OF HORSES

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Introduction

The New Zealand livestock industry is based on pasture, and over the last 60 years considerable research has gone into (a) breeding more productive pasture species, (b) plants that respond to frequent grazing, (c) plants that are more resistant to disease (Tapper et al., 1999), and (d) the factors that influence pasture production (Korte et al., 1987). Associated with plant breeding programs have been fertilizer trials to improve plant nutrition (Roberts et al., 1996), the development of legumes (Caradus et al., 1996), particularly white clover, to fix atmospheric nitrogen, and grazing studies to improve pasture utilization (Clark and Brougham, 1979). In New Zealand, pasture is the major dietary component for broodmares and young horses. However, it is only recently that information on dry matter intakes (DMI) and digestible energy intakes (DEI) of pasture-fed Thoroughbred horses has become available, as well as observations on the influence that fresh herbage has on the growth and development of young horses.

Pasture Species

New Zealand pastures are usually a mixture of grasses and clovers with perennial ryegrass/white clover being the dominant pasture (Hunt, 1994). However, depending on climate, soil type, fertilizer applications, and livestock system, other grasses such as tall fescue, cocksfoot, phalaris, prairie grass, timothy, Yorkshire fog, and browntop are found in pastures, as well as red clover. When evaluating the feed value of grasses and clovers, in terms of lamb growth rates, it was found that the feed values of annual ryegrasses were greater than that of the perennial ryegrasses, while that of white clover was the highest (Ulyatt, 1971). The nutritive value or chemical composition of grasses change with season and plant maturity. Grasses in the leafy stage during late autumn, winter, and spring have the highest dry matter digestibilities, but this decreases as the seedhead emerges in late spring, because when the grass has become mature the soluble sugars and crude protein percentage decrease, while the cellulose and lignin percentage increase (Waghorn and Barry, 1987).

Seasonal Pattern of Pasture Dry Matter Production

The major determinants of plant growth are temperature and moisture, and these influence pasture dry matter (DM) production. Typically, in New Zealand the greatest pasture growth occurs during spring (October/November; 60 kg DM/ha/day), while the least growth occurs during winter (June/July; 14 kg DM/ha/day) (Milligan et al., 1987). This seasonal pasture production pattern influences livestock farming practices, with calving and lambing being planned for the spring when the quantity and quality of the pasture is at its best. In New Zealand mares foal from September to November with weaning occurring in March and April.

Relating Daily Pasture Dry Matter Production and Daily Dry Matter Requirements of the Horse

The supply of pasture DM and the DM requirements of the horse need to be matched in order to determine the number of horses that can be grazed per hectare, and to predict seasonal shortfalls in the supply of pasture DM. An example is illustrated in Figure 1 based on an annual mean pasture production of 11,500 kg DM/ha and a seasonal pattern of growth (kg DM/ha/day) of March 30, April 25, May 17, June 14, July 14, August 25, September 40, October 53, November 60, December 45, January 30, and February 25. The daily DM requirements for lactating mares, weanlings, and yearlings were 13.6, 5.5, and 6.8 kg DM/day, respectively, to ensure adequate milk yields and good growth rates.

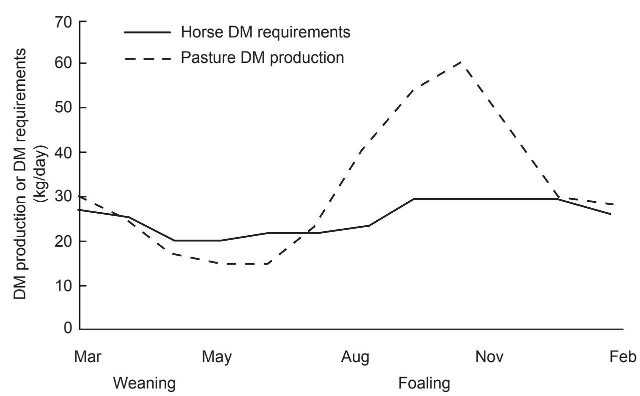

Figure 1. Relationship between daily pasture DM production and daily horse DM requirements. Stocking rate of 1.5 mares and their foals per hectare.

Foaling and mating occur in spring and weaning in autumn when pasture DM production is high, and therefore the horse's DM requirements are met. However, the pasture does not provide an adequate DM intake during mid to late pregnancy in winter (June-August), and supplementary feeding of pasture and legume hay is needed. Further, it is necessary that the surplus DM in spring and early summer (November-December) is conserved as good-quality hay for feeding during winter. The removal of the excess spring pasture also slows down the time period that the pasture becomes more mature, with its associated decrease in DM digestibility and digestible energy content. This is important in order to maintain pasture quality for lactating mares and their foals during the summer.

Feed Value of Pasture

The feed value of pasture for horses is determined by DM intake and its DM nutritive value, or chemical and mineral composition. Many factors such as the physiological state of the animal, its preferences, nutrient density, and environmental conditions can influence DM intakes, while other factors (e.g., pasture species, soil type, and fertilizer applications) can influence pasture chemical and mineral composition.

Determination of Dry Matter and Digestible Energy Intakes

The determination of the DM intakes of grazing animals is more difficult to measure than that for animals fed indoors, where the amounts of feed offered and refused can be accurately recorded. The technique to determine the DMI of grazing ruminants involves measuring the daily total fecal DM output, using indigestible markers such as chromium sesquioxide (Cr_2O_3), and dividing this by the indigestible fraction (1-digestibility) (Langlands, 1975). In many cases the digestibility of the pasture is determined using an in vitro technique.

In the case of the horse, the daily fecal DM outputs can be determined directly. Individual horses were placed behind electric fences on pasture areas of 50 m x 100 m, and each day all the fecal material was collected, weighed, and a subsample dried to determine the daily fecal DM output. The collection period was 8-9 days (Grace et al., 2002a). The indigestible fraction (1-digestibility) was determined immediately after the fecal collections by bringing at least 8 weanlings or yearlings indoors and placing them in sawdust-bedded loose boxes (3.5 m x 3.5 m). The digestibility study consisted of an eight-day preliminary period followed by a six-day collection period (Grace et al., 2002a; Grace et al., 2003). Each day the weanlings and yearlings were offered 50-60 kg of fresh pasture from the area they originally grazed, cut with a reciprocating mower to limit the damage to the fresh herbage, then packed in hay nets and fed as two meals (at 0800 and1730 h). All pasture not immediately fed was stored at 2-4° C to prevent deterioration of herbage quality. During the eight-day preliminary period all residual pasture and feces were collected and discarded. Water was available at all times. During the six-day collection period, the amounts of fresh pasture (50-60 kg) offered and the uneaten residual pasture were collected, weighed, and subsampled for DM determinations. The daily DM eaten was determined from the difference between the DM offered and the residual DM. Over the same period the feces were collected every hour, and the 24-hour fecal output was weighed and subsampled for DM determinations. Subsamples of pasture and feces were prepared for chemical and mineral analysis, as well as the determination of energy content.

A similar technique was used for the mares except they, with their foals, were placed in a bare 20 x 20 m corral fitted with a custom-made feeding station that ensured pasture was available to the mare, but not her foal. Each station consisted of a wall 1.2 m wide x 2.4 m high, a 1 m deep tray fitted to the wall 1.2 m from the ground, and a roof made of clear plastic sheeting to protect the cut pasture from the weather. The mares were offered 100-120 kg fresh pasture as two meals, while their foals were also provided with their own small amount of pasture not accessible to the mare (Grace et al., 2002b).

Dry Matter and Digestible Energy Intakes

The daily fecal DM output, DM digestibility, and pasture DE data used to calculate DM and DE intakes for pasture-fed horses in all our studies are summarized in Table 1 (Grace et al., 2002a,b; Grace et al., 2003).

The determined DE intakes of 146.9, 78.3, and 62.7 MJ DE/day for grazing mares, yearlings, and weanlings, respectively, are similar to the values of 134, 83, and 69 MJ DE/day recommended by the National Research Council (1989).

Table 1. Mean dry matter (DM) and digestible energy (DE) intakes of lactating mares, yearlings, and weanlings.

Parameter	*Mare*	*Yearling*	*Weanling*
Daily fecal DM output (kg/d)[1]	5.44	2.46	2.09
DM digestibility[2]	0.6	0.64	0.62
DM intake (kg/d)	13.6	6.8	5.5
DE of pasture (MJ/kg DM)[2]	10.8	11.5	11.4
DE intake (MJ DE/d)	146.9	78.2	62.7

[1]Determined in grazing horses.
[2]Determined in a subsequent indoor digestibility study.

Nutrient Value of Pasture

The nutritive value of a pasture is a reflection of its chemical and mineral composition.

Table 2. The chemical composition (g/kg DM) of pasture fed to mares, yearlings, and weanlings in the dry matter and digestible energy intake studies.

Nutrient	*Spring Mare*	*Spring Yearling*	*Autumn Weanling*
Crude protein	190	155	222
Soluble carbohydrate	112	71	72
Neutral detergent fiber	494	432	402
Acid detergent fiber	314	242	239
Lipid	25	28	33
DE content (MJ/kg DM)	10.8	11.5	11.4

CHEMICAL COMPOSITION

A summary of the mean crude protein, soluble carbohydrate, natural detergent fiber, acid detergent fiber, and lipid content (g/kgDM) of the pastures fed in the mare, yearling, and weanling intake studies (Grace et al., 2002a,b; Grace et al., Grace et al., 2003) is given in Table 2.

In general, the DE content of pasture is lower (11.2 v. 13.5 MJ/kg DM) and the crude protein is higher (190 v. 135 g/kg DM) than for grains.

There is a marked seasonal change in the chemical composition of pasture because as pasture plants mature, with head emergence and seed setting, the crude protein and soluble carbohydrate content decrease (30-50%), while the hemicellulose, cellulose, and lignin content (i.e., neutral and acid detergent fiber) increase (30-50%). This can result in about a 30% decrease in DM digestibility (Waghorn and Barry, 1987).

MINERAL COMPOSITION

The mineral content of pasture also shows a seasonal change, and this is illustrated in Table 3. The data presented are from the yearling study (Grace et al., 2002a).

Other factors influencing the mineral composition of pasture include pasture species, soil type, and fertilizer applications. In New Zealand some soils are low in Se and Co, and this is reflected in the need to supplement grazing livestock with Se and Co (vitamin B_{12}) in some areas (Grace, 1994).

A comparison of the daily mineral intakes of the pasture-fed horses in these studies and the mineral intakes recommended by the National Research Council (1989) and Duren (1996) would suggest that the intakes of Cu, Zn, Se, and Ca are not adequate to meet the daily requirements of horses (Table 4).

Table 3. Seasonal change in the mineral composition of pasture fed to yearlings (Grace et al., 2002a).

Month	*Na*	*K*	*Ca*	*P*	*Mg*	*S*	*Cu*	*Fe*	*Mn*	*Zn*	*Se*
	(g/kg DM)						*(mg/kg DM)*				
Aug	2.0	38.5	3.4	4.0	2.0	3.7	8.9	145	71	32	0.02
Sep	2.6	43.6	3.7	4.6	2.1	3.5	10.4	174	77	29	0.01
Oct	2.4	39.8	3.5	4.6	2.1	3.6	8.3	267	94	32	0.01
Nov	3.2	34.4	3.7	3.1	1.9	2.8	7.2	168	68	25	0.01
Dec	2.0	22.3	3.3	2.6	1.7	2.6	7.0	124	79	25	0.02
Jan	3.1	28.5	3.9	2.5	2.4	2.3	7.0	129	70	24	0.02
Feb	1.2	22.5	3.6	2.3	2.4	2.6	6.6	231	119	29	0.02

Table 4. Mineral intakes of New Zealand Thoroughbred yearlings, averaging 350-kg live weight and gaining 0.6 kg/day compared with recommended National Research Council (1989) dietary mineral intakes.

	Pasture-fed yearling[1]	*National Research Council*
Macroelements (g/day)		
Ca	24.5	34.0
P	24.0	19.0
Na	16.8	7.0
K	232.0	18.2
Mg	14.8	6.0
Microelements (mg/day)		
Cu	56	70
Zn	198	280
Mn	588	280
Fe	1249	350
Se	0.11	0.7

[1]Grace et al., 2002a.

Animal Performance

The most effective and informative approach used to detect a mineral deficiency is to compare animal performance such as growth, changes in tissue mineral concentrations, or the appearance and absence of clinical signs in mineral supplemented and unsupplemented control horses managed under the same conditions.

GROWTH

During all DM and DE studies the weanlings and yearlings were weighed at about monthly intervals, while the foals of the lactating mares were weighed weekly for about 8 weeks, and then at about monthly intervals. The observed growth rates were 0.70 kg/day for 280-kg weanlings and 0.60 kg/day for 350-kg yearlings fed only pasture. These growth rates were similar to those observed in North America (Hintz et al., 1979; Pagan, 1998). Likewise, the daily milk yields of the mares were satisfactory as the mean growth rate of their foals was 1.34 kg/day.

TISSUE MINERAL COMPOSITION

In the yearling grazing study (7 horses/group), one group was given extra Cu (185.7 v 55.7 mg/day), Zn (547.7 v 197.7 mg/day), Se (2.11 v 0.11 mg/day), P (34.0 v 24.0 g/day), and Ca (44.5 v 24.0 g/day), while the other group was unsupplemented. No mineral supplement treatment differences were observed in mean serum Cu (1.5 mg/L [23.8 μmol/L]), serum Zn (0.6 mg/L [9.2 μmol/L]), and liver Cu concentrations (20.2 mg/kg DM). Further, as there were no significant differences in animal growth rates between supplemented and unsupplemented horses, and the above tissue Cu and Zn values were within the normally expected ranges for horses (Frape, 1998), it was concluded that Cu and Zn intakes of the pasture-fed horses were adequate.

Table 5. Effect of Cu, Zn, and Se supplementation of young horses for 205 days on the liver Cu, serum Cu, serum Zn, and blood Se concentrations.

	Liver Cu mg/kg DM	*Serum Cu mg/L*	*Serum Zn mg/L*	*Blood Se μg/L*
Day 1				
Unsupplemented[1]	13.6 ± 2.5	1.6 ± 0.2	0.51 ± 0.03	41.3 ± 2.8
Supplemented	12.4 ± 0.8	1.7 ± 0.1	0.53 ± 0.04	41.6 ± 3.0
Day 150				
Unsupplemented	22.0 ± 2.8	1.5 ± 0.2	0.62 ± 0.05	40.5 ± 2.8[a]
Supplemented	18.2 ± 1.1	1.7 ± 0.2	0.61 ± 0.04	218.0 ± 8.3
Day 200				
Unsupplemented[1]	19.5 ± 2.7	1.4 ± 0.1	0.43 ± 0.01	73.6 ± 2.1[a]
Supplemented	19.4 ± 2.5	1.4 ± 0.1	0.47 ± 0.02	267.0 ± 8.5

[a]Unsupplemented and supplemented significantly different ($p < 0.001$).
[1]The pasture provided 55.7, 197.7, and 0.11 mg/day Cu, Zn, and Se, respectively. The supplement provided an extra 130, 350, and 2 mg/day of Cu, Zn, and Se, respectively.

In contrast, Se supplementation, in this study, resulted in the blood Se concentrations being increased from 40.5 to >218 µg/L (500 to >2760 nmol/L) but had no significant effect on the growth rates of the yearlings (0.6 v 0.59 kg/day) over the 205 days of the trial (Grace et al., 2002a). However, the Se status of the unsupplemented yearlings was considered to be too low, as the accepted blood Se concentration range is 1600-3200 nmol/L (Caple et al., 1991) and given that white muscle disease has been observed in foals from mares with blood Se concentrations <27 µg/L (<350 nmol/L) (Caple et al., 1978). Therefore, horses grazing New Zealand pastures containing 0.01-0.05 mg Se/kg DM should be supplemented with Se to ensure that their Se status is always adequate. The National Research Council (1989) dietary Se requirement for horses is 0.1 mg Se/kg DM.

CLINICAL SIGNS

In the yearling mineral supplementation study (Grace et al., 2002a), physitis was observed and the condition was scored by the same observer in December, January, and February. The medial and lateral aspects of the distal radial physis were scored separately by the observer standing directly in front of the standing horse. Score 0 was considered normal, having no significant prominence in the region of the distal radial physis, 1 indicated some prominence, 2 indicated distinct enlargement, and 3 indicated gross enlargement. Medial and lateral scores were combined to give an overall score. The limbs were palpated to determine if pain in the radial physical area was present or not. The mineral supplementation had no significant effect on the condition while the mean physis scores (of unsupplemented and supplemented horses) were 2.6, 5.1, and 3.2 for December, January, and February, respectively. These reflected a mild to moderate distal radial physical swelling which was not associated with any painful response to palpation. In this study the above condition should be regarded as a physiological "normal," probably a growth-related physical prominence which resolved completely without treatment.

Overseas studies have reported a decrease in the incidence of developmental orthopedic disease (DOD) lesions when the dietary Cu was increased to 25 mg Cu/kg DM (Knight et al., 1990; Hurtig et al., 1993). The dietary Cu requirement recommended by the National Research Council (1989) is 10 mg/kg DM. The effect of Cu status on the evidence of bone and cartilage lesions was investigated in 21 Thoroughbred foals, where foals and their dams grazed pasture containing 4.4-8.6 mg Cu/kg DM (Pearce et al., 1998). Four treatment groups were set up by randomly allocating mares and their foals to either Cu-supplemented (0.5 mg Cu/kg live weight; equivalent to pasture containing 25 mg Cu/kg DM) or unsupplemented control groups. The design allowed the effect of Cu supplementation of the mare and foal to be examined independently. Mare Cu supplementation increased foal liver Cu concentrations (253.9 v 423.8 mg/kg DM). At euthanasia at 150 days of age, a detailed examination was made of all limb and cervical spine articulations, as well as an examination of the physes from the proximal humerus, proximal and distal radius and tibia, distal femur, third metatarsus, and third metacarpus. Articular cartilage lesions were minor in all foals, with no evidence of clinical DOD in vivo, with the exception of minor radiographic changes assessed at postmortem. Copper supplementation of the foals had no effect on any of the bone and cartilage parameters. Copper supplementation of the mares did not abolish DOD in growing foals in the New Zealand pastoral situation, emphasizing the likely multifactorial nature of this condition (Pearce et al., 1998).

To determine whether New Zealand pastures provide an adequate Ca intake to ensure optimum bone growth and development in weanlings, a Ca supplementation trial was carried out (Grace et al., 2003). Seventeen weanlings were randomly divided into three groups and fed pasture containing 3.5 g Ca/kg DM, and fed none or calcium carbonate ($CaCO_3$) supplement for 84 days. Group 1 was on a low-Ca diet (3.5 g/kg DM); Group 2 medium-Ca diet (6.3 g/kg DM), and Group 3 high-Ca diet (12.0 g/kg DM). Just before and after Ca supplementation, the horses were anesthetized and the left radius, third metacarpus, and first phalanx were scanned using a peripheral quantitative computed tomography scanner to determine cortical Ca content, cortical density, cortical area, periosteal circumference, and bone strength (strain stress index). A significant increase in bone strength was observed with time, but the changes in bone strength were not associated with increased Ca intakes, showing that the pasture provided an adequate Ca intake.

In summary, the various mineral supplementation studies to date show that New Zealand pastures (Table 3) with the exception of Se, provide adequate intakes of minerals including Ca, P, Cu, and Zn to ensure optimum growth and development in young horses, as well as satisfactory milk yields in mares.

Other Considerations

Pastures must be well managed to maintain their feed value, because once they become long and mature, various plant components change and feed value of the pasture decreases. For example, crude protein and soluble sugars decrease, while cellulose, hemicellulose, and lignin increase, and this is associated with a decrease in DM digestibility (Waghorn and Barry, 1987). Horses have a preference for prairie grass and ryegrasses compared with timothy, tall fescue, and white clover (Hunt, 1994). The selective grazing behavior of horses results in uneaten pasture plants eventually becoming the dominant species in the sward, thereby greatly reducing the value of the pasture for horses. Grazing these pastures with sheep and cattle helps to maintain the sward at an even height, and grass species that are unpalatable to horses do not become dominant. Soil fertility must be maintained with regular applications of fertilizer, and pastures may have to be resown every 4-5 years to maintain the presence of grass and clover species that are palatable and are of high nutritive value.

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