

A practitioner's guide to pasture quality

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Abstract

Pasture quality has a major effect on performance of grazing animals. Intake and nutritive value of pasture are major determinants of liveweight gain, milk production, health and reproductive performance of livestock. Digestibility and metabolisable energy concentration are the two most commonly used measures of nutritive value in New Zealand. In some situations protein, soluble carbohydrate, and mineral and trace element concentrations are also important. Fungal toxins, parasite larvae or other deleterious compounds lower pasture quality by compromising animal health. Potential intake of high nutritive value herbage is also greater because of rapid speed of passage through the animal. The major determinants of nutritive value are botanical and morphological composition, the environment in which the pasture is growing, and the regrowth period (i.e., herbage age). Legume leaf has higher nutritive value than grass leaf, leaf has higher quality than stem, and dead material has very low quality. Herbage grown at cooler times of the year has higher nutritive value than when grown in warmer conditions, and quality declines with age more slowly. Grass leaf declines in nutritive value as it ages, as does stem to an even greater extent. Soil moisture has only minor direct effects on nutritive value. Fertiliser application has direct effects such as increasing protein (by fertiliser nitrogen use) or trace element concentrations (if added to the fertiliser). It also has indirect effects through changing botanical and morphological composition.

Keywords: digestibility, metabolisable energy, nutritive value, pasture quality

Introduction

In this paper we present concepts that are pertinent to a practical understanding of pasture quality and its influence on animal performance.

Three main factors control the performance of grazing animals: genetics, health status, and nutrition. Nutrition relates to the amount of pasture that the animals

eat (their intake) and the quality (nutritive value, NV) of their diet. Intake and NV are major determinants of liveweight gain, milk and fibre production, health and reproductive performance of livestock.

Nutritive value relates to the digestibility of herbage eaten by the animal, and the efficiency with which the digestion end products are used (Ulyatt 1981). A percentage (55–85%) of the pasture eaten is digested, and this is known as its *digestibility*. The remainder is excreted as faeces. Some of the energy in this digestible material is not available to the animal because of losses in urine and methane. The energy remaining is *metabolisable energy* (ME), and typical values for pasture herbage are 8–12 MJ/kg DM. The ME is used with differing efficiencies depending on the characteristics of the digestion end products, and the purpose for which the energy is used e.g., maintenance, growth, lactation, pregnancy (Waghorn & Barry 1987).

Metabolisable energy and digestibility are the two estimates of NV most commonly used in New Zealand. Both are good estimates of pasture quality, but ME has more utility because it is expressed in quantitative units that can be used in allocating feed to animals.

Rate of intake is mainly determined by the amount of pasture offered to the animal, and this is highly related to pre- and post-grazing mass or height. However, intake is also influenced by pasture quality, because herbage of low NV has a slower speed of passage through the animal's digestive tract constituting a physical limitation to intake. Hence pastures that are of high NV contain more useful energy per unit DM, plus animals eat more herbage (Poppi *et al.* 1987).

Pasture chemical composition

Plant tissue contains a high proportion of water, and DM content ranges from 10–50%. In general, high quality pastures have low DM%. Pasture DM consists mainly of two constituents, highly digestible cell contents and less digestible cell walls. Cell contents include soluble carbohydrates, soluble proteins, and minerals. Cell walls are mainly the slowly digestible complex carbohydrates cellulose and hemicellulose. Cell walls also contain lignin an indigestible compound that binds the cell wall carbohydrates in a process called lignification, which further reduces their

digestibility. The cell wall proportion of herbage can be expressed as the neutral detergent fibre (NDF) content. Pasture DM also contains 2–4% of DM as fat, and about 10% of DM as minerals (Fisher *et al.* 1995).

Digestion of pasture by ruminants

Sheep, cattle, deer and goats are ruminants, and microbes break down herbage in the first stomach of their digestive tract (the rumen). Feed particles need to be reduced in size before they can leave the rumen, which is achieved by chewing during grazing and rumination (chewing the cud). About 60% of organic matter digestion occurs in the rumen, the remainder in the small and large intestine (Waghorn & Barry 1987).

Carbohydrate digestion

All the soluble carbohydrate digestion and about 85% of the complex carbohydrate digestion takes place in the rumen. Energy uptake from the rumen to the blood occurs as volatile fatty acids produced by microbial fermentation, and energy is lost from the rumen as methane by eructation (belching). Methane is a greenhouse gas and emission from ruminants is seen as an environmental problem in New Zealand.

Protein digestion

Protein in feed consists of true protein (60–80%), and non-protein nitrogen including nitrate. Microbes break down about two thirds of the plant protein to ammonia and amino acids in the rumen. Some of this is re-synthesised into microbial protein, using energy from carbohydrate digestion. The remaining ammonia is absorbed into the bloodstream and converted into urea in the liver. Some urea is recycled to the rumen in the saliva, and the remainder is excreted in urine. Some of the nitrogen in urine is leached as nitrate or is lost as gaseous N to the atmosphere, both of which represent negative environmental impacts. Microbial protein, and plant protein that has escaped rumen degradation, moves down the digestive tract to the small intestine where it is degraded to amino acids and absorbed (Waghorn & Barry 1987).

Protein content of New Zealand pastures ranges from 10 to 30%. In most situations, intake of digestible energy is considered the major nutritional limitation to animal performance rather than protein content.

Soluble carbohydrates and the cost of high herbage protein content

The soluble carbohydrate content of herbage is currently a topical issue, particularly for dairy pastures in early spring. Low soluble carbohydrate content of herbage limits the readily available energy supply needed by

the microbes that incorporate ammonia into microbial protein. In addition, if soluble carbohydrate levels are low, this implies a higher proportion of total carbohydrates is in the less digestible cell wall and hence overall rate of digestion will be lower.

Implications of high ammonia conversion to urea in the liver are two-fold. Energy is required to manufacture urea, and also urea manufacture consumes amino acids, effectively lowering their availability for production. High ammonia levels may also interfere with reproduction in dairy cows. Hence high levels of protein and low levels of soluble carbohydrates, which often concur in early spring pastures, may in theory limit animal production in New Zealand (G.C. Waghorn pers. comm.). However, to date this has not been proven experimentally.

Other factors that influence pasture quality

Tannins

Condensed tannins are compounds in some plant species e.g., sulla and lotus, that reduce the degradability of plant proteins in the rumen. This results in a greater supply of protein to the small intestine, and may improve protein quality if the microbial protein is deficient in some essential amino acids necessary for production (Waghorn *et al.* 1987). So tannin-containing crops may improve production in high-performing or parasitised animals if protein quantity or quality is limiting animal performance. Tannins also protect ruminants against bloat (Familton 1990) and may have a direct negative effect on internal parasites (Molan *et al.* 1999).

Minerals, trace elements and vitamins

Minerals are required by ruminants for normal function. The amount available to the animal is influenced by many factors including the levels in herbage, the diet selected, the rate of pasture intake, the amount of soil eaten, the efficiency of absorption from the digestive tract, and interactions with other minerals in the digestive tract (Familton 1990). Minerals that are present in very small amounts are known as “trace” elements. Common mineral deficiencies in New Zealand livestock include magnesium, selenium, cobalt, copper (often caused by high molybdenum levels) and iodine.

Vitamin levels of fresh herbage generally are adequate for grazing livestock in New Zealand. Low cobalt availability can lead to vitamin B₁₂ deficiency, as rumen microbes that synthesise this vitamin have a cobalt requirement.

Anti-nutritional factors

A range of compounds in herbage can reduce the level of animal performance. The *Neotyphodium* fungus co-

exists with perennial ryegrass, and produces toxins that cause ryegrass staggers. A *Pithomyces* fungus that grows on plant litter causes facial eczema (Familton 1990). *Fusarium* fungi growing on plant litter produce a range of toxins including zearalenone and trichothecenes, which affect reproductive performance and possibly liveweight gain (Towers 1997).

Some legumes e.g., some varieties of red and subterranean clover, contain oestrogenic compounds that interfere with reproductive function. Some forage brassicas contain sulphur-containing compounds in sufficient quantities to cause sub-clinical goitre and/or anaemia, and high herbage nitrate concentrations can cause nitrate poisoning (Familton 1990).

Internal parasite larvae

Internal parasites in the digestive tract of sheep and cattle lay eggs that are excreted in animal faeces. These eggs hatch into larvae that crawl onto herbage and are ingested by the animal. Parasitised animals have reduced intake and impaired protein nutrition. Also, larval ingestion (leading to sub-clinical parasitism) causes the animal to mount an immune response which uses energy.

Diet selection

Grazing animals generally select a diet of higher quality than the average of the pasture offered. The preference of animals for particular components, and their accessibility in the pasture, governs selection. Grazing animals prefer not to ingest dead material, and in addition these components are often in the base of the pasture and inaccessible. The diet selected often contains a disproportionately high amount of clover, and this is strongly related to the accessibility of clover leaves, which are positioned near the top of the canopy. The size and shape of their muzzle influences the degree to which animals are able to select preferred components. For example, animals with narrow muzzles (lambs) are more selective than those with wide muzzles (cows). The palatability of a pasture relates to the alacrity with which animals consume it. Hence palatability is affected not just by the pasture itself but also by the preferences of the animals grazing it (Hodgson *et al.* 1994).

When animals graze a pasture faster than it is growing, the quality of their diet declines as higher quality components are removed and potential for selection becomes less with time. This reduction in diet quality is coupled with lowered intake owing to the lower diet digestibility. Intake is often further reduced owing to lowered overall pasture mass, and lowered animal performance will result.

Plant and environmental factors influencing pasture quality

Differences in NV of plant components and among species, and changes with age and temperature, are in large part a function of differences in cell wall/cell contents ratio and degree of lignification.

Morphological composition

Pasture herbage has a number of fractions that differ markedly in NV. Green material has higher NV than dead material, which usually has very low NV (<8 MJ ME/kg DM). When herbage browns off rapidly at the onset of drought it can actually be of high quality as it is young herbage, in contrast to "old" dead material. The nutritive value of the leaf in green material is generally higher than that of the stem.

Age of herbage and temperature

Nutritive value of pasture decreases as it ages. Hence pasture spelled for 6 weeks has a lower NV than pasture spelled 3 weeks. As plant tissue ages the cell wall/cell contents ratio increases, and the degree of lignification increases. This decline in quality with tissue age is minor in clover leaves, significant in grass leaves, and greatest in stem tissue (Buxton & Mertens 1995). Quality decline continues through to death, at which stage clover leaves rapidly disappear from the pasture but grass leaves and stems tend to accumulate.

Nutritive value drops as temperature increases. This is caused by a combination of increase in cell wall/content ratio, increased lignification of the cell wall, and decreased leaf/stem ratio (Buxton & Mertens 1995). Hence pastures that have been spelled for long periods in warm conditions, even if leafy, are of lower NV. Where this is combined with accumulation of stem and dead material such pastures provide no better than maintenance feed.

A survey of the literature (e.g., Deinum & Dirven 1974, Demarquilly & Jarrige 1973) and unpublished data suggested the decline in NV is of the order of 0.03 MJ/kg DM/day for grass leaf, and 0.06 MJ ME/kg DM/day for stem, at a daily maximum air temperature of 18°C. The rate of decline is negligible in leafy pasture at temperatures less than 12°C, as in winter for much of New Zealand.

Soil moisture

Moisture deficit effects on pasture quality are small relative to effects on growth. Moisture deficit delays plant maturation and so increases leaf/stem ratio. Digestibility may be slightly increased owing to raised concentrations of cell soluble constituents (Buxton & Mertens 1995). Soil moisture may also affect legume content in pastures.

Fertiliser application

Fertiliser has only small direct effects on feed quality, with nitrogen fertilisation having the greatest effect through lifting protein concentration. Also, application of elements such as magnesium, selenium, cobalt and copper in fertiliser can help remedy specific animal health problems by raising concentrations in herbage. Most of the apparent positive effects of raising fertility level on NV and intake are probably indirect. These are associated with increased content of legumes and “easier to manage” grass species; and decreased build-up of stem and dead material owing to better pasture utilisation, and more rapid decay and disappearance of dead matter.

Pasture species

Legumes and herbs generally have higher feed quality than grasses e.g., as an extreme example, sheep grazing white clover have been found to grow 90% faster than sheep grazing perennial ryegrass. This was a function of both higher NV and a higher rate of voluntary intake even at equivalent NV (Ulyatt 1981).

The NV of most temperate perennial grass species is similar if plant parts are compared at the same age. Cocksfoot is a notable exception, digestibility of leaf being slightly lower than for other species (Barker *et al.* 1993), and NV of tetraploid ryegrasses is thought to be enhanced because of a lower cell wall/cell contents ratio. Differences in animal performance amongst grass species occur mostly because proportions of the different morphological components vary across species in response to different management practices. This suggests that some species are more “manageable” than others. Lancashire & Ulyatt (1974) found that animal performance on well-grazed browntop and ryegrass pastures was similar early in the season. Later in the season stem and dead material accumulated in the browntop pastures and animal performance on ryegrass was superior.

Feed intake of animals grazing sub-tropical grasses such as paspalum and kikuyu is generally lower than when grazing temperate grasses such as ryegrass and tall fescue. Herbage of sub-tropical grasses generally has a higher cell wall/content ratio than that of temperate grasses at the same stage of development. Also, because the sub-tropical species grow in warmer environments, decline in NV with age occurs faster, plus leaf/stem ratio tends to be lower and substantial build-up in low-quality material can occur (Buxton & Mertens 1995).

Practical implications for farmers

Pasture botanical and morphological composition is a good field indicator of pasture quality, and can be used

to estimate digestibility or ME. In some situations protein, soluble carbohydrate and mineral concentrations may also be important. Presence of fungal toxins, parasite larvae or other deleterious compounds in or on herbage may effectively lower pasture quality by compromising animal health.

The following characteristics are common attributes of high quality permanent pastures: high legume content, high leaf content, low stem content, low dead matter content, young herbage age, and grown at cool temperatures. Such pastures are associated with high soil fertility conditions, southern parts of New Zealand, cooler times of the year, and management practices that inhibit development of stem and dead matter and favour clover and ryegrass growth.

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