# Grazing management for integral health

Pablo Gregorini[1*]; Anita Fleming[1], Iain J. Gordon[1,2], Frederick D. Provenza[3]

[1]Lincoln University, Lincoln 7647, Christchurch, New Zealand; [2]The Australian National University, Canberra ACT 2600, Australia; [3]Utah State University, Logan, UT 84322-5230
*Corresponding author: pablo.gregorini@lincoln.ac.nz

**Simple summary:** Animal products echo the way we graze ruminants manifested though soil and plant chemistry, and thereby our health and that of the planet…

**key words**: Ruminants, foraging, environment, health, people

## An argument to graze differently

Grazing herbivores fulfil essential roles in ecology, agriculture and economies at many levels, including family, farms, regions and nations' landscapes by providing food, wealth and ecosystems services. However, pastoral livestock-production systems are under increasing social pressures and consumer scrutiny… What went wrong?

Consumers of animal products are increasingly aware of the intricate connections between the health of the land, animals, and humans, as well as of our collective responsibilities to sustain and enhance our land for future generations (Gregorini and Maxwell, 2020). Consequently, land users, policymakers and wider society are calling for alternative approaches to pastoral systems; a call for functionally diversified, adaptive, and integrative agro-ecological and food-pastoral systems that operate across multiple scales and 'scapes' (Leroy et al., 2020, 2022) - from landscapes and foodscapes to healthscapes (Provenza et al., 2015).

Chronic postprandial inflammation has been linked to several chronic diseases such as obesity, diabetes, cardiovascular disease, and cancer, as well as metabolic syndrome; all of which have been associated with consumption of red meat and dairy products (Micha et al., 2012; Chan et al., 2011). Moreover, under intensive temperate grazing systems, highly dependent on synthetic N inputs to grass, approximately 82% of urinary N gets discharged onto pasture. Typically, 20–30% of this N is leached into the waterways and 2% is lost as the greenhouse gas $N_2O$. High levels of N in waterways have been associated with widespread environmental degradation including eutrophication, which produces algae on the water surface, can occasionally kill fish, and can even "kill" a lake by depriving it of oxygen. In addition, N losses to the environment can also be detrimental to human health; blue baby syndrome is a health problem largely associated with high levels of nitrates in drinking water resulting in methemoglobinemia in infants, which can be fatal in severe cases. High levels of nitrates consumed in drinking water can also increase risk of developing colorectal cancer, thyroid disease, and neural tube defects (Marshall and Gregorini, 2021). No wonder that some consumers pursuing health are increasingly demanding foodscapes that are absent of animal products!

Grazing, as a descriptive adjective, locates 'herbivores' within a particular spatio-temporal domain, the pastures, where they naturally graze (a verb) or are grazed through the actions of humans. For decades, grazing (as a verb) has been viewed as a succession of feeding events structured around other animal activities, with those events as building blocks of daily herbage intake. Viewed as a process, grazing is not so simple. Grazing is in fact an arrangement of decisions leading to ingestive actions nested within spatio-temporal domains (Senft et al.

1987). These decisions include trade-offs affecting short-term behavioural and physiological tactics and mid- to long-term strategies related to how animals acquire nutrients and medicines, seeking comfort. The spatio-temporal domain and animal features delimit the dimensions at which these decisions are made and can be managed. Thus, our decisions to manage 'their' decisions (i.e., grazing management) set the context and thereby modulate the animal's grazing and the consequences for them and the land that nourishes and sustains them and us.

The question then arises, are there eco-physiological implications and connections between grazing management, forages and human health? If so, grazing must be considered in order to understand the effects of consuming animal products on human health.

In search for an answer to this question, in this 'invited talk', we summarise published and unpublished results of a series of studies of Lincoln University's Pastoral Livestock Production Lab, in where we challenge *status quo* monotonous dietary managements (SQ) and present the concept of functional dietary diversity.

Functional dietary diversity (FD) refers to that part of a continuum of the composition, presentation and arrangement of dietary components that allows an animal to meet its nutritional, medicinal, prophylactic, hedonic and eudaemonic requirements through time and in space (Garret, 2022). In contrast, dietary monotony reduces intake, growth, production and welfare at health, hedonic and eudaemonic levels (hedonics: happiness through pleasure; eudaemonics: happiness through the pursuit of purpose; Beck and Gregorini, 2020). Repeated presentation, even of a nutritionally balanced diet, has been linked to sensory-specific satiety, a decrease in the pleasantness of a specific food that has just been eaten to satiation, while other non-eaten foods remain pleasant (Provenza et al., 1996). Dietary monotony, no matter how balanced the ration, therefore, violates four of the freedoms used to assess animal welfare, as well as every domain in Mellor and Beausoleil's (2015) model, including the presence of positive welfare and internal (e.g., mental) and external physical states associated with behaviour, health and nutrition. By these definitions, and depending on specific conditions, even a multispecies sward can be considered as monotonous.

## *Supportive data*

Lincoln University Pastoral Livestock Production Lab research is comparing SQ [a monotonous allocation (once a day, every day) of ryegrass-based sward], CMS [a monotonous allocation (once a day, every day) of a complex multispecies (20 + forage species) sward] and FD [adjacent monoculture strips of lucerne, ryegrass, red clover, plantain, and chicory. The swards were sown in equal areas longitudinally, to be grazed horizontally (strip grazed)]. We then compared animal performance, wellbeing, tissue metabolomics and human health.

### *Animal performance*

On average, sheep and lambs grazing FD showed a 48% increase in weight gain, 20% reduction drip loss, 10% increase in dressing percentage, 25% increase in hot carcass weight and bigger shoulders and sirloins as compared to SQ (Beck et al., 2020, 2021; 2024; Garret et al., 2021, 2022a,b; Kumara et al., unpublished). Figure 1 and Table 1, as extra illustrative examples, present the results of an experiment where we evaluated the concept of 'functional variety' (VAR, i.e., FD over time) against a monotonous diet of alfalfa and herbage composed by a mix of five forage species (ryegrass, alfalfa, chicory, plantain and red clover) (Grarret et al., 2022b).

**Table 1**. Intake, Liveweight gain, and feed conversion efficiency lambs fed 'functional variety' (VAR, i.e. FD over time), an alfalfa (SFA) and a mix of five forage species (DIV, ryegrass, alfalfa, chicory, plantain and red clover) (Adapted form Garret et al., 2022b).

| | SFA | DIV | VAR | SEM | *P-value* |
|---|---|---|---|---|---|
| Initial LW, kg | 33.9 | 33.9 | 32.8 | 1.0 | 0.63 |
| Total DMI, kg DM/ d | 1.54$^{b}$ | 1.64$^{a}$ | 1.59$^{ab}$ | 0.03 | 0.04 |
| ADG, g BW/d | 227$^{c}$ | 296$^{b}$ | 378$^{a}$ | 22 | <0.01 |
| FCE, gBWgain/ kg DMI | 146$^{b}$ | 183$^{b}$ | 238$^{a}$ | 14 | <0.01 |

DMI, Dry Matter intake; ADG, Average Daily Gain; FCE, Feed Conversion Efficiency

**Figure 1**. Time to reach slaughter liveweight of lambs for 'functional variety' (VAR, i.e. FD over time), a monotonous diet of alfalfa (SFA) and herbage composed by a mix of five forage species (DIV, ryegrass, alfalfa, chicory, plantain and red clover) (Adapted from Garret et al., 2022b)

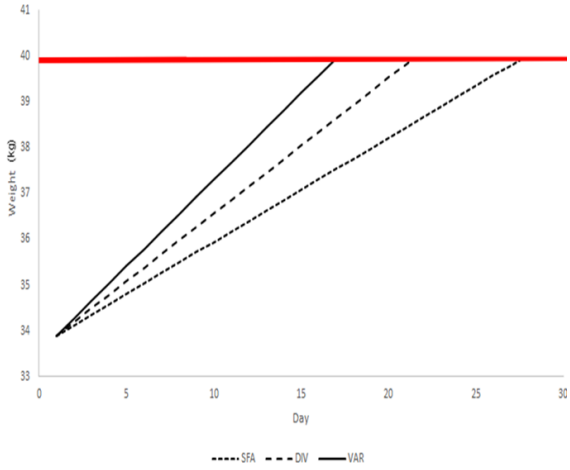



Table 2 presents performance and carcass characteristics of lambs grazing SQ at 100 $m^2$/ram/week stocking rate or FD at a stocking rate of 80, 95, 100, or 110 $m^2$/ram/week.

Cattle also seemed to perform better on FD, with dairy cows having a numerical difference in milk production (FD (5% more milk solids), and growing beef cattle showing an 8.5% increase in liveweight gain (Fleming et al., 2024, and Submitted a).

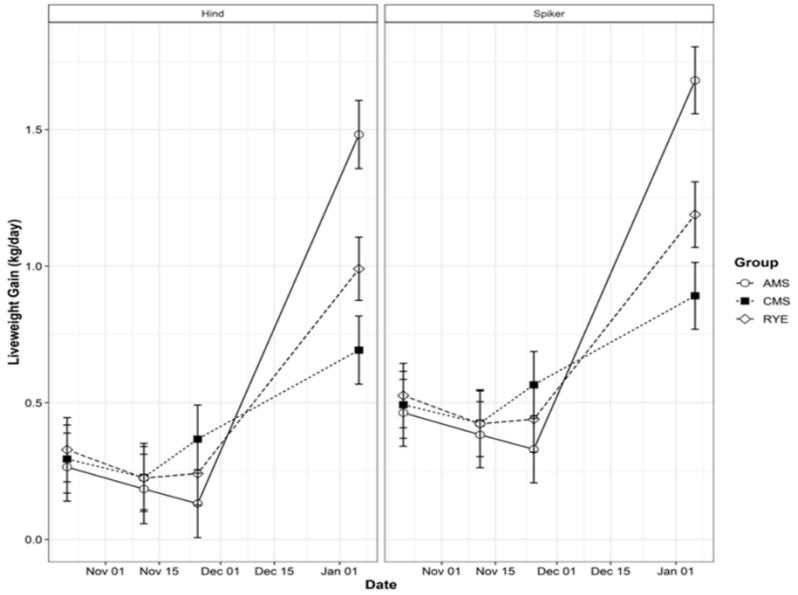
Deer grazing FD swards had remarkable difference in liveweight gain (Figure 2).

**Table 2.** Performance and carcass characteristics of lambs grazing SQ at 100 $m^2$/ram/week stocking rate or FD (chicory, dock, alfalfa, plantain, and ryegrass) at a stocking rate of 80, 95, 100, or 110 $m^2$/ram/week.

| | MON | FD | | | | | Poly. Contrasts | |
|---|---|---|---|---|---|---|---|---|
| Item | 100 | 80 | 95 | 100 | 110 | SEM | Linear | Quad. |
| Initial BW, kg | 40.7 | 41.3 | 39.1 | 41.5 | 43.5 | 2.76 | 0.42 | 0.38 |
| Final BW, kg | 46.0 | 50.1** | 54.5** | 53.6** | 52.5** | 1.10 | 0.22 | 0.12 |
| ADG, g/d | 100.5 | 183.3** | 270.5** | 246.6** | 225.8** | 21.9 | 0.26 | 0.12 |
| HCW, kg | 18.8 | 21.3** | 25.3** | 24.1** | 23.9** | 0.71 | 0.06 | 0.20 |
| Aged CW, kg | 17.9 | 20.3** | 24.3** | 23.2** | 23.1** | 0.69 | 0.09 | 0.06 |
| Dressing %[e] | 40.8 | 42.5* | 46.5** | 44.9** | 45.3** | 0.90 | 0.15 | 0.09 |
| Drip Loss, g | 884.3 | 932.2 | 1005.9* | 931.7 | 825.3 | 64.6 | 0.25 | 0.23 |
| Drip Loss, % | 4.7 | 4.4 | 4.0** | 3.9** | 3.5** | 0.3 | 0.04 | 0.79 |

BW, Body Weight; ADG, Average Daily Gain; HCW, Hot Carcass Weight; CW, Carcass Weight.

**Figure 2**. Liveweight gain of red deer (*Cervus elaphus*) calves (females/hinds or males/spikers) grazing SQ (RYE), CMS (Complex Multi Species) of FD (Adapted from Fleming et al., submitted b)




**Environmental impact**

Arguably, increases in animal performance and feed conversion efficiency reduced negative environmental impact of animal under FD. Under such grazing management animals

reach slaughter weight earlier and emit less methane in total, and intensity (g methane/ kg animal tissue produced) is less. Moreover, animals under FD excreted less urinary N, for example, Garret et al. (2021) reported a reduction of 30%. Fleming et al., (submitted a) reported that dairy cows under FD had a reduction of daily excretion of urea of 42%, with urea in milk being linearly related to urinary N excretion (Beck et al., 2023).

**Animal Welfare**

All species, that is sheep, cattle and deer under FD, presented improved markers of welfare and wellbeing. For example, Garret et al. (2022), reported an 8% increase in total antioxidant status and 80% reduction in non-esterified fatty acids (NEFA) of lambing ewes. Moreover, just born lambs had a 5% reduction in cortisol in their wool. Fleming et al. (submitted) reported a strong trend reduction of more than half for NEFA as compared to CMS and 8% compared to SQ. Interestingly, but only numerically, cows in FD had 47% less somatic cell counts in milk. Furthermore, growing deer showed a 13 % greater TAS (total antioxidant status, and the venison at slaughtering time contains 59-fold increase in pepicolic acids, which is associated with protection against free radicals and secretion of GABA, the latter being associated with relaxation Fleming et al. (Submitted b).

**Nutraceutics and human health**

Milk, venison, beef and lamb from the above trials were analysed for metabolomics, with beef and lamb fed to humans in a replicated and randomised experiment.

Milk of cows under FD had a 1.4-fold increase in deoxycarnitine. Deficiencies of this metabolite have been associated with reduced intake in infants, renal failure, weakness and fatigue, diabetes and myocardial ischemia. This milk also showed a 1.2-fold increase in pantothenate, which helps humans use fat and protein and is used to prevent depression. More, there was a 2.1-fold increase in tyrosine, which has a positive effect on mental wellbeing (anxiety and depression) and enhances cognitive performance. Finally, the milk contains 50% less trimethylamine N-oxide, which is associated with CVD and inflammation, fatty liver disease and risk of type II diabetes (Fleming et al. Submitted a).

Functional diversity also increased the relative abundance of pantothenic acid (vitamin B5) in beef. In addition, 3-hydroxybenzaldehyde (3HBA) also increased in beef produced under the FD grazing system. Vitamin B5 and 3HBA both have vaso-protective, anti-inflammatory and ‘heart-healthy’ roles that were upregulated in the FD beef, suggesting human health benefits compared with SQ. Gamma tocopherol (γ-tocopherol, vitamin E) was elevated in the FD sward and relative intensities of benzoate and 3-hydroxybenzaldehyde, metabolites, increased with FD too. Functional diversity also reduced ether-linked phosphatidylethanolamines and increased several phosphatidylcholines, phosphatidylglycerol and lypophosphatidylcholine, while reducing triacylglycerol lipids (Fleming et al. 2024).

Venison differences were even more striking. Venison from FD contained 27-fold increase in proline betaine, which has been associated with foetal brain development and cognitive function, as well as anti-inflammatory, antioxidant anti-carcinogenic, anti-diabetic effects. Venison also had a 59-fold increase in pipecolic acid, a metabolite associated with protection against free radicals and stress, as well as enhancement of GABA secretion, i.e., relaxing. FD also down regulated tri-acyl glycerides formation and reduced putrescine -a biomarker of freshness- by 20% Fleming et al. (Submitted b).

Based on these results, we conducted the first ever of their kind 'cause and effect' complete randomized - cross over - feeding trials with humans, evaluating post-prandial metabolomics and health markers as affected by the consumption of either beef (Fleming et al., 2024) or lamb (Kumara et al; unpublished) coming from animals grazed on SQ, CMS and FD. Here we present a summary of the remarkable work of Fleming et al. (2024).

Beef from the functional diversity grazing system had increased circulating concentrations of γ-tocopherol in people following a simple meal. Gamma tocopherol - a major form of vitamin E -, is the most effective anti-inflammatory, inhibiting cyclooxygenase and 5-lipoxygenase activity, and antioxidant through capture of lipophilic electrophiles (Jiang et al., 2001). It is also superior to α-tocopherol in its ability to reduce cancer cell growth, trapping of reactive N-species through formation of 5-nitro-γ-tocopherol (Jiang et al., 2022). Ju et al. (2010) suggest this form of Vitamin E is the most effective in preventing cancer. When eating FD beef, people also presented five other features i.e., 3-hydroxymethylglutarate (HMG), indoxyl sulphate, arginine, oxoadipate, and D-sedoheptulose. People had greater relative abundance of HMG, arginine and oxoadipate, while indoxyl sulphate and D-sedoheptulose declined. These differences add to the positive effects of FD grazing systems for humans. For example, HMG, also known as "statins," are used adjunctively with diet and exercise to treat hypercholesterolemia by lowering total cholesterol. The decline in indoxyl sulphate is is significant as it is a uremic toxin that accumulates in the plasma of chronic kidney disease patients and induces adverse side effects in the kidneys, bones and cardiovascular system. Arginine is used by the body to help build muscle and rebuild tissue. The body also converts this this amino acid into the chemical nitric oxide, which helps the blood vessels open. These results cry out for further investigation and for longer-term human studies (Fleming et al. 2024).

## Concluding remarks

There are eco-physiological implications and connections among grazing, forages and human health. Grazing management, therefore, can help improve animal, human, and environmental health… in other words, integral health. More specifically, our studies suggest that chemically and spatio-temporally diverse arrangements of forages grazed by ruminants, while increasing animal performance and feed conversion efficiency, can also increase total antioxidant levels, reduce oxidative and physiological stress and enhance hedonic and eudemonic well-being. The ability to meet individual hedonic requirements and self-medicate/nourish, thereby improves health integrally, is believed to improve well-being through pleasure and lack of discomfort. As, defined by the WHO, Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. Consequently, thoughtful grazing management presents an opportunity to transform pastoral agriculture and counteract the negative connotations of animal products while promoting ethical and sustainable foodscapes with animal products that offer consumers hedonic well-being (i.e., 'healthy' pleasure). This is done knowing that, in fact, such products not only are in tune with the land and animals, but integrally are healthier for us and the land we all inhabit. These benefits all challenge the points made in the Eat-Lancet report (Willett et al., 2019), suggesting to take the animal out of our diets to protect the environment and our health.
As Fred, says "*We are members of nature's communities... What we do to them, we do to ourselves. Only by nurturing them, can we nurture ourselves… And by healing them, can we heal ourselves*". And Pablo, asks smiling: "*Which steak will you offer to your mother-in-law*?"

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