A view on pasture management for preventing obesity in horses

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Summary

Horses are non-ruminant animals and their digestive tract is designed to digest fibrous roughage. In the wild they mostly eat grasses supplemented with herbs and parts of shrubs and trees. Generally, they eat mostly young, nutritious grasses which are short (lawn).
The average intake of a pasture is between 1.5% and 3.3% dry matter per kg body weight per day. The intake of a 600kg horse is around 1kg DM per hour, which equals about 5 to 6 kg of grass per hour.
In general, the amount of minerals and vitamins in grass is sufficient to cover the maintenance requirements in horses. It is advisable to test the grass to see if there are mineral deficiencies..
To determine the weight of a horse there are various methods such as commercially available tape measures, and a formula. There are also several Body Condition Scoring systems that provide a good estimate of the nutritional condition of the horse.
For horses the most important energy supply is in carbohydrates. The digestive system is designed for the digestion of structural carbohydrates.
The proportion of non-structural carbohydrates (NSC) in grass varies throughout the day. This is partly dependent on fertilization, grass species, light, drought and temperature during the day and night. In general, the NSC values are lowest during the morning, except when the nighttime temperature is below 5^{o}C.
The grass species selection depends on various factors such as climate, natural conditions present and nutritional value for horses, and can withstand short grazing by horses and trampling. With overgrazing, undesirable and unpalatable grasses (and sometimes poisonous) herbs are easier to establish in the pasture. Many common weeds often contain more minerals than grasses; however, some herbs are higher than ryegrass in NSC content.
Restricted energy intake can be effected in different ways, including limited grazing on pasture, a grazing muzzle, and several grazing systems.
Limiting the grazing time is less effective than most people think; since horses can graze with an increased intake rate, i.e. higher than normal. Thus limiting grazing time is less effective. The use of a grazing muzzle is far more effective in preventing obesity in horses.
In addition to the limit the intake form pasture, the owner should also take in account the fact that the excess weight can be reduced by increase the labour intensity or duration.

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Chapter 1: Introduction

The Nederlandse Vereniging van Vrijetijds ruiter, (NVVR, Dutch Organization of Leisure Riders). Is an organization for drivers and riders who enjoying hacking and other leisure activities. The organization started up 25 years ago and has 1,000 members. Most members own or take care of 1 or more horses or ponies, from different breeds, for example, New Forest Ponies, Friesian, Norwegian Fjord Horse, Arabians, Icelandics or Warm bloods NVVR posted a question to the Wetensschapswinkel.

What does the best horse pasture look like?

Most NVVR members visit their horses daily, but train on average 2 to 3 times per week, with low intensity rides, hacking and training, allowing the horses have a low workload.
Many pastures and paddocks used for horses are generally sown with nutritious, improved grasses, designed to produce animals for meat or milk. These grasses are a rich source of sugars and starch (non-structural carbohydrates (NSC)).
The combination of rich pastures and low workload results in high body condition score (BCS). A high BCS can lead to Equine Metabolic Syndrome (EMS) or insulin resistance, or cause laminitis.
In this report, I will try to answer the following question: How can the horse pasture in the Netherlands maintain the optimum management for sustainable use, so that recreational horses in a healthy and safe way can stay full-time on the pasture?

1.1 Audience

The ultimate target group is the NVVR members, but it is also important for horse owners and livery owners, to know how to prevent a too-high Body Condition Score by means of changes in grazing management and use of the pasture.

1.2 Method

Report from the literature for an answer on how obesity in horses can occur, how the inclusion of grass can be limited, and how the energy value of grass can be cut so that horses can eat more grass without resulting in too much energy intake.

1.3 Structure

The Second chapter examines the effects of obesity and how we can recognize obesity in horses with the Body Scoring System and how weight can be determined by means of a tape measure, plus what the average weight of certain types of horses might be. The Third chapter looks at the requirements of the horse, what natural grazing behaviours, and what time they spent on grazing, what the average intake from the pasture per day is, and what the average intake per hour for a horse is. Finally, this chapter looks at the energy and protein requirements of the horse and whether the intake from the grass is sufficient to fulfill the mineral and energy requirements. The Fourth chapter concerns food analysis, what the different nutrients of a food are - water, dry matter, ash, proteins, fats and especially the different carbohydrates in the feed. The fifth chapter examines various factors that play a role in the development of the non-structural carbohydrates. The sixth chapter explores which grasses are suitable for a horse pasture. The Seventh chapter is about how you can limit the grass intake by using grazing time reduction and the grazing muzzle but also at the different grazing systems. The eight chapter shows what the effects of the different grazing techniques are. The last chapter offers conclusions and recommendations of this thesis.

Chapter 2: Obesities in horses.

Why we should adept our management and use our pasture, that important to know. Our pastures are sown with high nutritional value and that can cause obesities in horse. Obesities can cause and are connected with other diseases as EMS, IR and laminitis.
To estimate the weight of the horse and recognize under and overweight we can adept the diet or change the workload of the horse, it is important to ask a vet or nutritional specialist when the horse is extreme under or over weight.

2.1 Obesities

Obesity is a problem for riding and recreation horses. Especially for easy keepers and native horses obesity is a big. In a research conducted is Scotland, 45% of 319 pleasure riding horses had prevalence for obesity. (Wyse, et al., 2008). In a different research in Virginia, of a random sample of 300 horses 51% where obese and of 19percent where serve obese (Thatcher, et al., 2008). Also in dogs, cat and in humans is obesity becoming a bigger problem. (Edney and Smith, 1986; Allan, et al., 2000; Mokdad, 2003; German, 2006).
Horse with a Body Condition Score of 5 or higher on a scale 0-6) will be recognized as obesities (Wyse, et al., 2008) the first noticeable difference in horses with obesity is the loss of activity and or presentation or sweating at light work (Lewis, 1995). There are strong connections between obesity and Equine metabolic syndrome (EMS), Laminitis, Insulin Resistance in horses (Frank, et al., 2010). Obesity decreases the live span and gives higher risks of diabetes, arthritis, reproductions and decrease quality of life (German, 2006). Obesity shortens the live span of a horse.

2.1.1 Equine Metabolic syndrome.

Equine Metabolic syndrome (EMS) will be at this moment being recognized as a collective name for various problems in the horse, (Monroe and Weese, 2011) such as Obesity, Insulin resistance, Sensitive to laminitis and also probably Cushing syndrome. EMS is strong related with Metabolic Syndrome in human, with the same clinical sign (Frank, et al., 2010)
There are no Specific management strategies currently available except losing weight. Horses with EMS tends to be constant at a weight with little amounts of feeding

2.1.2 Laminitis

Laminitis is a syndrome which is defined as a series of pathological events that damaged the laminae, which weakens the connection between the laminae of the hoofs, when this is permanent, it deals with chronic laminitis. (Monroe and Weese, 2011)
Laminitis can ben occurs with overdose of NSC. 7.5 gr /100kg BW fructan was enough to cause laminitis in clinical studies (van Eps,and Pollit, 2006) therefore it is important to decrease the sugar content of the grass.
Management strategies for laminitis are preventing of high NSC intake, removal of the pasture (Monroe and Weese, 2011).

2.1.3 Insulin resistance

Insulin resistance (IR) is a syndrome that effect the receptor of the cell, so that the losses the sensitive for insulin. Therefor it will be longer and the stays more glucose in the blood, so the metabolic system is disturbs. In general, it is recommended to high amounts of NSC in the feed to be prevented. So pastures with low concentration NSC.

2.2 Recognizing weight gain / loss

To determine the weight of the horse, there are several methods. The most accurate is a scale, but also through commercial weight measuring tapes available to estimate the weight, but also using a measuring tape and formula you can fairly accurately estimate the weight. Table 8 shows the average weights of different breeds. In addition you have the Body Condition Score (BSC) to independently assess the nutritional status.

Table 1: Average weight of different breeds (Bishop, 2003)

Breed	Wither height	Average Weight Kg
Dartmoor pony	112	200-250
Welsh A & B	122	250-350
Riding pony	132	350-450
Welsh C	134	300-400
New forest	142	350-450
Arabic	142	400-450
Welsh Cob / Fell	144	450-500
Small hunter	152	475-520
Riding horse	154	500-550
Thoroughbred	163	500-550
Iris sport horse	165	550-600
Warm blood	173	580-640
Shire	183	700-800

2.2.1 Scale.

The scale is most accurate / easiest instrument for determine the actual weight. But not every on has a scale that is suitable for a horse. Another possibility is to use a weight bridge for lorries.

2.2.2 Measuring tape

There are different commercial measuring tapes available. Many horse feed companies like Pavo, Dodson & Horrel and Spiller sells measuring tapes.
You can also estimate the weight with a formula of Carroll and Huntington (1988) where the girth and length of horse is being used to estimate the weight of the horse.

$$Weight\ in\ kg = \frac{grith * length}{11877}$$

Girth is just behind the front leg and behind the withers. Where the tape is around the body., The lengts is form the middle of the sternum to the ischium.

2.2.3 Body Condition Score

The body condition score (BSC) is a system to accessing the nutritional condition of the horses objectively. BSC uses palpation and visual assessment of the degree of fatty degeneration of the neck, shoulders, ribs, withers, hip and tail of the horse (Carrol and Huntington 1988)
A thick winter coat can be misleading when assessing the BCS. Also the conformation can be misleading, for example a prominent shoulder, a flat back, Can give a different BCS than it with actually would be. However when a BCS is correctly applied, the method is independent of race, and conformation of the horse. In Appendix I you can find the BSC table.

2.3 Conclusion

Overweight and obesities by horse is becoming a bigger problem 45 to 51 of the riding horse are obese; obesity is when a horse has a 5 or higher on a 6 point scale. Obesity can lead to other diseases as Equine Metabolic Syndrome, insulin resistance and laminitis.
To estimate the bodyweight of a horse the different systems available like scales and measuring tapes. Body Condition Scoring is a way to recognize change in nutritional health of the horse.

Chapter 3: Natural requirements of a horse.

In this chapter I discuss the different needs of a horse, how much time spent on grazing, what the daily and the hourly dry matter intake of a horse is. What influences the dry matter intake from the pasture of the horse? What are the requirements for proteins and, energy and is the pasture sufficient to accommodate the requirements of a horse with regard to vitamins and minerals?

3.1 Grazing Behaviour of a horse

The horse is a large, non-ruminant that has evolved from herbivores by means of digestion in the caecum to obtain energy from fibrous roughage (Janis, 1976). Their diet is mainly based on grasses: in their semi-wild environment they eat about 20% of their diet in scrub and herbs, even during the peak of grass growth (Hansen, 1976; Putman et al., 1987). This is limited for the domestic horse at pasture. (N.R.C, 2007). The average grazing time for the semi wild horses (Camargue horse in the Rônhe detla): between 50 and 70% of the time budget is spent in forage behavior (Duncan, 1980,1985, 1992) At nightfall the grazing time decreases and the resting period increases. (Kieper and Keenan, 1980; Mayes and Duncan, 1986), whereas grazing peaked at dusk or sunrise (Mayes and Ducan, 1986)
The horse has a selective grazing behaviour, tending to graze on short grasses (lawns) instead of the longer grasses (roughage) (Fleurance, et al., 2001,; Olberg and Francis-Smith, 1976) The shorter grasses have a higher nutritional value, being higher in crude protein and lower in fibre, than the longer grasses (Fleurance, et al., 2001). Daily removal of manure seems to prevent overgrazed lawns (Olberg and Francis-Smith, 1977).

3.2 Structure value

Fibrous roughage is the basis of the diet of horses in the wild. There is evidence suggesting that an inadequate ration of crude fibre may lead to hindgut acidosis, (Medina et al., 2002) colic (Tinker et al 1997) stomach ulcers (Marray and schusser 1989), an increased risk of crib-biting and wood eating (Keenan, 1986, McGreevy, et al., 1995; Redbo, et al., 1998) and behavioural problems. (Gillham, et al., 1994)
Keenan, (1986) reported that young horse that grazed on lush, low-fibre pasture indulged in substantial bark stripping. Lactating mares grazing on a pasture with low dry matter and low crude fibre, ate greedily of foods containing additional, high crude fibre.. Marlow et al 1983). It is a general observation that when horses have access to lush, young pastures and also to an older, less digestible pasture, will spend time grazing on the quality poorer pastures. However, this is to date not observed in a scientific experiment (McMeniman, 2003)
Elia et al. (2010) showed that horses with a diet that contains a low crude fibre were motivated to work for a food that contains high crude fibre content.

3.3 Voluntary food intake

Horses are more adapted to structural feed with a low energy value (Janis, 1976) Cattle are more efficient per unit roughage. But when the digestibility decreases, so also decreases the passage rate of the cow. With horse instead, when the digestibility decreases, they can increase the intake rate and passage rate. Horses are more efficient with the unit of time (Vandernoot, and Galbraith, 1970).
The Estimated Voluntary Intake of dry matter of a pasture is between 1.5% and 3.3% of the bodyweight (NRC, 2007), with an average for an adult horse of about 2% of the body weight (Dulphy, et al., 1997). Ponies have probably got a higher dry matter intake than horses. The voluntary dry matter intake of a mature pony is between 1.5 – 5.2 kg / 100kg BW. For horses the voluntary dry matter intake is of 1.8 and 3.2 kg / 100kg BW. (N.R.C., 2007)

Several authors have reported that increased roughage s with the increased quality of the grass in terms of digestibility (Morffit, et al., 1987), and a high sugar content (Rogalski, 1984). However, other studies have reported a decreased intake of high quality pasture. For example young thoroughbred fillies were more active and spent less time grazing when on a high-nutritional pasture (Nash and Thomson 2001). As a result, it is possible that the voluntary intake is associated with the digestibility of the pasture. This could lead to control of the pasture energy intake of the animals (Hoskins and Gee, 1995) (NRC 2007)
In 2008, for the first time it has shown that in the individual horse the roughage increased when the digestibility and quality decreased. (Edouard, et al., 2008), But not all horses respond to all types of roughage in the same way, On a diet of fresh grass most horses compensated the partial loss in digestibility of the forage by an increased intake. This reaction is different in cattle where the intake decreases with the low quality of the forage / grass.

3.4 Voluntary intake per hour

There are few studies about the voluntary intake per hour for extended periods in a day, Often these studies are done after an period of feasting, with can result in a higher intake. The average voluntary dry matter intake is approximately 0,162kg / 100kg BW / hour (table 1). If it is assumed the average grazing time is about 15 hours per day, the average intake is about 2.4% dry matter per day.
According to Dowler, (2012) after a period of feasting, the average dry matter intake increase in the first four hours was about 55% of their energy requirements, around 0,17kg dm/ 100BW / hour. That declined to 0,09kg DM / 100kg BW / hour. Most studies are performed over periods of 3 hours, so that can explain the high intake rate of the horses.
The values of Ince, et al., (2011) and Longland, (2011), are still in the range of the maximum dry matter intake by ponies; between the 1.3 and 5.2 kg DM / 100kg BW / day.

Table 2: Summary of published data about the dry mater intake per hour

Study	Physiological State	Grazed grass species	DM intake (kg/100kg/hour	DM intake per day (15 hour grazing)
Duren, et al., (1987)	Growing (yearlings)	Orchard grass	0,164	2,46
Duren, et al., (1989)	Growing (yearlings)	Orchard grass	0,168	2,52
Ince, et al., (2005)	Maintenance(ponies)	grass type not stated	0,09	1,35
Moffitt, et al., (1987)	growing (2year-old)	Orchard grass	0,124	1,86
Moffitt, et al., (1987)	growing (2year-old)	Orchard grass	0,132	1,98
Dowler, et al., (2012)	mature idle horse	Tall fescue	0,12	1,9
Longland, et al., (2011)*	Growing (yearlings)	grass type not stated	0,2667	3,25
Ince, et at., (2011)*	Maintenance(ponies)	Ryegrass and clover	0,1633 – 0,3033	2,4 – 4,55
Average			0,16024	2,4

3.5 Energy requirements

The requirement for a horse depends of different factors like weigh, sex, temperament, work intensity, growth, gestation and lactation of the horse. But also the environmental factors like temperature and humidly. In the Netherlands we use the EWpa system (Energie waarde paard) Energy value horse. 1 EWpa equals to net energy value of 1 kg DM of oats

3.5.1 Energy requirements

Maintenance requirements is the requirement for maintaining the body functions and the metabolic rate and the energy that is required for intake en processing of the food, as well the energy for some movement in the stable of pasture and for the embryo growth. Even on maintenance level the horse will move around the pasture or in the stable. The amount of movement is dependable on the temperament of the horse.

The maintenance requirement is based on the metabolic weight (Bodyweight $^{0.75}$). This is based on the literature data (Vermorel, et al., 1984) is the maintenance requirement set at 0,039 EWpa / BW $^{0.75}$. The maintenance is depending on the breed, sex and temperament of the horse. Stallion has 10-20 higher energy requirements than mares and geldings. (Axelsson, 1949, Nadal'Jak, 1961); Kossila, et al. 1972) And horses has a 5 – 15% higher maintenance requirement then horses at rest.

Table 3: The calculated maintenance requirements (rounded) in EWpa / BW¬ for an adult horse at maintenance (C.V.B 2004a)

Type	Mare /gelding	Stallion
Cold blood horses	0,0390	0,0432
Thoroughbred and there crossbreds	0,0411	0,0453

3.5.2 Energy requirements for work

To determine the intensity of work, there are 2 systems in the Netherlands: the most common systems of the CVB (2004a) and "paard en voer" (horse and feed), that is based on the work of Ellis (2005)

2.5.2.1 CVB

A working horse has increase energy requirements above the maintenance requirements due an increased metabolic level. For prevention of unnecessarily complicated calculations the EWpa system has chosen for a fixed fee per kg $bw^{0.75}$. This is based on the maintenance requirement of the thoroughbreds and crossbreds. The horse that preform labour, get an allowance of 0.0021 EWpa / $BW^{0.75}$.

The CVB has in allowance for labour divided in to 4 working classes, A distinction can be made in class 1 t/m 4: Recreation/light, moderate, Heavy and very heave. The intensity is determined by the speed and possible obstacle, and the time that a particular activity is maintained.

Table 4: Work intensity with the according speeds (CVB 2004a)

	Walk	Trot	Trot	Gallop	Gallop	jumping	Total
Class \ meter min-1	120	240	540	360	720	400	
I	29	29		2			60
II	14	34		7		5	60
III	14	23		10		13	60
IV	12	15	12	9	2	10	60

Table 5: Allowance on labour (C.V.B. 2004a)

Class	200+rider	400+rider	600+rider
Extra allowance	0,11	0,19	0,25
Work intensity class I	0,44	0,80	1,18
Work intensity class II	0,70	1,29	1,90
Work intensity class III	0,91	1,67	2,47
Work intensity class IV	2,16	3,98	5,89

3.5.3.2 Paard en Voer (horse and feed)

Ellis (2005) has in her system tried to determine the work intensity with a simpler and more accurate. Her system is based on the different energy systems and takes in account the duration, the number of times per day, and number per week, and the intensity of the work. From the system will eventually point of intensity which will corresponds with an intensity class. With the using a table you can find the requirements of the horse. In the appendix II you can find the the system of Ellis.

3.5.4 Thermo Neutral Zone

The Thermo Neutral Zone is the temperature range of an animal's body temperature, where he does not actively have to regulated, by adjustment of blood supply to the skin and in which the metabolic rate is constant, with a constant body temperature. , this zone lies between 5^{o}C to 25^{o}C (Morgan, 1998) or -5^{o}C to 25^{o}C. And it depends on humility, coat, weather influence and adaptation of the horses.

Horse can accept temperature between -40^{o}C and 40^{o}C. And cold weather influence more the energy requirements then warm temperatures. Horse that are adapted to cold temperatures and feed to maintenance was the LCT (lower critical temperature) of -15^{o}C. By temperature lower than the LCT is the energy requirements +2.5% per degree (Cymbaluk, 1994).

You can support horse that isn't adapted to cold weather conditions with a shelter, rug or blanket or both. They reduce the temperature loss by respectively, 9, 18 or 26%. (N.R.C. 2007)

3.6 Proteins requirement

The proteins requirements are based on the loss of nitrogen with urine and manure, growth, gestation and lactation and / or build muscles

3.6.1 Maintenance

For maintenance for an adult hoses, the CVB uses 3g/kg bodyweight ^{0,75} VREp (Verteerbaar ruw eiwit) (Digestible crude proteins which is correct for horses) According to Meyer lead a protein coverage to 20% below this value to a protein deficiency.

Table 6: Proteins requirements for maintenance (VREp) (C.V.B., 2004a)

Kg LG	VREp
100	95
200	160
300	216
400	268
500	317
600	364
700	408
800	451

3.6.2 Work

The protein requirements of a working horses, compared to horses a maintenance level, doesn't change. A low charge may be desirable because the increase feed intake and metabolic activity and to compensate the loss of nitrogen in sweat. The allowance in VREp for labour (gr / day) Ewpa allowance maintenance at work * 73.

Table 7: Extra allowance work. (VREp / hour of labour) (C.V.B. 2010)

Class	200+rider(50)	400+rider(60)	600+rider(80)
Extra allowance *	8	14	19
1	32	58	86
2	51	94	139
3	66	122	180
4	158	291	430

*Extra allowance per day

3.6.3 Excess proteins in the diet.

An excess of proteins in the diet can be used as an energy source. The proteins will be broken down and the free ammonia will be converted to urea and discharged in urine. (Lewis, 1995) water losses will increase therefore the water intake will be increased (Meyer, 1987). An excess of proteins won't cause any problems in a healthy horse with normal renal function. But it is advised to lower the proteins intake low as possible.

3.7 Mineral requirement

Even minerals are small part of the diet of the horse; they play an important role in the health of the horse. Minerals are in important part of different physiological processes in the body, acid-base balance, bones, haemoglobin, enzymes and energy pathways.
You can define minerals in macro elements and trace elements. Macro elements are group that the body requires great amount per day. Trace elements are required by the body is small amounts.
A mature adult horse on maintenance can be provided in the mineral requirements with pasture excess (Hoskin, and Gee, 2004). Remind there is little research done to the minerals requirements of horses. Often with small amount of horses often feed on a grain roughage mix. Secondly there is little information available to the relative, biological absorption of the different minerals. The advice of the NRC is the minimal mineral requirements for horses. The optimal minerals intake for horse is poorly defined. (Hoskin, and Gee, 2004)
It is advisable to test ground and grass samples on the availability of the minerals. Shortages can be solved with supplements or certain herbs, with often they are high in minerals.

3.8 Vitamins

Vitamins are organic compounds in the body that are necessary in small concentrations, to promote or regulate biological processes in the body. There are 2 different groups of vitamins. Fat soluble (A,D,E,K) and water soluble vitamins (Vitamin B complex and C).
Under normal circumstances the intake from the pasture should cover the requirements of the horse. Most pastures are a rich source of the fat soluble vitamin (A and E) and water soluble vitamin (B complex with exception of B12). The utilization of Vitamin K and B12 (when there is enough cobalt) and other B vitamins, by the bacteria in the caecum of the horse is linked to the pasture intake (Hoskin and Gee, 2004). Vitamin D is utilized by the horse in the skin under influence of sunlight (N.R.C., 2007). Vitamin D deficiency is unlike when the horse is turned out in the pasture. Vitamin C is utilized by enzymes in horse (N.R.C., 2007) therefore horse are not required any Vitamin C supplement (Lewis, 1995)

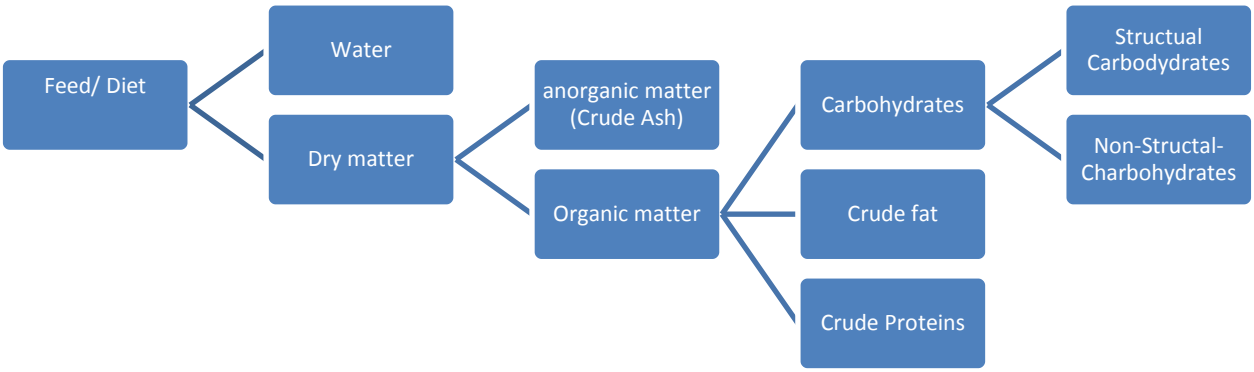
3.9 Conclusion

In semi environment wild horses graze between 10 and 17 hours per day. The grazing behaviour concentrated mostly around sunrise and dawn. Horses are selective grazers, mostly short and young grasses with a high nutritional value.
The diet of a horse should contain at least 1% of their bodyweight as fibrous feed. Where the average dry matter intake form the pasture is around 1.5% and 3.3%. The average dry matter intake is proximally 2% of the bodyweight. The average dry matter intake is about 0,162 kg / hour /100kg BW. With an average of 15 hours per grazing, this result in an average intake of 2.4% of the body weight as dry matter.
Nutritional requirements depend on different factors like, weight, work, growth, gestation and lactation. An excess of proteins will be broken down in kidney as urine. In healthy horses excess proteins will not give any problems.
The minerals and vitamins requirements are covered by the nutritional value of grass. But it is advisable to test the grass and soil of the pasture.

Chapter 4 Feed analysis

Of what nutrient consist a horse food or grasses, is important to know to make a proper diet, what nutrient are important for horses in their diet and which nutrients contains grass.

Figure 2: proximate analyse



4.1 Water

Water is most important nutrient in the diet. Two thirds of the bodyweight of an adult animal consist of water (Ruth, 2003). For calculation for the animal nutritional value it not important.

4.2 Dry matter

Dry matter is what remains after the water has evaporated in the oven. Solids can be divided into inorganic substances (ash) and organic substances.

4.3 Inorganic matter

Inorganic substance is what is left after burning of the material. Crude ash contains minerals, usually in the form of oxides, carbonate and sulphate, often in addition sand.

4.4 Organic substances

The matter that evaporates during combustion is the organic substances, which consist of carbohydrates, fats and proteins.

4.5 Crude protein

Large part of the body consist of proteins, they are a source of calories and amino acids, proteins composed of amino acids are again played a role in enzymes, hormones, transport of nutrients and oxygen (haemoglobin) and structure of muscles, ligaments, hooves and hair (keratin). There are 20

different amino acids from which all proteins can be formed. Most amino acids, the body itself, but there are some that have included the dietary essential amino acids (Ruth, 2003)

4.6 Fats

Fats are a source of energy. Dietary fats are made up of chains of triglycerides. These are again composed of a chain of fatty acids which are connected to each other by glycerol. The fatty acids can be divided into essential and nonessential fatty acids. The dietary essential fatty acids should be included, these are the omega 3-6-9 fatty acids. (Ruth, 2003)

4.7 Carbohydrates

Carbohydrates are the main source of energy in the diet of horses, the most carbohydrates can be found in forage, grain and grain products (NRC, 2007).The carbohydrates can be divided into different groups. The main groups are:

- Monosaccharaides
- Disaccharides
- Oligosaccharides,
- Polysaccharides.

Monosaccharaide / disaccharide carbohydrates are composed of single or double sugar molecules. The oligosaccharides are between 3 and 10 of the sugar molecules long. And Polysaccharides are complex carbohydrates that are often large number of sugar molecules. Starch and cellulose are Polysaccharides (Ruth, 2003).
Although all carbohydrates are composed of sugar molecules and about the same gross energy, digestibility and nutritional value are different (N.R.C, 2007. You can divide carbohydrates into two different groups the non-structural carbohydrates (NSC) and structural carbohydrates (NDF).

4.7.1 Non-structural carbohydrates

Non-structural carbohydrates (NSC) consist of several simple sugars (Monosaccharaides, Disaccharides, Oligosaccharides), for example fructan, starch, glucose. The non-structural carbohydrates are broken down with an enzyme that's called amylase; amylase is produced by pancreas and released into the small intestine (Lewis, 1995). NSC which is not digested in the small intestine will enter the colon. When excessive amounts of NCS enter the large intestine can this result in a disturbed intestinal flora, which in turn gives risk of colic and laminitis (N.R.C. 2007). Non-structural Carbohydrates interpreted as sugars, starch, fructan.

4.7.2 Structural carbohydrates

Structural carbohydrates (crude fibre) are all carbohydrates that are resistant to the digestive enzymes of the horse. These carbohydrates are in the cell wall of the plant and must be fermented by bacteria that are living in the cecum of the horse. The structural carbohydrates are fermented be it can be absorbed as volatile fatty acids by the horse.

4.8 Conclusion

A food consists of several components: water, ash, crude fat, crude protein, structural carbohydrates and non-structural carbohydrates. The primary energy source for horses are the carbohydrates. The combustion values of all carbohydrates are similar, the digestibility determines the energy value of

different carbohydrates. The digestive system of the horse is especially built for the digestion of structural carbohydrates and to a lesser extent for non-structural carbohydrates, an abundance of non-structural carbohydrates can cause laminitis in horses.

Chapter 5: Non-structural carbohydrates accumulation

During the photosynthesis that occurs in the green parts of the plants, available CO_2 and water under in influence of Sunlight converted to sugars (NCS) and O_2. The glucose serves as a power supply for the plant. If the output of the sugars is higher than the growth and metabolism of the plant, the excess will be converted to the NSC storage (reserve) carbohydrate. This is the accumulation of the NSC.

The amount of NSC in a plant varies throughout the day and night due to an imbalance between the production and metabolism in the plant (Bowden et al, 1968). The sugar content can rise up to 400g per kg dry matter (Longland, and Byrd, 2006).

Various influences, such as climate, play a role in the growth and metabolism of the plant, but also the fertilization of the pasture and grazing affect growth and therefore to the carbohydrates of the pasture.

You can draw a comparison with a factory where all the "suppliers" (water, nutrients) do their work can be produced, and there will be few stocks of semi-finished products are. But when a shortage occurs in certain parts of the production line, the "intermediate goods" go to the storage. When shortages are resolved the factory can work again at full production.

Grass is about the same thing. When the growth is good, there will be little NSC are present. However, when growth is inhibited by a shortage of water or nutrients are already NSC acclamation place.

5.1 Choice of grass species.

Different grasses have different predisposition to accumulation of non-structural carbohydrates (NSC). NSC is what the people say as sugar. Warm-season grasses contain less NSC than cold-season plants (Longland et al, 1995). However, warm-season grasses have a higher optimal growth temperature (26^{o}C - 32^{o}C) than cold-season grasses ((NRC 2007) and are therefore less suitable for the Dutch climate. Especially ryegrass and tall fescue have on average higher fructan content than other grasses, which grow under the same conditions (Watts, 2004).In addition, perennial ryegrass higher digestibility content as compared to other types of grass (Wilman, et al, 1996). A higher digestibility for horses again has disadvantages because a higher digestibility frequently has a higher energy value. In table (11 and 12) contains a number of grasses, and with the amount of non-structural carbohydrates.

5.2 Temperature

With the accumulation of NSC plays day and night temperature an important role. The speed of the enzymes that facilitate in the metabolism of sugar is reduced at temperatures below 5 ° C, and the stops below the freezing point. Therefore, cool-season grasses and some broadleaf herbaceous, sugars accumulate in cold conditions.

A study to 128 cold-season and 57 warm-season grasses under controlled condition grew at 10^{o}C daytime and 5^{o}C at night or 25^{o}C daytime and 15^{o}C 'night under the full 12-hour light exposure, showed that the grasses under elevated temperature conditions had lower NSC accumulation then the group growing under 10^{o}C (Chatterton, et al, 1988). Traditionally spring is seen as dangerous moment for laminitis, but also overweight. The warm spring weather with the combination of cold nights causes the NSC level rises,

because the metabolism of the plant does not get the chance to sugar produced from the previous day into growth.

5.3 Nutritional deficiencies at the plant

When the fertilization level is low, here and there due to lack of nutrients, the grass growth is inhibited, with accumulation of NSC result. Too low fertilization level provides high NSC levels in grain (Batten et al, 1993), grasses (Peyraud 1998, Valk, et al, 1996) red fescue grass (Berkeley, et al, 1991) and ryegrass (Ferri, 2004). Table 10 are a NSC values at different fertilization levels.

Table 8: The dry matter, NDF and sugar content at different nitrogen fertilization in different year course, in different periods. Adapted from Valk, et al, (1996)

Year	1991			1992					1993		
Period	1	2	3	1	2	3	4	5	4	5	Average
Treatment											
N 150 kg/ hectare											
DS (gr/kg PR)	176	136	174	166	257	170	139	143	175	132	166,8
NDF(gr/kg DM)	443	454	471	560	440	510	543	473	488	483	486,5
Sugar (gr/kg DM)	170	145	155	93	239	112	54	100	120	143	133,1
N 300 kg/ hectare											
DM (gr / kg PR)	165	122	172	158	251	152	126	134	158	127	156,5
NDF (gr/kg PR)	444	454	481	548	443	530	536	481	486	515	491,8
Sugar (gr/kg DM)	144	125	125	81	239	78	68	107	129	91	118,7
N 450 kg/ hectare											
DM (gr/kg PR)	163	133	154	169	231	159	124	139	157	120	154,9
NDF(gr/kg DM)	433	464	466	515	467	527	518	490	503	503	488,6
Sugar (gr/kg dm)	136	70	92	76	188	79	69	101	108	68	98,7

NDF=Neutral Degent fibre

5.3 Drought

When the absorption of water is limited because of drought, the enzymes which play a role in the metabolism will stop earlier then the enzymes which play a role in the photosynthesis. This means that the mass of the grass gradually increase is limited, but the mass which is more concentrated .Therefore it

is sufficient available water is essential for the grass. When sufficient water is available, we will be grass grow and therefore contain less NSC.

5.5 Light

The photosynthetic capacity and the production of sugar are linked to the light intensity and the duration of light. The NSC concentration early in the morning is at the lowest point, provided the temperature was high enough to the sugars produced from the previous day to be used for metabolism and thus growth. In a field study, using the grass *Phalaris sp*., The NSC level was significantly lower in the shade and rose in 2 to 4 hours to a level of sunlit grass (Watts, 2004).

As a result, throughout the day and night rhythm creates a difference in the accumulation of the NSC during the day, during the morning, the NSC is the lowest concentration and rises during the day and reaches the optimum during the evening, then again at night decreases. (Longland, et al, 1999; Holt and Hilst, 1969; Bowden, et al, 1968)

5.6 Maturity of the grass

It is sometimes assumed that older long grass is lower in NSC content than young / short grass, but this is not always true. Mature grass contains less nutritional value lower than young grass. Thus, they contain less protein and energy and a higher amount of structural carbohydrates than young grass, but the NSC content can still be high (Watts 2004, 2008) especially when they are stressed by lower temperatures.

5.7 Grazing

Overgrazing can ensure that the composition of the pasture changes. The duration and amount of grazing determine which grasses can survive to reproduce. When grazing is applied the horse will choose for the more favourable grass species. Which is often has higher sugar content. Because by overgrazing, new spices introduced in the pasture, these herbs can sometimes contain high amounts of sugar house. In table 9 you can find the different NSC values for different herbs.

Table 9: NSC content of different herbs. (Watts, 2005) checken

	NSC (% DS)	Starch (%DS)	Sugar / fructaan (%DS)
Dandelion	27	1,3	25,7
Red clover	18,1	1,8	16,3
Yellow melilot	14,1	3,3	10,8
White clover	11,8	0,1	11,7
Couch grass	18,1	1,6	16,5
Wild Oats	26,4	3,4	23

Figure 3: Over grazed pasture, (own photo)

Figure 4: Dandellion (Own photo)

5.8 Conclusion

The NSC concentrations change varies in the day / night cycle. Factors like species selection, drought, light, temperature, grazing intensity and fertilization influence the NSC concentration in the grass. Perennial ryegrass is often higher in the concentrations of NSC in comparison with other grasses. But it depends also on other factor. In periods of drought, and cold temperature the NSC concentration can rise.

It is advisable to add fertilization to the pasture, because fertilized grass tends to be lower in the NRC concentration than unfertilized grass.

Over grazing can introduce unwanted grasses and (sometimes poisonous) herbs in the pasture. Most herbs contain high levels of minerals in compared with grasses but sometimes also high levels of fructan.

Chapter 6: Grasses

Besides the management is the choice for certain grasses essential for good pasture management. Not every grass species are suitable for a horse pasture, they can't stand short grazing or contain too high a nutritional horses.

In general, most horse pastures in the Netherlands contains a mixture of BG11 or BG4. BG11 and BG4 are particularly suitable for cattle. A BG11 mixture contains for 69% ryegrass, timothy 14%, Field meadow grass 14% and smooth meadow grass 3%. The BG4 mixture mainly composed of 72% ryegrass and 28% from timothy. Ryegrass generally contain more than other breeds NSC

6.1 Suitable grasses for pasture.

The selection of grasses depends on several factors such as climate, soil and grazing pressure. Important factors to keep in mind are, vegetation, habitat, and drainage of the soil and plant and animal nutrition. The grass species that you select for the horse pasture should withstand short heavy grazing and treading by horses.

Grasses doesn't grow all year round. The growth depends on the temperature, moisture and fertilization. In addition, the growth of the grasses is also influenced by the management of the pasture. Overgrazing will reduce the yield of the pasture and the growth of unpalatable and unwanted grasses and herbs promote.

Ideally, a pasture contain a mixture of grasses that is be adapted to local conditions and can tolerate short grazing and treading (NRC, 2007). The majority of horses have a surplus of protein in their diet so legumes won't be necessary.

Grass can be divided into cool season and warm-season grasses. Cool-season grasses have a growth starts from 7^{o}C, with an optimum temperature of 16-24^{o}C. Warm-season grasses have started growing from 15^{o}C and an optimum of 26-32^{o}C (NRC, 2007). For the Dutch climate, the cool-season grasses are most suitable.

6.2 Suitable types of grass

The following grass species are suitable for pasture:

Orchard grass (*Dactylis glomerata*).Is a late flowering grass, with average production values, develops early, produces a lot of mass and is hardy but vulnerable to late frost. It is more resistant to drought, shade and heat than timothy grass and ryegrass, but less resistant to a wet surface. (Hall 1994a)

Tall fescue (*Festuca arundinacea*) is resistant to a wet surface and intensive entry. In addition, the resistance to drought and heat, and can maintain themselves in poor soils. (Hall 1994b)

Kentucky Bluegrass, **Smooth Meadow-grass**, (*Poa pratensis*) is a highly palatable grass species that can adapt to soil and climate, sufficiently hardy. It grows best under normal moisture content, but also under dry conditions and cool temperatures. It is less suitable for higher temperatures. (Hall 1996b)

Creeping red fescue (*Festuca rubra*). Can tolerate intensive grazing and short entry, but has a lower nutritional value than other grasses. (N.R.C 2007)

Timothy (*Phleum pretensse*) is a traditional production type of grass for horses, produces late flowers in the middle of summer and is leafy forage, but is less resistant to the short grazing. (N.R.C.). Besides this, no rhizomes or suckers, Timothy has shallow roots (Lacefield, 1980) making it less resistant to entry.

Perennial ryegrass (*Lolium perenne*) is a palatable grass species, has a high yield and has a high nutritional value which makes it less suitable for use in the horse field. But it has a good recovery and ability to tolerate heavy grazing. (N.R.C., 2007)

Meadow Fescue (*Festuca pratensis*) is one of the main grasses for agriculture. Has a fertile soil necessary, is less suitable for very dry, poor soil nutrition and is hardy. With heavy grazing fescue gradually supplanted by other grasses (Petersen, 2005)
Field Meadow Foxtail or Meadow Foxtail (*Alopecurus pratensis*) of all the grasses, meadow foxtail will bloom early and is only suitable for wet pastures. (Petersen, 2005)

When the pasture is properly maintained, would orchard grass, creeping red fescue and timothy most suitable pasture grasses. However timothy won't tolerate short graze as the other grasses by horses. Preventing overgrazing timothy should prevent the loss of timothy from the pasture.
Fescue grass has a lower nutritional value for horses and tolerates heavy good entry, and also has low fructan content. Orchard grass is widely used in other countries but less common in the Netherlands and it has low fructan content.

The following tables (10, 11) are the fructan content of different grasses species during an investigation in Hanover with different grasses and 2 pasture mixtures. The grasses where growing under the same conditions. (Von Borstel and Gräβler, 2003).

Table 10: fructan content of different grasses (Perennial ryegrass and annual ryegrass and 2 grass mixtures) (von Borstel en Gräβler, 2003)

Nr Grass species Fructan content (% van DM)

		1st cut		2nd cut		3rd cut		4th cut	Year average	
		Early	Late	Early	Late	Early	Early	Late	Early	Late
1	Perennial ryegrass, Sambin	8,4	8,4	6,4	5,7	3,3	2,4	4,3	6,4	7,2
2	Perennial ryegrass, Anton	10,6	5,5	7,2	6,8	4,9	4	6,7	8	5,4
3	Perennial ryegrass, Respect	6,3	7,1	6,2	5,4	2,4	3,7	3,4	4,9	6,1
4	Perennial ryegrass, Edda (	8,9	5,8	6,6	5,5	3	3,3	6	6,6	5,4
5	Perennial ryegrass, Stratis	7,7	11,2	8,8	5,8	2,6	2,5	4,8	6,2	8,9
6	Perennial ryegrass, Gemma.	7,7	6,4	7,5	8,2	6,4	4,2	5,5	6,9	6,2
7	Annual ryegrass (Lemtal)	7,8	12,1	5,3	6,9	3,5	2,7	7,4	6,7	9,7
8	Annual ryegrass (Lipo)	6,5	11,7	4,1	4,6	5,3	3,5	10,3	6,8	9,4
9	Pasture Mixture "Standard GI"	8,8	13,5	6	3,5	3,5	4,8	5,5	6	9,9
10	Pasture Mixture "Standard GIII"	9,7	13,3	6,1	5,6	3,2	2,6	4,5	5,8	10,9
Average Perennial and Annual ryegrass		8,0	8,5	6,5	6,1	3,9	3,3	6,1	6,6	7,3
Average Perennial		8,3	7,4	7,1	6,2	3,8	3,4	5,1	6,5	6,5
Average Annual ryegrass		7,2	11,9	4,7	5,8	4,4	3,1	8,9	6,8	9,6

Table 11: Fructan content of different grasses (von Borstel en Gräβler, 2003)

Nr Grass species Fructan content(% per DM)

		1st cut		2nd cut		3rd cut		4th cut	Year average	
		Early	Late	Early	Late	Early	Late		Early	Late
11	Timothy	4,5	2	2,9	2,6	2,3	2,9	5	4,1	2,2
12	Meadow Fescue	7	9,7	4,2	4,5	2,3	3	4,9	4,8	7,3
13	Smooth meadow grass	*	*	*	*	8,2	7,6	3,1	5,2	7,6
14	Creeping red fescue	3,8	4,7	3,8	4	4,8	4,4	6,3	4,8	4,5
15	Orchard grass	6	6,1	4,1	4	3,7	2,9	6,2	5,1	5,1
16	Creeping red fescue	5,8	10,5	4,9	5,9	1,8	2,3	3,5	4	8,5
17	Meadow Foxtail	1,6	4,3	2,5	2,2	1,1	1,8	2,1	1,8	3,3
18	Rough-stalked meadow-grass	7,2	5,9	8,5	7,5	4,6	2,8	8,5	7,4	5,8
19	Rough-stalked meadow-grass	1,4	6,1		2	3,5	7,1	5,8	3,7	6,3
20	velvet grass	2,2	3,7	3,8	3,3	1,6	1,4	2	2,3	3,3
Average		4,4	5,9	4,3	4,0	3,4	3,6	4,7	4,3	5,4

*Didn't had any yield in the first year.

6.3 palatability of grasses

In an extensively research to the palatability of 38 grass species in Pennsylvania USA, the horses had a preference for Kentucky bluegrass, (Washko, et al., 1974) timothy, and smooth broom grass above orchard grass, fescue grass, an large foxtail.
With grass species that were adapted the British climate, was fescue and creeping red, above great foxtail (Acher, 1973)

6.4 Herbs

Besides the fact that on the grass that is overgrazed contains higher content of sugars, reduce the yield of the grassland, and promotes the growth of unpalatable and unwanted grasses and (sometimes poisonous) herbs (NRC, 2007). In addition, horses grazed on a overgrazed paddock has a greater risk of sand colic (Bradford, 2004). There may also be introduce herbs that may contain higher amounts of sugar and therefore less palatable for horses with insulin resistance. Dandelions (Taraxacum officinale), Wild

chicory (*Cichorium intybus*) for instance, contain many inulin, a fructan type that causes laminitis in horses and cattle (in clinical trials) (Thoefner, et al., 2004; NRC, 2007).In contrast, contain herbs again high concentration of minerals and proteins in comparison with perennial ryegrass (Harrington et al, 2006).
In organic livestock production is dynamic use of herbal seen conducive to the health of cows and other livestock. However, here is no scientific research has been done. (Smidt and Brimer, 2005).

6.5 Conclusion

The choice of the pasture mixture is essential for the pasture management. The most common grazing mixtures contain too high nutritional value for the majority of horses. By choosing gas mixtures that are low in fructan and low energy content may reduce the risk includes obesity and other related diseases. Avoid where possible ryegrass, perennial ryegrass contains too high a nutritional value for most horses is therefore unsuitable as a forage crop for horses. Herbs are generally quite easily introduced into the common pasture by overgrazing. Sometimes these herbs contain high levels of NSC. However at the same time, some herbs have a positive effect on health of the horse. So you become a balancing act between the possible advantages and disadvantages

Figure 5: Horse pasture (Own photo)

Chapter 7: Reducing the energy consumption.

Reducing the intake form is the pasture is important. Even horses at maintenance can get too much energy from the pasture causing a high bodyweight. The restriction of the intake can be done in different ways; with a grazing muzzle, limiting the grazing time or using a different grazing system.

7.1 Restricting grazing time

Some nutritionists and vets recommend limiting grazing time to limit the caloric intake of the grass. In one study, the estimated intake of grass in a 3-hour grazing period to 21% of dry matter required per day (Ince et al 2005). In a six-week experiment with 4 ponies 3 hours per day grazed in the pasture and remaining time in a stall with unlimited amount of haylage were supplied. During the experiment the ponies reduced their intake and increased the intake from the pasture to a 0.91% DM / kg BW in 3 hours and up to 41% of the daily dry matter intake. (Ince et al, 2011). The total dry matter intake did not increased as compared to the first week. This is support by other studies. According Glunk and Siciliano (2011) and Dowler (2009) increase their grass horses grazing time when the record is limited. As a result, the limitation of the uptake, by means of restriction time period is less suitable for the control of obesity.

Because horses are a relatively small stomach, they will naturally not fast longer than 4 hours of fasting. The longer fasting (> 6 hours) varies the acidity in the stomach greatly to the detriment of a healthy intestinal flora and can cause stomach ulcers (Neijenhuis, 2012). So it is not advisable for a horse more than 6 to fasting. Restricting grazing time will take more time, because you need every time the horses from the pasture get. Unfortunately, there is no solution to solve this problem.

7.2 Grazing muzzle

A strategy in order to restrict the recording of the grass during the grazing is by using of a grazing muzzle. The grazing muzzle is attached to the halter and breaks when it under tension. A grazing mask is a partially closed base with a 2 cm hole in the middle. Trough base grazing muzzle allows a certain amount of grass. A grazing muzzle prevents an excessive intake of the grass. This allows horses / ponies on pasture longer stay and still keeps their weight or loses weight.

A comparison between ponies with a grazing muzzle and ponies without grazing muzzle (Longland et al, 2011). Both groups were grazed for three hours a day, and half of the group received a grazing muzzle. The next day the groups were switched. The ponies grazing without the mask had a dry-matter intake of 0.8% body weight. This amount is equivalent to an intake of 0.266 kg DM / h / kg BW. This is higher than the 0.12 kg DM / h / kg BW (Dolwer, 2012) on average of 8 hour grazing. And also more than the 0.17 kg DM / h / kg BW in the first 4 graze. Ince, et al (2011), showed a maximum absorption of 0.91% DS / LW in a 3 hour period. This equal to a intake of 0.303 kg / hour / 100 kg BW. The group with the grazing Muzzle (Longland et al, 2010 had a lower uptake of 82% resulting in an intake of 0.144% DS / LW (Longland, et al, 2011). Also the ponies showed no behavioural problems, this concludes that a grazing muzzle can be an effective tool against obesity. Not all horses grazing accept a mask as well. Not all owner want a grazing muzzle, it prevent natural grooming behaviour.

7.3 Management and maintenance

There are different grazing systems available. Continuously grazing, rotational grazing and stripgrazing are suitable for horses. Or a combination of both.

7.3.1 Grazing Systems

To meet the nutritional needs a horse is annually 1ha pasture per horse (500kg on maintenance) is required (NRC 2007). With management strategies as overproduction of the spring and summer should be conserved as hay or haylage. This is of course dependent on climate and fertilization.

7.3.2 Continuously grazing

Continuously grazing the horse gets the entire grazing season / year access to the pasture. The animals graze the whole area of the plot so that the grass is always uniform in length (except at the places where there is manure). If the number of horses in the field has been adapted to the absorption of the grass is equal to the increase, there will always be sufficient grass is available. In the spring it will be necessary due to the rapid growth of the grass, a wire tensioning and cut the grass. Low stocking rate will result increase losses because the grass is too long and loses its taste. Overgrazing means that there is a constant grazing too short, so that the growing points are affected which is a stress factor for the grass surface, with the consequence of sugar. Weeds and unwanted grasses also get the chance to settle.

7.3.3 Rotational grazing

Rotational grazing is technique that the horse just days or weeks on a plot. It strives to ensure that the grass a length of about 15 cm as the horses come on the plot. The grass is grazed for a time after which it has a chance to recover before it is taxed again through grazing. When the pasture is grazed, it is recommended that the non-grazed areas to mow and fertilize again. If 1 or more lots became to long for grazing it is, the possibility exists that instead of mowing to grazing. The advantage is that the grass offer better control, and there is more grass than with continuous grazing and less food losses (Webb et al 2009). In addition, rotational grazing has the following benefits: reduced grazing pressure improved yield, parasite control and the possibility of fertilizing in the season (Singer et al 1999).

7.3.4 Strip Grazing

Strip grazing is a system where every day or every several days, a strip of new grass is added. This tells the grazed area each time new grass added. For strip grazing you should have a visible wire, plastic prods and a power device, so the wires can be moved. In the beginning, the meadow in half or into smaller pieces which share a water source and shelter are present. The thread is then each time (preferably daily) moved. Later you can choose the same size to keep making you pasture again the chance to recover. By means of strip grazing a pasture can be used more efficiently (Singer et al 1999).

7.3.5 Paddock / Sacrifice area

Another option is to use a paddock or field 'to indicate' where you stand and let the horses roughage feeding. There is the possibility of shelter and drinking followed by areas can be grazed. Especially with wet pasture you can use the paddock when the ground is to wet.

It is also possible to use a combination of different systems to be applied. For example, a paddock with a shelter, water supply, places for feeding haylage or hay and a track around the pastures. The rest of the pasture can be used as rotational or strip grazing.

7.4 Effects of different grazing system

A stand meadow / continuous grazing generally has a lower energy value of fresh, new grass (CVB 2010) but at a fairly young grass understaffing and he will again sit higher in nutrition than in a meadow with well-applied strip grazing.

When a position is overgrazed pasture, there are several undesirable grasses and faster (sometimes poisonous) herbs and introduced faster so you should opt for re-sowing of pasture. By means of strip grazing / grazing rational you may choose to temporarily allow certain documents (over) grazing and other documents rest. Here you get a smooth meadow grass again and get the time to grow and recover.

You can also choose some pieces to mow when the grass is too long and / or when too much grass available. After this, the cut will feed maintenance fertilization so the risk of re-growth is greater. The mown grass can serve as roughage in winter.

A properly applied grazing system will definitely help to reduce the total energy: by selective grazing, pasture rest to pieces and give any surplus to cut and store for the winter. Especially in the spring when the growth of grass, is often higher than the absorption of the horses.

7.5 Fertilization

The pasture is to be fertilized on the basis of an analysis and soil to be fertilized at the optimum of N. (nitrogen) P. (Phosphorus) and K. Potassium and at a degree of acidity between a pH of 6-7. Under fertilization can cause distress, resulting in an increased risk of high levels of NSC (Peyraud 1998; Valk, et al, 1996; Berkeley, et al, 1991; Ferri, 2004). In a review of Sugawara (1983) on orchard grass (*Dactylis glomerata*) gave 3 times higher nitrogen (240 kg / ha) than the control (80 kg / ha) reduced NSC in the grass. The total yield of the grass will be higher so the amount of NSC will also increase. Therefore it is recommended to use a grazing system to prevent a higher intake.

7.6 Conclusion

The most effective method for a horse to restrict over-grazing is a grazing mask. But not everyone want a grazing mask and not all horses accept it. Restricting the grazing time, and certainly with very limited hours, is less effective for horses to prevent obesity. Several systems such as strip grazing and pasture rotational grazing can help prevent the absorption of the grass to limit also ensure a uniform grazing of the pasture. And less chance of long grasses who are less palatable and therefore spots can occur with long grasses. A good fertilization of the plants, the concentration of the sugars in the grass cut, but the total yield increase, and therefore, it is advisable to use it in combination with the reduction of the recording.

Chapter 8: Examples

In order to give an idea of what can and what can the influences of the different control systems, I give her a few examples. To avoid long calculation, the calculations are in the appendix 3

To assess the effects of different grazing systems , I start calculate the energy requirements of the different horses. Then I will show the energy balance when unlimited grazing and the effects of limiting of pasture time and a grazing muzzle. The examples are:

Mark.

Is a 18 year old KWPN horse with a weight of approximately 600kg. That is trained on a medium level. What is based on the C.V.B (2004). He allowed to graze on an average horse pasture with an average value of 0,9EWpa / kg DM of grass.

Harmke.

Is a KWPN mare 23 years old with a height of 1.53 cm and weighing approximately 520 kg. She stands in a pasture with a BG 11mix (production mix grass for cows). Every day she does light work (work going on in step: Circles, with straight shoulder and bend inward or on the lunge walk and trot), 1 time a week, an outdoor ride of 30 minutes in quite a snappy pace. On average they are about a half hour a day with low labour intensity. She stands on a fresh pasture (for example April with a yield of 2,400 kg / DM / ha)

Rakker.

A Shetland pony of approximately 200 kg, that serves as a companion pony for another horse He isn't trained at this moment so he is at maintenance. He is standing on a pasture with continuous grazing (0.79 EWpa / kg DM)

Pjotter

A national eventing horse. A 14 year old gelding is heavily and intensively trained. And is full time in the paddock (May with a yield of 2,400 kg / DM / ha)

With the first example (Mark) I will show how the energy and protein requirements have come. (Annex 3) as the other calculations of the following parts. The results are in table 12

Table 12: energy requirements of the different examples

	Example 1	Example 1	Example 3	Example 4
Weight	600	520	200	600
Intensity	Medium	Light	none	Very heavy
Duration of training (hour)	1	0,5	0	1
Energy (EWpa / day)				
Maintenance (EWpa / day)	5,24	4,70	2,07	5,24
Extra allowance work (EWpa /day)	0,25	0,23	0	0,22
Allowance work (EWpa / day)	2,09	0,52	0	5,89
Total	7,58	5,45	2,07	11,38
Protein (VREp /day)				
Maintenance (VREp / day)	364	327	160	364
Extra allowance work (VREp / day)	19	17	0	19
Allowance work (VREp / day)	152	37	0	430
Total (VREp / day)	535	381	16	723

8.1. Unlimited grazing

The inclusion of the grass is on average 2% of body weight (Section 1.3 page()). Together with the average energy and protein content (Table 13) you can determine the energy intake from the pasture.

Table 13: Average and EWpa VREp and value of fresh grass (CSA 2004a; CSA 2010)

Cutting time	KG DM / ha	DM DM / kg product	Ewpa EWpa / kg DM	VREp VREp / kg DM
Grass pasture april	1400	172	1,023	182
	2400	172	0,980	166
Grass pasture mei	1700	164	0,970	170
	2700	164	0,925	148
Grass pasture Juni	1700	169	0,974	171
	2800	169	0,927	129
Grass pasture Juli	1700	159	0,955	181
	2600	159	0,916	151
Grass pasture Augustus	1500	150	0,951	187
	2200	150	0,928	159
Grass pasture September	1300	149	0,961	204
	1800	149	0,944	189
Grass pasture Oktober	1100	163	0,970	200
	1600	163	0,968	195
Fresh grass year average		161	0,9	185
Fresh grass year average with continue grazing		177	0,79	145

With the Energy form the grass and the requirement you can calculate de the energy balance for the different horses. This can you find in Table 14.

Table 14: Energy and protein balance in grazing.

	Example 1	Example 2	Example 3	Example 4
Dry matter intake (kg / day)	12	10,4	12	400
EWpa value grass	0,9	0,98	0,79	0,925
VREp value grass	185	166	145	148
Energy intake (EWpa)	10,80	10,19	3,16	11,10
Energy requirements (EWpa) (table 12)	7,39	5,44	2,07	11,38
Energy excces / shortage (EWpa)	3,41	4,75	1,09	-0,28
% of the diet	146%	187%	153%	98%
VREp intake (VREp)	2220	1726	580	189
VREp requirements (VREp) (table 12)	522	381	160	2268
Proteins excces / shortage) (VREp)	1698	1345	420	1455
% of the diet	425%	453%	363%	279%

For all horse there was an protein and energy excess. As mention in section 1.6.3 (page …), excess of proteins will be excreted by the kidneys, so an excess proteins for an healthy horse won't give any problems. However, it is advisable to the amount of protein as low as possible.

The excess energy intake can lead to a high Body Condition Score. In the 1st to 2nd examples, the excess energy intake for these horses in around 45% to 87% per day higher than the requirement. For the 4th horse the fulltime pasture won't cover the energy requirements. Based on this information you can tell that the higher energy intake can be compensated with higher work intensity or a longer duration. To cover the maximum intake of the horse by the energy requirement you need to train at international eventing or racehorses. But this work intensity is for most horses / owners are not feasible.

Example four will not be further used in these examples, without restriction, it is still a lack of 2%. But that will generally no problem.

8.2 Grazing time shortening

You can make the grazing time shorter, and during the day or night in a in a paddock or stabled, you can limit the uptake. However, due to a shorter time for grazing, intake rate can also increase. For this example I will use 0.125kg DM / 100 kg BW / hour as grass. The dry matter intake for a horse is 0,162 kg DM / 100 kg BW/ per hour. (Table 1 / Chapter 1.4) but must researches are done with limited access time for a short time span (max 3hours). In addition, the fasting before the experiment also increase the intake rate per hour compared with longer periods (Dowler, 2012) .In the following Table 17 shows the maximum duration that the horses in the pasture may (grazing time) where there is a balance between energy demand and consumption (table 15)

Table 15: Maximum grazing times, associated with energy intake, the grazing time is rounded up to a Quarter.

	Example 1	Example 2	Example 3
Energy requirements	7,39	5,44	2,07
EWpa value grass	0,9	0,98	0,79
VREp value grass	185	166	145
Drymatter intake (kg / day)	8,21	10,4	12
Maximum grazing time	11	8,5	10,5
DM intake	8,25	5,525	2,625
Energy intake (EWpa)	7,43	5,41	2,07
Energy requirements (EWpa) (table 12)	7,39	5,44	2,07
Energy excces / shortage (EWpa)	0,04	0,03	0,00
% of the diet	101%	98%	100%
VREp intake (VREp)	1526	1022	381
VREp requirements (VREp) (table 12)	522	381	160
Proteins excces / shortage) (VREp)	1004	641	221
% of the diet	292%	268%	238%

Because it is not advisable for a horse to feast for more than 6 hours in between to different feeds. It is advisable to provide extra hay or haylage with a low quality. According to Ince, et al (2011) generally it is to advice to give a low quality roughage. The energy value and protein value of grass hay can you find in table 16

Table 16. (Energy and protein value of grass hay. (C.V.B., 2010)VREp (VREp / kg dm) EWpa (EWpa / kg dm)

	VREp (VREp/kg ds)	EWpa (EWpa/kg ds)
Grass hay good quality	845	0,764
Grass hay average quality	845	0,682
Grass hay moderate quality	845	0,632

When we give 0.33% DM / kg BW in the diet of the horse, which is equivalent to 2kg dry matter in a horse of 600kg. And you give moderate hay (Table 16) for all horses then the maximum grazing time like this can be seen (Table 17)

Table 17: Maximum grazing time by supplementation of roughage

	Example 1	Example 2	Example 3
Energy requirements	7,39	5,44	2,07
EWpa value grass	0,9	0,98	0,79
VREp value grass	185	166	145
Energy Intake from the Hay (EWpa)	1,264	1,06	0,632
Proteins intake from the hay (VREp)	370	321	111
Maxium intake from the pasture	8,21	10,4	12
Maximum grazing time	9	7	8,25
DM intake	6,75	4,55	2,0625
Energy intake (EWpa)	7,344	5,55	2,05
Energy requirements (EWpa) (table 12)	7,39	5,44	2,07
Energy excces / shortage (EWpa)	-0,05	0,12	-0,02
% of the diet	99%	102%	99%
VREp intake (VREp)	1619	1042	396
VREp requirements (VREp) (table 12)	522	381	160
Proteins excces / shortage) (VREp)	1097	661	236
% of the diet	292%	274%	247%

If accepting that intake rate doesn't increase with the shorter grazing time. Research showed that especially in the first 3 -4 hours of grazing increased uptake was seen (Dowler, 2012; Ince, et al, 2011; Longland, et al, 2011). The maximum time allowed to complete the horses graze (between 8 and 11 hours) depends on the energy value of grass and the work intensity, the higher the work intensity or the lower the energy value the longer they are allowed to graze.

8.3 Grazing muzzle

Besides shortening the grazing time you can also reduce the intake rate, with the grazing time of 16 hours. Longland, et al (2011) wrote that the intake rate of the muzzle group was reduced by 82% with the control group that was allowed grazing for the same time. Because in the experiment the grazing time was limited is could increase the grazing overall. The DM intake of the control group was (0.266 g / kg BW / h) is much higher than the average (0.162 g / kg BW/h). If you compare the intake rate with the average intake rate, that will give a reduction of 63%. A reduction of 50% should eventually fit better.

Table 18: Maximum intake of dry matter

	Example 1	Example 2	Example 3
Energy requirements	7,39	5,44	2,07
EWpa value grass	0,9	0,98	0,79
VREp value grass	185	166	145
Dry matter intake (kg/ h)	0,75	0,65	0,25
Dry matter intake rate with grazing muzzle (kg/hour)	0,375	0,325	0,125
Dry matter intake with 16 grazing	6	5,2	2
Energy intake (EWpa)	5,44	5,1	1,58
Energy requirements (EWpa) (table 12)	7,39	5,44	2,07
Energy excces / shortage (EWpa)	-1,99	-0,34	-0,49
% of the diet	73%	94%	76%
VREp intake (VREp)	1100	754	290
VREp requirements (VREp) (table 12)	522	381	160
Proteins excces / shortage) (VREp)	588	373	160
% of the diet	192%	198%	181%

In order to limit the intake of grass I a grazing muzzle an effective method. Horses are all within less than their requirements. And it is even possible to add some period without a grazing muzzle. Especially for the 1st and 3rd example you can add a short period without a grazing mask, so the horse can groom.

7.4 Conclusion

When horses are fully allowed unlimited grazing, most horses have an excess in the energy and protein balance during any period of growth of the grass. Horses with extremely heavy work intensity will be fully able to stay in the pasture without any restriction. Horses at maintenance or light work will be given grazing restriction. It is true that the higher the intensity the more grass they may record without the risk of an energy surplus. Grazing limitation for shorter periods (3 hours) is less effective than most people think. They take much more gentile on the speed of the recorded image. The most effective method is to limit the recording through a grazing mask, but not all owners / horses to accept this. And besides adjusting the diet is the best method is still increasing the work intensity, so the pasture time can be increased.

Chapter 9: Conclusion

Horses are large ruminant herbivores are not adapted to digesting to fibrous feed. On average they graze between 10 and 17 hours per day depending on the circumstances. Where the average intake of a pasture is between 1.5 to 3.3 kg dry matter per 100kg LW. The average intake of a horses / ponies is around 0.162 kg / 100kg LW / hour and thus DS 2% of their body weight per day.
The energy and protein requirements of a horse depend on the size of the horse and any work intensity. The pasture may provide for the mineral and vitamin needs of the horse but it is wise to regularly testing the grass on the availability of minerals and vitamins. The higher grass along with recordings of the lower energy level will need for most horses can cause problems such as obesity and other related disorders such as EMS, laminitis and insulin resistance. Obesity can shorten the life expectancy and general health can decrease.
There are several factors that have influence of the NSC level of the grass. It is advisable to fertilize the pasture, because unfertilized pasture is often higher in the NSC concentrations than fertilized grass. The total amount of sugars will probably rise due to increased growth and thus dry matter, and therefore you limit the grass intake. It is best to graze on warm days in the morning instead of the evening, at colder nights it depends on the weather. And horses that are sensitive to insulin resistance and laminitis is to prevent grazing when the grassland is stressed and therefore contains a higher concentration of NCS.
The grass in the must be adapted to the local climate, soil, grazing pressure and good resistance to the short and heavy treading by grazing horses. Despite the fact that good at treading perennial ryegrass and grazing can short it is unsuitable for a horse pasture because it has a high nutritional value compared to other grasses. Better choices are orchard grass, red fescue, smooth meadow, tall fescue.
By overgrazing can introduce unwanted grasses and (sometimes poisonous) herbs in the pasture. Generally herbs contain higher levels of minerals, but some broadleaf herbs can be containing high levels of NSC. Certainly in horses prone to laminitis or Insulin resistance is recommended to reduce the amount of spice. For the other horses a limited amount of spice in itself not a big problem, but where there are too many herbs, it is advisable to apply to pasture renewal.
In order to limit the grass recording, there are several ways. By means of the shortening of the grazing time and then the horses to be put on a paddock with the roughage with a low energy level, with a grazing muzzle, or the application of grazing techniques and the fertilizing of the pasture can help prevent the absorption of excess energy. The limited grazing is less effective than most people think especially when horses grazing especially in a shorter time. Making the image often much higher than what you would expect. The grazing on the pasture with a muzzle is more effective to prevent obesity in horses. However, not all horses want a grazing muzzle accept and not all owners want to start grazing muzzle.
In addition to the lowering of the recording, the owners take into account that the increase of the work is an effective means to prevent obesity. Horses with higher work intensity can eat more grass than horses to work.

References

Archer M, (1973) The species preference of grazing Horses *Brit Grass /Soc*, 28 (1973), p. 123

Archer M, (1978) Further studies on palatability of grasses to Horses. *J Brit Grass /Soc*, 33 p. 239

Axelsson, J.,(1949). Standard for nutritional requirements of demestic animals in the Scandinavian Countries. *In: V Congress International Zootechnie*, Paris, 123-144

Batten, G. D., A. B. Blakeney, V. B. McGrath and S. Ciavarella (1993) Non-structural carbohydrate: Analysis by near infrared reflectance spectroscopy and its importance as an indicator of plant growth. *Plant and Soil.* 155-156 (1) pages 243-246

Belesky, D.P., S. R. Wilkinson, J. A. Stuedemann, (1991) The influence of nitrogen fertilizer and Acremonium coenophialum on the soluble carbohydrate content of grazed and non-grased Festuca arundinacea. *Grass and Forage Science* Volume 46, pages 159–166

Bishop, R. (2003) The horse nutrition bible: the comprehensive guide to the feeding of your horse. Newton Abbot: David & Charles

Bowden, D.M., D.K. Taylor, W.E.P. Davis, (1968) Water-soluble carbohydrates in orchardgrass and mixed forages. *Can J Plant Sci.* 48 page 9

Bradford, G. B.(2004) Understanding Equine Colic, Lexington,KY, Eclipse Press

Carroll C.L., and P. J. Huntington P. J, (1988) Body Condition Scoring and Weight Estimation of Horses, *Equine Veterinary Journal* 20 (1), 41 – 45.

Coenen, M., (2005) Exercise and stress: impact on adaptive process in involving water and electrolytes. *Livestock production Science.* 92 (2) Pages 131-145

CVB, (2004)a Het EW-pa en VREp systeem Lelystad, the Netherlands

CVB, (2004)b Voederwaarde (EW-pa en VREp) van voedermiddelen voor paarden. Centraal veevoederbureau, Lelystad, the Netherlands

CVB, (2010) tabellenboek veevoeding 2010, Lelystad, the Netherlands

Dowler L E, P. D. Siciliano, S. E. Pratt-Phillips, M. Poore (2012) Determination of Pasture Dry Matter Intake Rates in Different Seasons and Their Application in Grazing Management. *Journal of Equine Veterinary Science*. 32 pages 85-92

Dowler L. E., D. P. Siciliano, (2009) Prediction of hourly pasture dry matter intake in horses. *Journal of Equine Veterinary Science* 2009;29(5) pages354-5.

Dulphy JP, W. Martin-Rosset ,H. Dubroeucq,J. M. Ballet, A. Detour, M. Jailler, (1997) Evaluation of voluntary intake of forage trough-fed to light horses. Comparisons with sheep. Factors of variation and prediction. *Livestock Production Science* 52: 97–104.

Duncan P.,(1985) Time-Budgets of Camargue Horses III. Environmental Influences. *Behaviour*, Vol. 92, No. 1/2, pp. 188-208

Duncan P.,(1992) Horses and Grasses. The nutritional ecology of equids and their impact on the Camargue, Springer-Verlag, NY, 1992, 287 p.

Duncan, P.,(1980), Time-Budgets of Camargue Horses: II. Time-Budgets of Adult Horses and Weaned Sub-Adults, *Behaviour*, Vol. 72, No. 1/2, pp. 26-49

Duren, D.E., C.T Dougherty, S.G. Jackson, J.P. Baker, (1987) Forage intake of yearling horses grazing tall fescue. In: Annual Report of the Kentucky Agricultural Experiment Station, University of Kentucky, Lexington,KY; 1987:104.

Duren, S.E., C.T. Dougherty, S.G. Jackson, J.P. Baker. (1989) Modification of ingestive behavior due exercise in yearling horses grazing orchardgrass. *Appl. Anim. Behaviour Science* 22 pages 335-345

Edouard N., G. Fleurance, W. Martin-Rosset, P. Duncan, J. P. Dulphy, S. Grange, R. Baumont, H. Dubroeucq, F. J. Pérez-Barbería and I. J. Gordon, (2008) Voluntary intake and digestibility in horses: effect of forage quality with emphasis on individual variability. *Animal* 2 page 1526-1533

Edouard, N., G. Fleurance, W. Martin-Rosset, P. Duncan, J. P. Dulphy, S. Grange, R. Baumont, H. Dubroeucq, F. J. Pe´rez-Barberı´a and I. J. Gordon (2008). Voluntary intake and digestibility in horses: effect of forage quality with emphasis on individual variability. *Animal* 2 10, pages 1526–1533

Elia J. B., H. N. Erb, K. A. Houpt, (2010) Motivation for hay: Effects of a pelleted diet on behavior and physiology of horses. *Physiology & Behavior 101* 623–627

Ellis, A., M. van Oostende, C Staal,(2004) Paard Voer. Zutphen Roodbont Uitgeverij.

Ellis, A.D., (2005) Moving from a range of systems currently assessing practical workloads in equines to a common system. *In: 56th Annual Meeting of the European Association of Animal Production*, Uppsala, Sweden, 2005. Wageningen Academic Press

Ferri, C.M., N.P. Stritzler, J.H. Pagella (2004) Nitrogen Fertilization on Rye Pasture: Effect on Forage Chemical Composition, Voluntary Intake, Digestibility and Rumen Degradation. *Journal of Agronomy and Crop Science* Volume 190 (5) pages 347–354

Fleurance G., P. Duncan, B. Mallevaud, (2001) Daily intake and the selection of feeding sites by horses in heterogeneous wet grasslands. *Animal Research* 50 (2001) 149–156

Gillham, S. B., N. H. Dodman. L. Shunster, R. Kream and W. Rand, (1994). The effect of diet on cribbing behavior and plasma beta-endorphin in horses. *Appl. Anim. Behav. Sci*. 41 pages 147-153

Glunk E.C., P.D. Siciliano, (2011) Effect of Restricted Grazing on Dry Matter Intake Rate, *Journal of Equine Veterinary Science*, 31 (5-6), Pages 296-297

Hall. M. H, (1994a) Orchardgrass Penn State Coop. Ext. Agronomy Facts #25. http://cropsoil.psu.edu/extension/facts/agfact25.pdf accessed 23 april

Hall. M. H, (1994b) Tall fescue , Penn State Coop. Ext. Agronomy Facts #28 http://cropsoil.psu.edu/extension/facts/agfact28.pdf accessed 23 april

Hall. M. H, (1996.)Kentucty Bluegrass, Penn State Coop. Ext. Agronomy Facts #50 http://cropsoil.psu.edu/extension/facts/agfact50.pdf accessed 23 april

Hansen, R.M., (1976) Foods of free-roaming horses in southern New Mexico. J. Range Manage 29 pages 347

Harrington K.C., K.C., A. Thatcher and P. D. Kemp,(2006) Mineral composition and nutritive value of some common pasture weeds. *New Zealand Plant Protection* 59:261-265

Henneke D. R., G.D. Potter, J. L. Kreider and B. F Yeates, (1983) Relationship Between Condition Score, Physical Measurements and Body Fat Percentage in Mares, *Equine Veterinary Journal* 15 (4), 371 – 372.

Holt, D.A., A.R. Hilst, (1969) Daily variation in carbohydrate content of selected forage crops. *Agron J.* 61 pages 239.

Hoskin, S. O. and E. K. Gee. 2004. Feeding value of pastures for horses. *N. Z. Vet. J*. 52:332-341.

Houpt K.A., M.F. O'Connell, T. A. Houpt, D. A. Carbonaro,(1986) Night-time behavior of stabled and pastured peri-parturient ponies *Applied Animal Behaviour Science Volume 15*, (Issue 2May), Pages 103–111

Imme Petersen, (2005) (vertaald door Willemien Werkman) Suiker is gras, (mensport) Cavallo – das magazin Für Aktiees reiten 4/2005, http://www.natuurlijkpaardenhouden.nl/Suiker_in_gras.pdf [Beschikbaar op 30mei]

Ince J., A.C. Longland, J.C. Newbold, P.A. Harris, (2011) access to pasture and haylage for 3 and 20 hours per day respectively, for six weeks. *Journal of Equine Veterinary Science*, 31 (5-6), Page 283

Ince J.C, A Longland, M. J. C. Moore-Colyer, C. L. Newbold, P.A Harris, (2005) A pilot study to estimate the intake of grass by ponies with restricted access to pasture. In: *Proceedngs of the British Society of Animal Science Annual Conference*, 4-6 April 2005, University of York, York, UK; page 109.

Ince JC, Longland AC, Moore-Colyer M, et al. A pilot study to estimate the intakeof grass by ponies with restricted access to pasture. *Proceedings of the British Society of Animal Science*. York, England, April 2005

Janis, C.,(1976) The Evolutionary Strategy of the Equidae and the Origins of Rumen and Cecal Digestion *Evolution* 40 (4) Page 757 of 757-774

Keenan, D. M., (1986) Bark chewing by horses grazed on irrigated pastures. *Austral. Vet. J*. 63 pages 234-235

Keiper R.R. and M. A. Keenan,(1980) Nocturnal activity patterns of feral ponies. *J. Mammal*., 61 (1), pp. 116–118

Lacefield, G.D., J.C. Henning, T.D. Phillips, and M. Rasnake, (1980) Thimothy. Accessed [30 mei 2012] http://www.ca.uky.edu/agc/pubs/agr/agr84/agr84.pdf

Lewis , L.D. (1995) Equine clinical nutrition: Feeding care. Williams and Williams USA.

Longland A.C., C. Barfoot, and P.A. Harris, (2011). The effect of wearing a grazing muzzle vs not wearing a grazing muzzle on pasture dry matter intake by ponies. *Journal of Equine Veterinary Science*, 31 (5-6), Pages 282–283

Longland, A.C. and B.M. Byrd, (2006) Pasture Nonstructural Carbohydrates and Equine Laminitis. *American Society for Nutrition* Vol 136 pages 2099S – 2102S

Longland, A.C., A.J. Cairns, M.O. Humphreys, (1999) Seasonal and diurnal changes in fructan concentration in Lolium perenne: implications for the grazing management of equine predisposed to laminitis. Proceedings of the 16th equine nutrition and *physiology society symposium.* June 2–5, Raleigh, NC. 1999 pages 258–259.

Longland, A.C., Theodorou, M.K., Sanderson, R., Lister, S.J., Powell, C.J. and Morris, P. (1995). Non-starch polysaccharide composition and in vitro fermentability of tropical forage legumes varying in phenolic content. *Animal Feed Science and Technology* 52 pages 161-177

Marlow, C H. B., M. van Tonder, F. C. Hayward, S. S. van der Merwe, and L. E. G.Price, (1983) A report of on the comsumption, compostition and nutritional adequacy of a mixture of lush green perennial ryegrass (lolium perenne) and cocksfoot (Dactylis glomerata) Fed ad libitum to thoroughbred mares. *J. S. Afr. Vet. Assoc.* 54 pages 155-157

Martin-Rosset W., M. Vermorel, M. Doreau, J.L. Tisserand, J. Andrieu, (1994) The French horse feed evaluation systems and recommended allowances for energy and protein. *Livestock Production Science*. 40, (1) 1994, Pages 37–56

Mayes E. and P. Duncan, (1986) Temporal Patterns of Feeding Behaviour in Free-Ranging Horses. *Behaviour,* Vol. 96, No. 1/2, pp. 105-129Published

McGreevy, P. D., P. J. Cripps, N. P. French. L. E. green and C. J. Nicol, (1995). Management factors associated with stereotypic and redirected behavior in the Thoroughbred Horse. *Equine Vet. J*. 27 pages 86-91

McMeniman, N.P., (2003) Pasture Intake by Young Horses. Rural Industries Research and Development Corporation, RIDCC Publication No. 00W03/005

Medina, B., I. D. Girard, E. Jacotot, and V. Julliand, (2002) Effect of a preparation of Sacchoromyces cereviasea on microbial and fermentation patterns in the large intestine of Horse fed high fiber or a high starch diet. *J. Anim. Sci* 80:2600-2609

Meyer, H., (1987) nutrition of equine athlete, page 644- 673 in equine exercise physology2. J. r. Gillespie and N.E. Robinson, eds Davis, C.A.: ICEEP publication.

Moffitt D.F., T. N. Meacham, J. P Fontenot, V. G. Allen, (1978) Seasonal differences in apparent digestibility of fescue and orchard grass/clover pastures in horses*. In: Proceedings of the 10th Equine Nutrition and Physiology Symposium*,11-13 June , Fort Collins Marriot, Fort Collins, CO; 1987:79.

Morgan, K., 1998. Thermoneutral zone and critical temperatures of horses. J. Therm. Biol. 23, 59 – 61

Munroe, G., and S. Weese. (2011) Equine Clinical Medicine, Surgery and Reproduction. London : Manson

Murray, M. J., and G. Schusser. (1989) Application of gastic Ph-metry in horses: measurement o 24 h gastric Ph in horse fed, fastend and threated with ranitdine. J*. Vet. Internal Med* 6: page 133.

N. F. Cymbaluk, (1994)Thermoregulation of horses in cold, winter weather: a review Livestock Production Science. 40 (1994) 65-71

N. Frank. (2009) Equine Metabolic Syndrome. Journal of Equine Veterinary Science. 24 (5) pages 259-261
N. Frank, R.J. Geor, S.R. Bailey, A.E. Durham, P.J. Johnson. (2010). Equine Metabolic Syndrome.Journal of Veterinary Internal Medicine. 24 (3), pages 467-475

N.R.C. ,(2007) Nutrient requirements of domestic animals. N°6. Nutrient requirements of horses, National Academy Research Council, Academy of Press, Washington, D.C., Sixth Revised E. National

N.R.C.,(1989) Nutrient requirements of domestic animals. N°6. Nutrient requirements of horses, National Academy Research Council, Academy of Press, Washington, D.C., Fifth Revised E. National

Nadal'jak, E.A.,(1961) Gaseous exchange and energy expenditure at rest and during different tasks by breeding stallions of heavy draught breeds. *Nutr Abstr Reviews, 32 (no 2332)*

Nash, D. G. and Thompson, (2001) Grazing behavior of Thoroughbred weanlings on temperate pastures. *in Proc. 17th Equine Nutr. Physiol. Soc. Symp. Lexington*, *KY.P.* pages 326-327

Neijenhuis, F., J. Westra, M. Verhoeven, M. van Wijhe-Kiezebrink, K. Visser (2012) Paardenhouderijen vergeleken: out of the box. online: *http://edepot.wur.nl/191940 (26mei 2012*

Olberg, F.O., and K. Francis-Smith., (1976) study of emilimative and grazing behavior - the use og field by captive horses. Equine Vet. J. 8 pages 147-149

Olberg, F.O., and K. Francis-Smith., (1977) Studies on the formation of ungrazed eliminative areas in fields used by horses. Appl. Animm Ethology 3 pages 27-34

Peyraud, J.L., L.Astigarraga. (1998)Review of the effect of nitrogen fertilization on the chemical composition, intake, digestion and nutritive value of fresh herbage: consequences on animal nutrition and N balance. *Animal Feed Science and Technology* 72 (3-4) Pages 235-259

Putman, R. J., R. M. PReatt, J. R. Ekin, and P. J.Edwards, (1987) Food and feeding-beheavour of cattle and ponies in the New Forrest Hampshire. Journal Applied Ecology. 24 pages 369-380

Redbo, I., P. Redbo-Torstensson F. O. Odberg, A. Hedendahl, and J. Holm, (1998). Factors affecting behavioral disturbance in race horses. *Anim. Sci*. 66 pages 475-481

Rogalski, M., (1984). Effect of carbohydrates or lignin on preferences for and intakes of pasture plants by mares. *Roczniki Akademii Rolniczej Poznaniu* 27 pages 183-193.

Singer, J.W., N. Bobs in, W.J. Bamka and D. Kluchinshi. (1999) Horse pasture management. *Journal of Equine Veterinary Science* 19, (9), Pages 540–545, 585–586, 588–592

Smidt N.W., and L. Brimer, (2005) The use of herbs in pastures: An interview survey among biodynamic and organic farmers with dairy cattle. *Agriculture and Human Values* (2005) 22: 355–363

Thoefner, M.B., C.C. Pollitt, A.W. van Eps, G.J. Milinovich, D.J. Trott, O. Wattle, P.H. Andersen, (2004) Acute Bovine Laminitis: A New Induction Model Using Alimentary Oligofructose Overload. Journal of Dairy Science. 87(9) Pages 2932–2940

Tinker, M. K., A. N. White, P. Lessard, C. D. Thatcher, K. D. Pelzer, B Davis, D. K. Carmel. (1997). A prespective study of equine colic risk factors. *Equine Vet. J*. 29:454-458

Valk, H. I.E. Kappers, S. Tamminga, (1996) In sacco degradation characteristics of organic matter, neutral detergent fibre and crude protein of fresh grass fertilized with different amounts of nitrogen Anim. Feed Sci. Technol., 63 (1996), pp. 63–87

van EPS, A. W., and C. C. Pollitt (2006) Equine laminitis induced with oligofructos. Equine Veterinary Journal. 38 (3) pages 203-208

Vandernoot G. W., E.B. Galbraith, (1970) Comparative digestibility of components of forages by geldings and steers. *Journal of Animal Science* 33, page38,

Vermorel, M., R. Jarrige, and W. Martin-Rosset, (1984) Metabolisme et besoins energetiques du cheval. Le systme des UFC. 237-276. in: R. Jarrige et, W. Martin-Rosset (Editors). "Le Cheval" Reproduction – Selection - Alimentation - Exploitation. INRA Publications, Route de St Cyr, 78000 Versailles.

von Borstel, U., and J. Gräβler, (2003) Untersuchungen zur Kennzeichnung der Fructangehalte verschiedener Gräserarten. Landwirtschaftskammer Hannover, AG Futterbau und Futterkonservierung e.V

Waghorn G. C, T. W. Barry, (1987)Pasture as a nutrient source. Nicol AM (ed). Feeding Livestock on Pasture. *New Zealand Society of Animal Production*, Pp 21–38

Washko, J.B., T.L. Merrit, R.H. Swain, W.G. Downs,T. V. Hershberger (1974) Forage mixtures for horse pastures and hay. Pennsy/Agri Ext Bull 793, 1974.

Watts K.A., (2005) A revieuw of Unlinkely sources of Exces Carhohydrate in Equine Diet. *Journal of Equine Veternary Science*. 25 (8) p 338-344

Watts, K.A.(2008) “Carbohydrates in Forage: What is Safe Grass?” Kentucky Equine Research Conference. Versailles, KY: Kentucky Equine Research Inc.

Watts. K, A., (2004) Forage and pasture management for laminitic horses, *Clinical Techniques in Equine* Practice Volume 3, Issue 1, March 2004, Pages 88–95

Webb G., C. Duey, S. Webb (2009) Continuous vs. Rotational Grazing of Cool Season Pastures by Adult Horses *Journal of Equine Veterinary Science*, Volume 29, Issue 5, May 2009, Pages 388-389

Webb G., C. Duey, S. Webb, (2011)Continuous vs. Rotational Grazing of Cool Season Pastures by Adult Horses *Journal of Equine Veterinary Science, Proceedings of the 21st Equine Science Society Symposium University, Springfield, MO, US.* Volume 29, Issue 5, May 2009, Pages 388–389

Wilman D., Y. Gao and M. A. K. Altimimi (1996). Differences between related grasses, times of year and plant parts in digestibility and chemical composition. The Journal of Agricultural Science, 127 , pp 311-318

Wright R.G, G. Rietveld, P. Lawlis,(1998) Body condition scoring of horses. OMAFRA Factsheet 98-101, 1-5.

Appendix I

Condition	Neck	Withers	Back & loins	Ribs	Hind Quarter
0 very thin	Bone structure easily felt No Muscle Shelf where neck meets shoulders	Bone structure easily felt	3 point of vertebrae easily felt	Each rib can be easily felt	Tail head and hipbone projected
1 Thin	Can feel bonestructure – slight shelf where neck meets shoulder	Can feel bone structure	Spinous process can be felt – transvers processes have slight fat covering	Slight fat covering but can be felt.	Can feel hip bones
2 fair	Fat covering over bone structure	Fat deposits over withers – dependenton conformation	Fat over spinous processes	Can't see ribs, ribs still can be felt	Hipbones covered with fat
3 Good	Neck flows smoothy into shouders	Neck rounds out withers	Back is level	Layer of fat over ribs	Can't feel hip bones
4 Fat	Fat deposited along neck	Fat padded around withers	Prositive crease along back	Fat spongy over and between ribs	Can't feel hip bones
5 very fat	Bulging fat	Bulging fat	Deel positive crease	Pockets of fat	Pockets of fat
W right., et al. (1998)					

Appendix II

WORKING OUT THE REQUIREMENTS FOR YOUR HORSE
- A new system by Andrea D. Ellis

This system allows you to calculate the requirements of your horse according to the work you really do

Types of work (A,B,C,D):
You will need to give details about all the different types of work you do on average in one week:
For example a Leisure horse may do jumping, dressage or flat schooling and hacking in a week (so 3-4 types of work). The current table gives opportunity for 4 types of work (A,B,C,D)

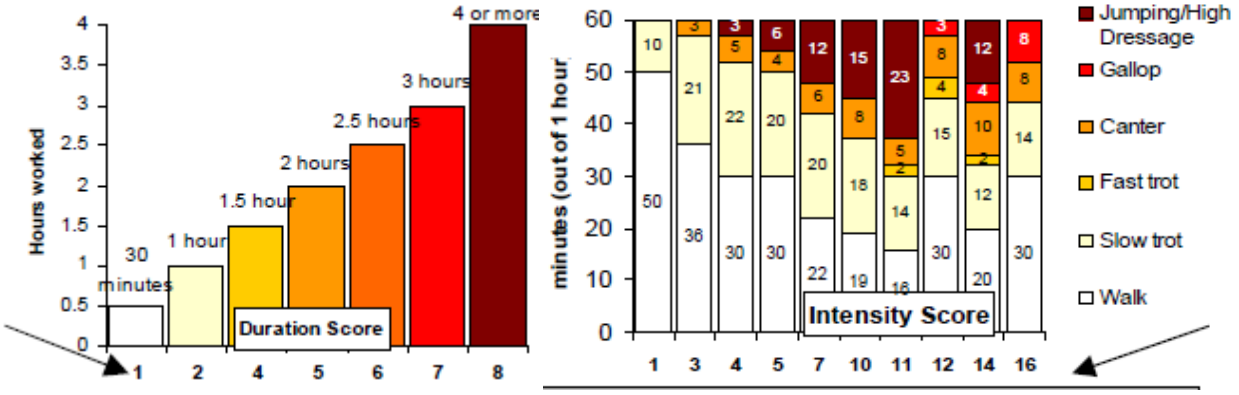
For each type of work you need to give:
a Daily *How many times do you do this work on any **one** day (mostly once a day)*
b Weekly *How many individual days per week do you do this type of work*
c Duration *For how long do you work – pick your score according to time from **'Duration Score'***
d Intensity *How hard is the work you do – pick an estimated score from **'Intensity Score'***

Adding up Scores for each Type of work
It all becomes clear from the examples given below – use the first column of the table to fill your own horse's scores in and calculate your points up to here for **each type of work (a*b*c +d)**

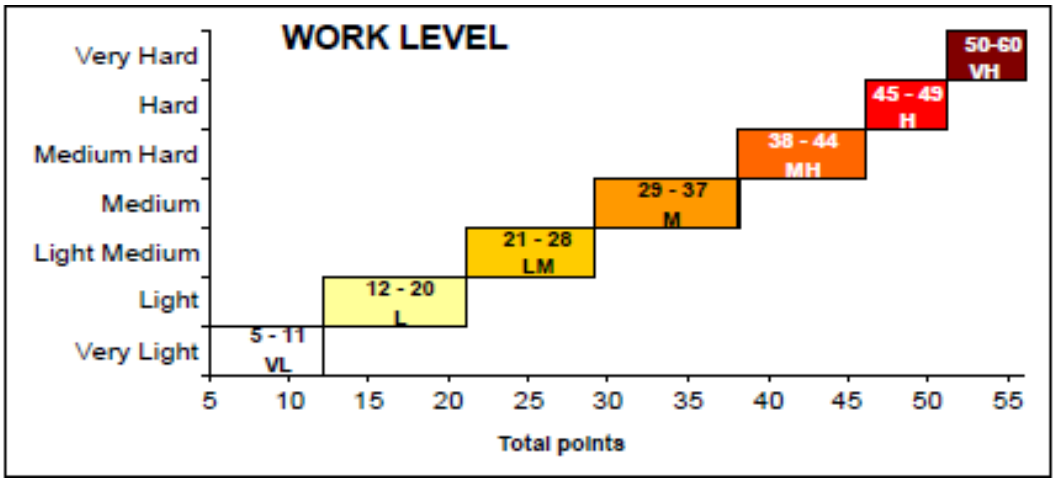
Additional Points – Extra E
The system allows for extra points in situations where your horse has to work harder. If you jump higher than 1.40 meters, work on a steep inclination for 10 minutes (up a hill or on the treadmill), work the horse at high temp (28ºC+), or your horse is pulling a carriage = you add **2 points** extra for each type of work where this occurs

Final Adjustments – Extra F
This adjustment is necessary if your horse does more than one type of work – if you only filled in one type of work ignore this box (=0). The requirements for maintenance (no work) are included in the first type of work and they will increase slightly for the second type of work but then not increase any further. So if you have filled in **B put 1** in the F box OR if you have used **C as well put 4** in the F-box instead OR if you have used **D** as well you need to put **5 in the F box.**

Finally adding up your Work level points
Simply add all types of work scores together (A+B+C+D + E) MINUS F
Your points will then tell you the work level and the energy requirements for your horse when you look at Figure 3.
On the following pages some general advise is given about what the diet of your horse may look like – of course you need to adjust it according to **temperament and body condition** of your horse. The ideal body condition means that when looking form behind the spine should be the highest point and you should still just be able to see the outline from the ribs. If you are not sure it is always useful to get some advice from professionals or look at a book with more detailed descriptions.
So have a look at the table on the following page – it may take a little practice but by looking at the examples you soon get the hang of how to fill in the scores:



	A	Type of exercise	Your horse
a	Daily	on any on day	
b	Weekly	Days per week	
c	Duration	Score	
d	Intensity	Score	
	sub total	a*b*c*d=	
	B		
a	Daily	on any on day	
b	Weekly	Days per week	
c	Duration	Score	
d	Intensity	Score	
	sub total	a*b*c*d=	
	C		
a	Daily	on any on day	
b	Weekly	Days per week	
c	Duration	Score	
d	Intensity	Score	
	sub total	a*b*c*d=	
	D		
a	Daily	on any on day	
b	Weekly	Days per week	
c	Duration	Score	
d	Intensity	Score	
	sub total	a*b*c*d=	
Extra E	Jump > 1.4,.steep inclination, high temp, carriage pulling = 2points extra / type		
Extra F	If B> 0 ad 1; if B + C > 0 add, B, C, D > 0 Add 5		
total	A+B+C+D+E minus F		



Ewpa	100	150	200	250	300	400	500	600	700
1	1233	1672	2074	2452	2811	3488	4124	4728	5307
2	1275	1733	2154	2549	2926	3639	4309	4947	5560
3	1420	1945	2432	2894	3337	4179	4978	5745	6486
4	1527	2103	2642	3155	3648	4591	5365	6357	7197
5	1589	2193	2758	3298	3818	4813	5927	6681	7572
6	1705	2366	2988	3584	4159	5265	6327	7355	8356
7	1863	2599	3295	3965	4614	5866	7073	8246	9392
8	1968	2750	3490	4203	4895	6881	7521	8774	10000

Appendix III

Examples.
For the calculations I use the first example. But the calculation are the same for all the examples**.**

Energy needs
Energy needs can over table 3 (page reference.

Maintenance requirements Warm blood gelding EWpa 600kg = 5,24 / day

Because work takes place, an additional allowance on labour. Namely;

Extra allowance labour = 0.25 EWpa / day

For labour it is more difficult. For calculating the energy requirements for labour. There are some difficult calculations. But make is simpler the C.V.B is using fixed allowance for labour for different intensity Table 4 lists the requirements for labour.

Energy requirements labour EWpa = 2.09 / day

This brings a requirement of.
5.24 + 0.25 + 1.90 = 7.39 EWpa / Day

Protein needs
When dietary protein is the same way as the energy demand. (Table 5) first determined maintenance and the allowance and the extra allowance for labour.
Maintenance Needs warm blood gelding by 600kg = 364 VREp / day

Because work takes place, an additional surcharge on labor. Namely;

Extra labor charge = 0.19 VREp / day

For labour it is more difficult. For calculating the proteins requirements for labour. There are some difficult calculations. But make is simpler the C.V.B is using fixed allowance for labour for different intensity Table 4 lists the requirements for labour.

Requirement for labour VREp = 152 / Day

This brings the total requirement to
364 19 152 = 535 VREp per day.

The average dry matter intake. Is about 2 percent. of body weight. So:
600% * 2 = 12 kg / day.

The nutritional value of fresh grass horses is 0.9 EWpa VREp and 185 per day.

The inclusion of the grass =

0.9 * 12 = 10.8 EWpa / day

185 * 12 = 2220 VREp / day

Energy excess on the balance =

Intake – Requiremets = excess or loss at the energy balance.

10.8-7.39 = 3.41

Equals 146% of the energy demand

2220 - 522 = 1698 VREp

What equals 425% excess

Effects of grazing restriction

The recording per hour is approximately at the 0.125% per hour (Table 1).

The energy value of the grass is still 0.9 and EWpa 185VREp / kg ds

The energy requirement =
Generating EWpa 7.39 / Day
Ewit need VREp 152 / Day

Energy value grass 0.9 EWpa
Protein value grass. 535 EWpa

When you need energy divided by the ewpa value of the grass, you count the maximum possible uptake of the grass

7.39 / 0.9 = 8.21 kg DM per day.

When the recording 0.125 g per hour / per 100 kg bw is. Is it a horse of 600kg.

600/100 * 0.125 / kg = 0.75 kg DM / per hour.

To the maximum grazing time to calculate;
8.21 / 0.75 = 10:56 min (rounded 11h) he may graze,

The uptake at 11 hours

0.75 * 11 hours = 8.25 kg DM / day

8.25 * 0.9 = 7.43

Recording Generating

7.43 to 7.39

And a excess of 0.04 EWpa.

For the VREp is the same.
8.25 * 185 = 1525

1526 - 522 = 1004VREp

Part 2
When 0.333333% ds / kg feed is supplemented the time that grazing may be changing.

Recording from the grass hay

Recording grass hay * nutritional grass hay
0.333% * 600 * 0.633 = 1.264

When you pick up the recording of the grass of the feed needs to get back what they can and record. And then using the same formulas as you come back here for the maximum possible recording and expensive.

7,39-1,26 = 6,13

6.13 / 0.9 to 9.07

So when they 9hrs be grazed, the energy intake

0.9 * 0.75 * 9 = 6.08

And then with the intake are then 7.34

Then the shortage , from 7.34 to 7.39 = 0.05

Grazing muzzle.
The mean is is 0.125 kg / 100 kg bw / h.
Which means that when a horse of 600kg recording is at 0.75

0.125 kg / 100 lw / hour * 600 * 6 = 0,125 kg = 0.75 kg / hr

When a reduction of 50%, the absorption:

0.75 * 50% = 0.375 kg / hr.

When there is assumed a recording of 16uur per day you come to 0.375 * 16 = 6kg per day.

The value of the grass energy = 0.9 EWpa
VREp = 185

0,9 * 6 = 5,4

Intake - Requirements = shortage on the energy.
7.39 to 5.4 = 1.99

24 per hour they graze grazing mask and finally 16 per day will this horse is too short to balance his food.

6 * 185 = 120

1110 - 522 = 488VREp