BEFORE THE ENVIRONMENT COURT

In the matter of	appeals under clause 14 of the First Schedule to the Resource Management Act 1991 concerning the proposed One Plan for the Manawatu-Wanganui Region.
between	**FEDERATED FARMERS OF NEW ZEALAND ENV-2010-WLG-000148**
and	**DAY, MR ANDREW** **ENV-2010-WLG-000158**
and	**MINISTER OF CONSERVATION** **ENV-2010-WLG-000150**
and	**HORTICULTURE NEW ZEALAND** **ENV-2010-WLG-000155**
and	**WELLINGTON FISH & GAME COUNCIL** **ENV-2010-WLG-000157**
	Appellants
and	**MANAWATU WANGANUI REGIONAL COUNCIL** *Respondent*

STATEMENT OF TECHNICAL EVIDENCE BY DR LUCY WALDRON ON THE TOPIC OF SURFACE WATER QUALITY – NON POINT SOURCE DISCHARGES

ON BEHALF OF WELLINGTON FISH & GAME COUNCIL

Dated: 5 March 2012

INTRODUCTION

Qualifications and experience

1. My full name is **Lucy Anne Waldron.**

2. I have the following qualifications: BSc in biochemistry, microbiology and physiology from the University of Lancaster UK (1991), and a PhD in Animal Nutrition from Harper Adams University College, UK (1992-1995).

3. My general area of expertise is in Animal Nutrition. Since 1995, I have worked in the animal feed industry, mainly in the development of feeds and speciality ingredients to improve feeding efficiency and welfare and reduce the dependency on chemical and drug prophylactics, including antibiotics and hormones. As part of this work, I have been involved in regulatory affairs in several countries, including the EU and USA, where pollution from farmed animals is a legal and economic consideration.

4. In 2005, I moved to New Zealand and set up my own consultancy company LWT Animal Nutrition Ltd., NZ. I currently work as an independent consultant to the animal feed and allied industries, and am an active researcher, holding the post of Research Associate at Massey University (since 2006), where I have the responsibility for post-graduate students and act as a conduit for commercial research. Since 2006, I have set up and run a nutrition research unit catering for larger animals. I have clients in several countries as well as New Zealand, act as Editor in Chief for two scientific journals, and I am a Registered Nutritionist in the UK and NZ.

Evidence considered

5. I am familiar with the evidence of those witnesses relevant to my area of expertise which is contained in the ñTechnical Evidence Bundleò lodged with the Court by the respondent, together with the additional evidence of Ms Barton, Dr Roygard, Ms McArthur, and Ms Clark dated 14 February 2012, and Dr Roygard and Ms Clark dated 24 February.

Expert Witnesses Code of Conduct

6. I have read the Environment Court◊s Code of Conduct for Expert Witnesses, and I agree to comply with it. I confirm that the issues addressed in this brief of evidence are within my area of expertise.

7. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed. I have specified where my opinion is based on limited or partial information and identified any assumptions I have made in forming my opinions.

BEST MANAGEMENT PRACTICES – SUPPLEMENTARY FEEDING

8. Best Management Practices for reducing Nutrient, sediment, and faecal, contamination of waterbodies is discussed in the evidence of Dr Monoghan (242a Officers report), Dr Alec MacKay (s42a Officers report), Dr Manderson (s42a Officers report), and Mr Peter Taylor (s42a Officers report), and is usefully summarised in the planning evidence of Ms Clare Barton through incorporation into Policy 13-2C (g)(14 February 2012)

   i. *Cut and carry;*
   ii. *Intensive forage cropping;*
   iii. *Herd homes and effluent capture;*
   iv. *Winter feed pads and effluent capture;*
   v. *Low nitrogen feeds;*
   vi. *Replace nitrogen fertiliser with equivalent supplement*
   vii. *Graze animals off-farm over the winter months*
   viii. *Reducing stock rate;*
   ix. *Best management (amount and timing and land area) of nitrogen fertiliser inputs;*
   x. *Management of infrastructure (e.g. reducing leaks in effluent irrigation systems and lining of effluent ponds and feedpads);*
   xi. *Nitrogen inhibitors;*
   xii. *Non pastoral land use; and*

xiii. *Creation of wetland and riparian zones*ò (Ms Barton, 24 February 2012, page 4928)

9. However, while low nitrogen feeds are listed as a mitigation option for reducing nutrient contamination to waterbodies, there has been limited discussion of utilising supplementary feeding and its influence on nitrogen excretion and herd productivity in the technical evidence. In summary, supplementary feeding is where animals are fed extra feed materials, in addition to pasture, typically to balance the diet in terms of nutrient supply.

10. This mitigation option was not considered nor applied to the 21 farms tested under Rule 13.1 The costs of supplementary feeding were briefly discussed in the evidence of Rhodes and Neilds (s42 Officerõs Report), but the benefits were not considered. I think that this is a serious omission in regards to the evidence. Appropriate feeding of livestock is appropriate not only for animal health and welfare reasons but also as a tool for increasing per cow productivity, reducing overall animal health costs, reducing per cow empty rates, and also in reducing the excretion of nitrogen in the urine of dairy cows which is the primary contributor to nitrogen contamination of groundwater and ultimately surface waterbody receiving environments.

The influence of feeding strategies on dairy cow manure pollution

11. Feeding management is a key factor in reducing the amount of manure (urine and faeces) by minimising the undigested or poorly absorbed nutrients excreted from dairy cows. For many dairy cows in New Zealand, grazed grass is the primary fodder available, and often the costs related to pasture production are poorly accounted for by farmers, such as land value, labour inputs and externalities.

12. Milk producers who have invested in modern scientific methods of feeding their herd benefit from increased nutrient absorption and utilisation, resulting in better productive performance as well as improvements in fertility, immunity, hoof quality and longevity, which can enhance herd efficiency and productivity. In addition, a correctly fed dairy cow will not only have more access to nutrients, but, if these are more efficiently digested and absorbed, will excrete fewer polluting nutrients (e.g.

nitrogen, phosphorus, and minerals such as zinc and copper) into the environment. Correct nutrient access allows the diary cow to function optimally and become more efficient and productive.

THE RUMINANT DIGESTIVE SYSTEM

13. As mammals lack the enzymes required to digest cellulose (fibre) rich plants, cattle have evolved a rumen at the start of their gastro-intestinal tract that operates in symbiosis with micro-organisms (bacteria, yeasts and protozoans). A symbiosis is where both the host and the micro-organisms benefit from the arrangement. In this case, the micro-organisms benefits by being able to colonise a safe environment with a regular supply of food substrate. For the dairy cow, it derives energy and nutrients for their own requirements as a result of the breakdown of feed materials by the micro-organisms.

14. Ruminants are not born as such - calves are simple stomached (monogastric) animals initially, where they subsist on milk as their sole nutrient resource until weaning. Once weaned, the rapid and correct development of the rumen is essential for smooth transition to grazing behaviours and efficient nutrient breakdown and utilisation which ensure productive performance. The presence of a good supply of suitable feed is required for rumen development and function. There is some debate amongst scientists as to whether forage or grain/complete feeds achieve faster rumen development. However, it is known that the efficiency of absorption of nutrients is related to intake of rough chopped forages or large particle concentrates. Fibrous forages are considered to be the main stimulators of rumen muscular development and volume, contributing to the mature animal's ability to consume adequate amounts of feed for production purposes (dry matter intake).

15. Improving rumen development via correct feeding will optimise efficiency of digestion and energy production, affecting growth as well as subsequent milk yield in the adult cow. Obtaining stable and appropriate micro-organism populations on weaning and during rumen development is directly linked to fermentation of nutrients as well as protein and mineral digestion and its availability to the host.

16. The dairy cow consumes forage and/or other feed (either as individual materials such as cereals or as a total mixed ration), which then enters the rumen. Micro-organisms colonise the feed particles or grass sward, and begin a process of fermentation, which converts the fibrous materials into energy-rich volatile fatty acids (VFAs), which the cow can absorb directly from the rumen. This contributes approximately 70% of the animal's energy supply. Rumen fermentation results in a large amount of gas production (30-50 litres per hour in adult cattle) hence the eructation issues in dairy herds in terms of methane pollution.

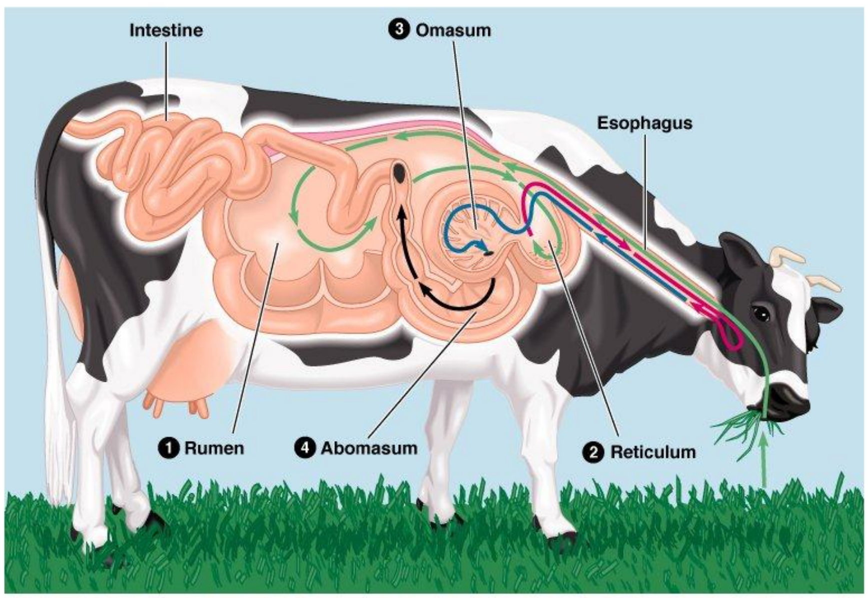

Figure 1. Digestive physiology and transit in a dairy cow

17. Cattle may regurgitate feed ("cudding") from the rumen, re-chewing it to reduce particle size and increase digestion. Sugars and starches (from high sugar forages or high starch sources) are quickly digested in the rumen and can promote microbial protein synthesis, which can lead to the development of problems such as acidosis due to the promotion of acid-producing bacteria in the rumen, which will lower the pH and cause diarrhoea. It has been shown that by feeding high forage foods, the pH rises (and is stabilised at a higher level) and rumen efficiency in terms of fermentation and energy production from fibre increases (Fig. 2). Overall, feeding high sugar and starch can lead to digestive upsets and poor feed efficiency.

18. Inefficiencies in rumen digestive processes caused by imbalances in the micro-organism populations have an impact on both levels of energy production (via VFAs) and all other nutrients. This is especially important in relation to nitrogenous compounds, whereby the proliferation of certain bacteria can restrict the availability of nitrogen to the host, or can divert it into ammonia, which is excreted. Ammonia enters the blood directly from the rumen and is lost in urine, without being available to the host animal for growth or milk production. It is also the main source of N excretion from dairy herds and of major importance in an environmental context.

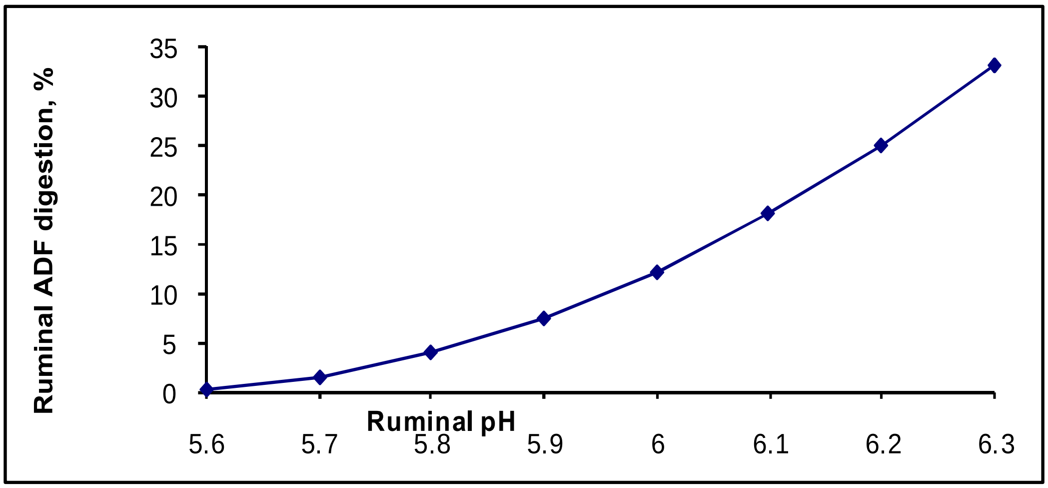

Figure 2. Impact of rumen pH and digestion of fibre to energy sources (Alvarez, 1998)

CURRENT FEEDING PRACTICES

19. Current dairy farming practices in New Zealand are typically focussed on grass growth, and as such tends to be reliant on fast growing, lush species of grass, such as sugar-rich rye grasses and nitrogenï rich clover combinations. One problem with this is that the fibre levels of these two pasture species tends to be much lower than ideal for cattle, and the clover is prone to spring flushes in growth, leading to high levels of protein intake. The rumen micro-organisms rely on a good level of fermentable fibre to optimise their own and general rumen activity, and hence produce more Volatile Fatty Acids and other useful nutrients in the presence of fibre

in the diet. In addition to the potentially high protein intake, a major issue with high sugar/ low fibre pastures for dairy cows is that the rumen doesn't function as efficiently, can become acidic and diarrhoeal problems then arise. When an animal has diarrhoea, nutrient uptake and absorption is severely impaired, resulting in high levels of nutrient excretion, and poor yield from the cow. The data regarding increased milk output from sugar-rich grasses is based on very low cow numbers and, in the opinion of nutritionists, is not robust.

MANAGING MANURE OUTPUTS FROM DAIRY HERDS

20. There are many feeding strategies and products that can be used to improve not only productivity from dairy herds but also limit manure and urine pollution. Much of the investigations into reducing manure and its polluting effects have been conducted by commercial companies investigating the use of specialist feed supplements and biotechnological applications in improving rumen efficiency and nutrient uptake. These include the use of products, such as antibiotic/ionophore products, yeasts and bacterial-based probiotics, to optimise the fermentation profiles in the rumen, or which modify the rumen micro-organism populations. The ionophore products are well established, and can deliver between 7-10% more energy from diets, especially on poor pastures (e.g. Rumenco, Elanco Ltd; Nevel and Demeyer, 1977; Mason, 1997). They modify the microbial profile of the rumen, reducing methane and lactic acid production and increase certain energy-rich VFAs. They are thought to decrease rumen breakdown of protein, thereby increasing supply to the host and potentially reducing urine N output, which has been demonstrated in ruminants (Maas *et al*., 2001). Research with fresh forage plus a balanced corn-based feed for dairy cows in the USA (Ruiz *et al*, 2001) showed a decrease in faecal N and an increase in N digestibility by over 5%, suggesting that the ionophore prevented the breakdown of protein and amino acids by the microbes.

21. Live yeast preparations have been shown to stimulate bacterial growth and optimise its profile in the rumen, stabilising pH and promoting fibre-digesting cellulytic bacteria. This can increase total rumen digestion (Tikofsky and Harrison, 2006). Live yeasts (Yea-Sacc, Alltech Inc, USA) have been reported to increase energy levels by 17%

through promoting fibre digestion and limiting oxygen availability in the rumen, which unbalances its function. Live yeast will use up sugars quickly, limiting lactic acid bacterial growth, preventing low pH conditions and resulting acidosis and diarrhoea. It also increases the levels of non-ammonia N available for the cow, and is therefore linked to reduced urine N, although estimates vary, as the outcome is dependent on feed inputs and management.

22. Yucca extracts are commercially available that have a strong affinity for binding ammonia. Weaver (1995) showed a decrease in ammonia in cow sheds when the animals received a yucca based product, however the level of decrease would depend on the diet and productivity of the animal. This effect of Yucca has been reported to reduce ammonia in intensive pig farms by up to 28%. Research data indicates that the product binds ammonia in the rumen, limiting its expression as urine N.

23. Long chain fatty acids have been reported to increase rumen efficiency and animal performance, and could be expected to influence N output as a result, although data to support this is difficult to find in the published literature.

24. Worldwide many of these products are regularly used to enhance herd performance, and reduce environmental impact, especially in areas where pollution is a concern and levies are applied to reduce manure outputs, e.g. Northern Europe and parts of USA (N Carolina).

BREAKDOWN AND UTILISATION OF PROTEIN

25. Nitrogenous compounds (protein) in feed are partitioned approximately as 20-30% being expressed in milk, 45-60% in urine and 40-55% in manure (Jarvis, 1993; Castillo *et al.*, 2001). A lactating dairy cow will produce somewhere in the region of 75 kg of manure per day, which can be reduced by around 2 kg per day if a well-balanced feed is provided for the animal. Under NZ conditions, with smaller dairy cows and hence lower dry matter intakes, this would correspond to a calculated output of around 60 kg per day. As the supply of protein (nitrogenous) materials

increases, typically N output increases, predominantly in urine. Research has shown that there is a direct relationship between N intake and urine and manure content, which allows predication of N output per cow, depending on protein intake (Gonda and Lindberg, 1994; Castillo *et al.*, 2001; Fig. 2). Intensive, pasture based systems appear to be linked to higher N losses (Beever, 2004), as pasture protein can reach or exceed levels of 25% in the daily ration, depending on presence of clover and time of year.

26. The threshold for increased urine N output appears to be around 400 g/head/day N intake (Castillo *et al.*, 2001; Kebreab *et al.*, 2002) or above 15% protein in the diet. In comparison, a NZ dairy cow averages an intake of 26% protein in the diet, which is greatly in excess of these levels, and represents an N intake of approximately 460 g N per day, based on a 450 kg cow consuming an average dry matter intake of 11 kg per day. In Europe, most dairy feeds are formulated to provide 17-18% total protein (Beever, 2004), which is more than required, especially as only about one third of this intake is expressed in milk. Previously, a minimum of 24 g/kg has been determined (Taminga and Verstegen, 1996), while other sources have recommended that less than 30g/kg dry matter as N should be fed (Gaminga, 1992). Whilst research has shown that feeding extra protein can improve milk yield (kg/d), it will not increase the overall concentration of protein per litre of milk.

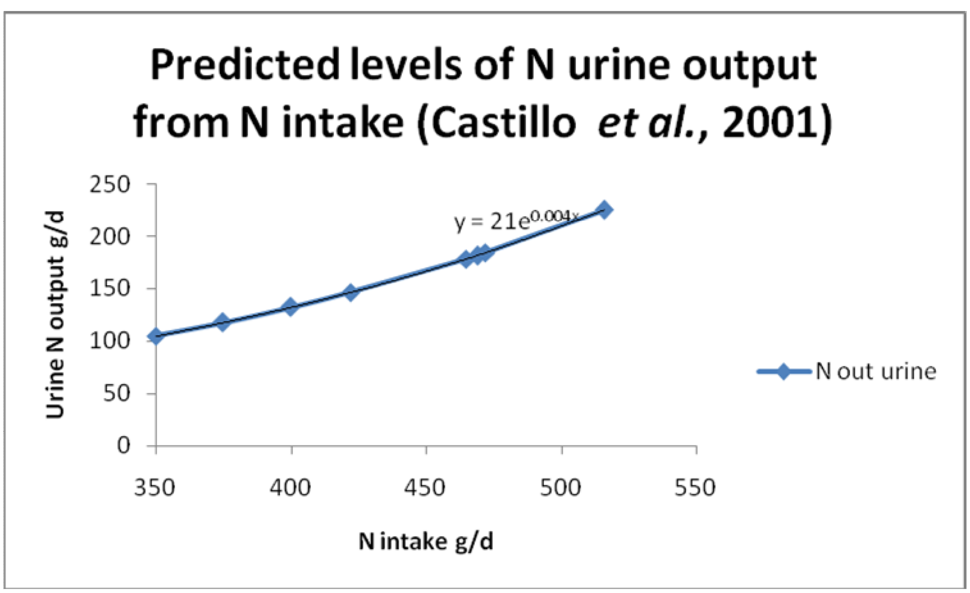

Figure 3. Influence of nitrogen intake on urine outputs (Castillo et al., 2001)

27. Taking these published findings, we can compare N intake versus urine output as a method of controlling environmental pollution problems. Using the relationship described by Castillo *et al.* (2001) (Figure 3), we can predict urinary N output on a g/d basis. This relationship can be applied to on-farm conditions, as long as the levels of N intake from protein are measured or at least calculated.

28. There are complex equations for estimating dry matter intake of feed per cow per day, and this is dependent on several factors, including ambient temperature, period in lactation cycle, milk yield and body weight. However, for purposes of simplicity, it can be assumed that a dairy cow consumes between 2 and 4% of its body weight per day, dependent on the concentration of energy in the diet. For example if they are fed a higher energy diet such as whole crop maize silage (8% protein) then they will consume less overall because they will naturally eat to satisfy their energy requirements first. If cows are fed a low energy/ low fibre source such as clover-based grass they will have to consume much more, including taking in much higher concentrations of protein, to meet their energy requirements. For example, a European cow of average 575 kg body weight will consume between 11.5 (2%) and 23 kg (4%) of (dry weight) feed per day dependent on the quality of the feed. If fed a clover/rye silage, which contains approximately 19% protein, equating to 3% (or 30 g/kg) N, daily N intake will range between 345 and 690 g/d for the lower and higher intakes respectively.

29. From the published relationship described above, it can be calculated that the level of N excreted from the cow consuming 345 g/d N will be 102 g/d N in urine versus 501 g/d N for 690 g intake levels. If this is part of a 200 cow herd, this equates to a range of 20.4 ï 100.2 kg of N excreted per day via urine alone. On average, in New Zealand, herd sizes are larger, at 386 cows, and so under local conditions, this amount of N excreted per day range between 39 ï 193.4 kg of N excreted per day. This will make a large difference to the environmental outputs (by a five-fold magnitude) or can be reduced by 80% if the lower level of intake is applied. Hence controlling N intake on a daily basis, or improving the utilisation of N in the diet for the host can moderate N excretion in urine, given the example above.

30. In New Zealand, cows are lighter in body weight, averaging only 450 kg. This affects their intake, and a mean value of 4 tonnes of dry matter intake per year is typically assumed for local conditions on dairy farms. This equates to a dry matter intake of 11 kg per day (2.4%). This increases slightly during early lactation (peak demand for nutrients) to 2.8% of body weight, or a dry matter intake of 13 kg per day. These values highlight the ongoing problems for New Zealand farmers in terms of getting enough dry matter intake into a cow to maximise productivity. Of the total daily intake, a proportion of famers in New Zealand feed PKM and maize (as whole crop silage) at an average level of 1.6 kg per cow per day. The following examples show how these different feeding regimes affect N excretion via urine.

At 11 kg dry matter intake per day for a 450 kg cow:

- ☐ 1.6 kg PKM/maize = 10 % protein = 26 g N intake per day
- ☐ 9.4 kg rye/clover pasture = 26% protein = 391 g N intake per day
- ☐ Total N intake per day = 417 g

Calculated N excretion in urine = 143 g per day

In contrast with a total grass system for a 450 kg cow:

- ☐ 11 kg rye/clover pasture = 26% protein = 458 g N intake per day

Calculated N excretion in urine = 173 g per day

31. The results show a 17% reduction in N excretion via urine per cow. Hence a complete pasture system will greatly exceed the guideline limits for controlling N excretion in urine. Ideally, if a higher, fibre-based energy system were used in dairy cows, the level of N excretion could be better controlled, below the 400 g N intake per day threshold.

For example:

At 11 kg dry matter intake per day for a 450 kg cow:

- ☐ 3.2 kg PKM/maize = 10% = 52 g N intake per day
- ☐ 7.8 kg rye/clover pasture = 26% protein -= 324 g N intake per day
- ☐ Total N intake per day = 376 g i.e. below **400 g** maximum recommended intake

Calculated N excretion in urine = 118 g per day

32. This equates to a saving of 55 g N (32%) output per day compared to the total pasture based feeding system.

33. These examples shows how nitrogen intake can be controlled by simply doubling the levels of palm kernel meal fed to a cow on a daily basis. It must be pointed out that this does not constitute a complete or balanced diet, as discussed in my paragraphs 37 and 38 respectively, PKM is high in Phosphorus, and copper, and so care must be taken to insure nutritional deficiencies or imbalances do not occur. However, use of PKM is an easily implemented way to ensure the N output in urine is controlled.

34. Feeding a ótotal mixed rationô(i.e. a diet which has been formulated, using different feed materials, to supply a complete and balanced feed) also results in significant reductions (26 ï 30%) in N excretion, as discussed under my paragraphs 30 and 32 below.

CONTROLLING AND MANIPULATING NITROGEN INTAKE AND UTILISATION TO REDUCE EXCRETION

35. Much research and commercial product development has focussed on providing óbypass proteinô(i.e. in a form that the microbes canôt break down) to cattle, in order to make nitrogenous nutrients more available to the host rather than the micro-organisms (which can utilise as much as 50% N), leading to higher expression of protein in meat and milk and less in urine (Ruiz *et al*., 2001). It appears from the published literature that, ideally, a low protein diet which has been formulated to meet amino acid requirements and can bypass the rumen should be fed to dairy cows to limit N excretion. In a trial where lactating cows at grass were supplemented with either a balanced total mixed ration (TMR) of 30% grass silage, 20% corn silage and 50% grain, or the same TMR supplemented with by-pass protein, N outputs were significantly reduced by 26% in urine for those fed the TMR only and by 39% for those fed TMR plus by-pass protein (Table 1; Dinn *et al.*, 1998). Faecal nitrogen was not significantly affected.

Table 1. Impact of supplementary feeding on nitrogen output from dairy cows (Dinn *et al.,* 1998)

Parameter	Unsupplemented	TMR only	TMR + bypass amino acids
Urine (litres/d)	23.3[a]	20.6[b]	17.7[c]
Faeces (kg/d)	38.8[a]	35.9[b]	35.4[b]
Urine N (kg/d)	0.264[a]	0.195[b]	0.162[c]
Faecal N (kg/d)	0.158	0.155	0.151

Means not sharing a letter in rows differ significantly (P<0.05)

36. The by-pass product Optigen (Alltech Inc, USA) has been reported to increase N availability to the cow as a by-pass product, which increased milk yield by 1.8% but, more importantly in this context, reduced N concentration in urine by 7% (Chalupa, 2007).

37. The easiest way to control N intake is by combining a high N source (e.g. clover silage) with cereals, and this has been shown to reduce N output in urine significantly by between 26-30% in practical studies, similar to the range recently quoted in New Zealand studies Castillo *et al.* (2001) which showed that feeding a digestible starch feed source (such as cereals or cereal-based silage) can control N losses. Trials in the US (Weiss *et al*., 2007) reported that a lactating cow produced on average 75 kg of manure per day, and a dry cow 42 kg. Feeding corn silage alongside grazing or hay reduced this level by 2 kg/d for every 10 units of N fed.

38. From research to date, it is clear that grazing alone does not promote efficient ruminant function, especially in modern dairy breeds which have high genetic potential. A suitable analogy to compare the importance of feeding for such an animal is comparing it to a high performance car, which needs high grade, suitable fuel to run properly. In much of the dairy industry, cows never reach their genetic potential in terms of yield, fertility and longevity as they are fed the equivalent of rough diesel. A key consideration is that grassland and soil testing needs to be done regularly throughout the year, in order to understand what the nutritive quality of the basal pasture is, and then to supplementary feed accordingly to ensure best balance of

nutrients and forms of fodder to optimise performance and minimise waste from manure and urine.

39. It has been stated that nutritional strategies to control nitrogen excretion from dairy cows is four times more efficient than control via other practises such as manure storage or treatments (Wright, 2003). Unbalanced energy:protein ratios will decrease efficiency, resulting in more ammonia production and greater urine N output. Additionally, high protein diets may be linked to the occurrence of laminitis (an inflammatory disease affecting the feet causing lameness, which is linked to inappropriate feeding) in dairy cows. Limiting protein intake, as per levels discussed above, can control this, substantially reducing animal health costs on farm.

OPTIMISING RUMINANT PRODUCTION, WELFARE AND EXCRETION VIA FEEDING

40. Culled dairy cows need to be disposed of, adding potentially to pollution levels from decomposition on burial. The main reasons for dairy cow culls are infertility, poor milk yield and persistent lameness. It is well known that feeding a balanced diet, including vitamins and minerals can address all these factors, and reduce the losses in real terms from dairy herds, as well as reducing the need to replace cows with more young heifers, which also contribute to N pollution from excretion. Feeding high cereal concentrates to provide up to 75% of DM intake to heifers can reduce overall feed costs by 3-16% and manure output by 12-40% depending on the feed types used (Zanton *et al.*, 2008). Annual replacement rates can be in the order of 30% (Beever, 2004). Although feed materials vary in costs from region to region, especially if they are imported, typically feeds can be balanced to allow for limited N excretion whilst better supporting milk production, hence may be neutral in terms of cost, as balanced out by better productivity.

41. Fertility is gauged by ‘empty rates’ which, in NZ are higher than many other counties, being around 10%, typically due to poor nutrition especially minerals. Herds may have first service conception rates of only 50%, and repeat AI services (whereby artificial insemination is used on farms to attain pregnancies in dairy cows and heifers) are a major consideration in terms of herd costs. Cows require a certain body

condition score for good fertility. Cows fed high protein diets typically drop condition score and become anoestrus as a result. Introducing a TMR has been shown to improve 80% of herds (Quinn *et al.*, 2003) in terms of feed efficiency, leading to better milk production, with 32 kg more fat and 29 kg more protein expressed in milk per year (Sheehy and Quinn, 2004). In the review by Beever (2004), an improvement from 1.1 to 1.3 kg milk per kg feed can reduce overall costs by GBP 0.013 (US$0.018) per litre, which, at the time of the publication, represented approximately 7% savings in production costs based on the farm gate milk price (average for 2004 of GBP 0.18/litre, as stated by Dairyco.org.uk).

42. Whilst feeding strategies and production intensity varies between countries, up to 40% reduction in N excretion has been demonstrated when more appropriate feeding methods have been applied to dairy herds, especially regarding providing a balanced diet. Cumulative benefits in terms of minimising N excretion, from applying the following strategies: balancing energy to protein ratio; use of by-pass protein; rumen conditioning supplements and better rumen development at weaning.

OTHER POLLUTANTS FROM INTENSIVE FARMING SYSTEMS

43. As well as considering nitrogen excretion, the role of phosphorous and minerals, such as zinc and copper as pollutants cannot be ignored, and are now subject to pollution legislation in many countries. Phosphorous (P) is an important mineral, which is closely tied to calcium in terms of balance and uptake in animals. This ratio must be carefully monitored if one or the other mineral is not to be excreted or become deficient in the animal. A major practise in NZ dairying is the use of palm kernel meal (PKM) as a source of fermentable fibre. PKM is known to be high in P, and care must be taken to ensure this is balanced out in a total ration by calcium in the right proportion to prevent P excretion.

44. If mineral pollution is taken into account, there are commercially-available óchelatedô minerals, which are in a form similar to those in natural feedstuffs, and are more available to the host animal. These products allow significant reductions in mineral inclusions in diets and can drastically reduce mineral output in faecal material without

loss in absolute uptake or milking performance. Of these, zinc and copper have received the majority of attention. Trials have shown a reduction of nearly 10% in urinary zinc and between 9-34% less faecal zinc, depending on form of zinc used. The lowest outputs were obtained with chelated zinc, which, due to its efficient use in the animal, could be used at a much lower dose with no significant impacts on milk yield. Again, the use of PKM in unbalanced total rations is a concern, as this contains relatively high copper levels, which may contribute to excessive excretion rates.

SUMMARY: OPTIONS AVAILABLE TO OPTIMISE RUMEN EFFICIENCY AND LIMIT N EXCRETION

- ☐ Improved young stock/heifer feeding to promote optimal rumen development to ensure efficiency in the adult.
- ☐ Improved feeding of the adult diary cow to optimise health leading to reductions in empty rates (around 4% compared to New Zealand average of 10%), increased lactating animal and minimise N output and subsequent overall N load in the environment, from herd replacements.
- ☐ up to 40% reduction in N excretion has been demonstrated
- ☐ N excreted in urine can be reduced 5 fold or by 80% by managing N content in feeds to optimise energy requirements while minimising protein ingestion. Hence controlling N intake on a daily basis, or improving the utilisation of N in the diet for the host can significantly moderate N excretion in urine, examples show 17% and 33%The easiest way to control N intake is by combining a high N source (e.g. clover silage) with cereals, and this has been shown to reduce N output in urine significantly by between 26-30% in practical studies, similar to the range recently quoted in New Zealand studies Castillo *et al.* (2001) showed that feeding a digestible starch feed source (such as cereals or cereal-based silage) can control N losses
- ☐ In a trial where lactating cows at grass were supplemented with a balanced total mixed ration (TMR) of 30% grass silage, 20% corn silage and 50% grain, and supplemented with by-pass protein, N outputs were significantly reduced by 39% for those fed TMR plus by-pass protein (Table 1; Dinn *et al.*, 1998).

- Regular, balanced ration formulation (e.g. via TMR) on an individual cow basis, including pasture analysis to ensure correct balance. This will require educational inputs for those working in the dairy industry in order to attain correct and practical implementation.

- Attention to feeding practises during spring and autumn grass flushes, where sugar and nitrogen peak in rye/clover grasses, such as feeding additional fibre to stabilise rumen efficiency. Typically in New Zealand, cows are allowed restricted access to pasture, with an average of 12 kg dry matter intake as opposed to their capacity of 18-25 kg dry matter intake per day. When this coincides with early lactation (e.g. spring), restricted feeding can result in poor lactation productivity over the whole cycle. Hence, there are benefits for improving feeding practices not only for N excretion, but also in terms of promoting milk yield and quality. Although there are New Zealand companies offering services to improve feeding practises and grazing of dairy cows, only a small proportion of farmers are applying these to their herds. Assistance with providing balanced feeds and grazing is readily available, but, as there is currently no ópenaltyô for inefficient and polluting herds, there is little compunction for farmers to take this up.

- Monitor milk urea nitrogen (MUN) levels ï this can (and is) being used as being a key point in reducing N outputs. Wright (2003) stated that in a 472 farm study in the USA, when MUN was decreased by 0.52 mg/dl, N excretion reduced by 126 t/year. In New Zealand, assisting farmers regarding the interpretation of their MUN levels (commonly reported on milk records) is necessary, with recommendations regarding how best to use this information to optimise their feeding strategy to address both environmental and productivity issues. Certain companies (e.g. Open Country Dairies) offer testing services to farmers for MUN, and nutritionists are available to translate these findings into provision of more balanced rations for dairy cows, hence improving herd production efficiency and limiting environmental pollution.

- Favouring high quality forages, as these are more digestible, and should be evaluated for protein and carbohydrate type/levels not grass yield alone. This will allow pasture-based feeds to be better balanced, allowing not only N excretion control, but also ensuring adequate energy intake and a correct energy:protein balance to optimise milk yield and enhance milk solids levels. This can be achieved by either growing on-farm or sourcing crops, such as good quality whole crop maize for silage, to provide lower N sources of fodder and reduce daily N intakes in cows. Farmers could then apply these high fibre/energy diets especially in times of strong pasture growth, and limit the unbeneficial impacts of high sugar/nitrogen on rumen activity and N output.

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