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TABLE OF CONTENTS


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This Symposium could not proceed without the hard work and dedication of all the staff of the *Dairy Science Group*.

PREFACE

The 2009 Dairy Research Foundation (DRF) Symposium marks the 50th anniversary of the DRF. This is an important milestone that highlights the unique role of the DRF within Australia's dairy industry. Over the years the DRF has supported research in Dairy Science by integrating cutting edge research with extension activities to disseminate this information among dairy farmers nationally and internationally.

A number of exciting changes have been instigated for the DRF Symposium this year. These changes are in line with the feedback received over the past few months and are aimed at increasing farmer attendance and the significance of outcomes of the event.

We are holding this year's event at the University of Sydney's new Liz Kernohan Conference Centre at Camden. The new Conference centre is a fantastic venue named after the late Liz Kernohan, former Director of the DRF and who made an enormous contribution to Dairy Science.

The focus the 2009 DRF Symposium is once again on the future and the core component of the program is *Feeding for the Future*. The program includes a variety of technical sessions where we will address some key issues such as feeding to maximise dry matter intake, feeding to boost profits, feeding to improve reproduction and feeding in future systems.

During the first day Dr Fernando Bargo, from (Elanco, Argentina), Santiago Farina and Ajantha Horadogoda from the FutureDairy project, will discuss important issues that can influence maximum dry matter intake. Joanne Bills (Dairy Australia) and Basil Doonan (Dairy consultant) are the main speakers of the Feeding for maximum profit session.

As always, a great and enthusiastic group of young scientists will present their work in very brief presentations to make the industry aware of their work. This year we will have two overseas young scientists: This is a great indication of our growing reputation worldwide.

During the second day the focus will be on Feeding and Reproduction and Feeding in the future. Professor John McNamara (Washington State University), Associate Professor John House (University of Sydney) and Tracey Russell (Dairy Farmer, NSW) will share their views on nutrition and reproduction in the modern dairy cow. Associate Professor Ian Yule (Massey University, New Zealand), Dr Kendra Kerrisk (FutureDairy project) and Mark Billing a (Dairy Farmer, Victoria) will discuss how to integrate modern technologies in dairy feeding systems.

Another new feature of this year's Symposium will be a 'workshop' session in which the Symposium delegates will have the opportunity to meet in small groups to discuss key points, messages and issues in relation to what was presented during the different sessions. All delegates will reconvene in the main auditorium for a general discussion session where the main take home messages of the DRF Symposium will be summarised.

The DRF Symposium will be concluded with a farm visit to Leppington Pastoral Company (Intensive feedlot operation with over 2,000 cows) where delegates will be able to observe some practical aspects of feeding high production dairy cows in a feedlot system.

We are grateful to all the sponsors who make this event possible. Their support allows us to not only keep a low registration fee but also subsidise the attendance of some 15 young farmers to the symposium.

During the annual dinner we will be presenting the Milk Marketing NSW Dairy Science Award to Professor Roy Kellaway, who has made a significant contribution to the Australian Dairy Industry by providing guidance and leadership as an educator, innovator, researcher and through the practical implementation of nutrition programs.

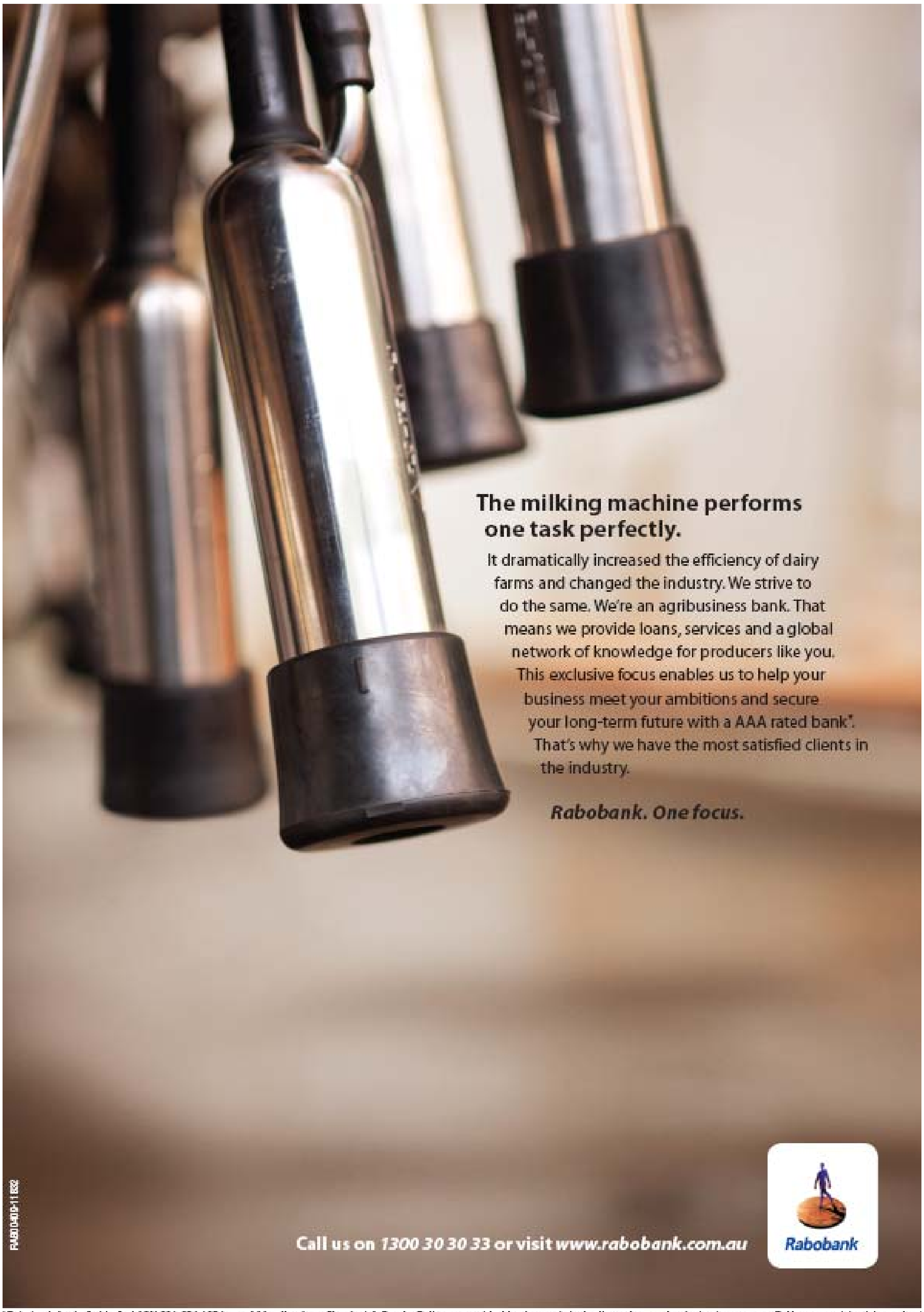
We would like to acknowledge the invaluable contribution of the DRF Symposium Committee and to the Dairy Science Group (Faculty of Veterinary Science) for their help and support.

We trust that you will enjoy this years DRF Symposium.

Kind regards

Dr Pietro Celi and Assoc Prof Yani Garcia

2009 Dairy Research Foundation Symposium



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DRY MATTER INTAKE OF SUPPLEMENTED DAIRY COWS ON PASTURE: BASICS CONCEPTS WITH PRACTICAL IMPLICATIONS

Fernando Bargo

Elanco South America

Dry Matter Intake of Grazing Cows on Pasture-Only Diets

Different theories about the control of dry matter intake (**DMI**) in ruminants have been presented (Forbes, 1995); however, detailed description of these theories exceeds the objectives of this paper. Hodgson and Brookes (1999) described three factors affecting pasture DMI of grazing cows: 1) "feeding drive" or nutrient requirements of the cow; 2) "physical satiety" or factors associated with distension of the alimentary tract; and 3) "behavioral constraints" or limits to the potential pasture DMI resulting from the combination of pasture and animal factors affecting grazing behavior.

Low pasture DMI has been identified as a major factor limiting milk production of high producing cows with a grazing system (Leaver, 1985; McGilloway and Mayne, 1996; Kolver and Muller, 1998). Leaver (1985) suggested that high producing dairy cows fed pasture-only diets could reach a total DMI of 3.25% of BW. Mayne and Wright (1988) estimated that with no pasture quantity and quality restrictions, pasture DMI of high yielding dairy cows might reach 3.5% of BW. Beever and Thorp (1997) proposed that total DMI of high producing cows fed pasture-only diets is lower than for cows fed pasture diets plus concentrates. This may be explained by physical constraints, rate of forage removal from the rumen, and water consumption associated with pasture.

Kolver and Muller (1998) reported that early lactation cows grazing high quality grass pasture in the spring had a pasture DMI of 19.0 kg/d, or 3.4% of BW. However, when compared with cows fed a nutritionally balanced TMR ration, grazing cows consumed 4.4 kg less DM. The intakes of DM and NE_L were lower on the pasture-only diet; however, intakes of CP and NDF did not differ between the pasture-only diet and TMR. The difference in DMI, rather than energy content of pasture, appeared to be the major factor responsible for the lower total energy intake and milk production (Kolver and Muller, 1998). Pasture DMI of unsupplemented dairy cows increased from 17.7 kg/d or 2.9% of BW to 20.5 kg/d or 3.4% of BW as pasture allowance (**PA**) increased from 25 to 40 kg DM/cow per day (Bargo *et al*., 2002a). Although Dalley *et al*. (2001) suggested that pasture DMI may be increased by more frequent allocation of new pasture, they reported no difference in DMI (15.8 kg/d) or milk production (25.3 kg/d) of early lactation cows grazing a ryegrass pasture when offered one or six times per day.

Effect of Pasture Allowance on Pasture Dry Matter Intake

Many pasture factors affect pasture DMI (Poppi *et al*., 1987; Hodgson and Brookes, 1999) including pre-grazing pasture mass (amount of pasture per unit area; kg DM/ha) and PA (amount of pasture offered per cow; kg DM/cow per day). Several researchers (Stockdale, 1985; Dalley *et al*., 1999) have reported that pasture DMI is closely related to PA. The relationships between pasture DMI and PA have been described as asymptotic (Poppi *et al*., 1987; Peyraud *et al*., 1996; Dalley *et al*., 1999). However, it is unclear what PA is required to maximize DMI. In a review, Leaver (1985) proposed a maximum DMI at a PA between 45 to 55 g DM/kg of BW or 27 to 33 kg DM/cow per day for a 600-kg cow. Pasture DMI increased as PA increased, but at a declining rate with a plateau when PA was 10 to 12% of BW or 60 to 72 kg DM/cow per day for a 600-kg BW cow (Hodgson and Brookes, 1999). Data from Australia (Doyle *et al*., 1996) showed that pasture DMI continues to increase as PA increases up to 15 kg DM/100 kg of BW or 90 kg DM/cow per day for a 600-kg BW dairy cow. Pasture DMI increased curvilinearly from 11.2 to 18.5 kg DM/cow per day as PA increased from 20 to 70 kg DM/cow per day, with a plateau at a PA of 55.2 kg DM/cow per day (Dalley *et al*., 1999). Peyraud *et al*. (1996) reported a curvilinear relationship between pasture DMI and PA from 20 to 40 kg DM/cow per day, with pasture DMI reaching a plateau at a PA of 32.6 kg DM/cow per day. Wales *et al*. (1999) reported that as PA increased from 20 to 70 kg DM/cow per day, pasture DMI increased linearly from 7.1 to 16.2 kg DM/cow per day with a pre-grazing pasture mass of 3100 kg DM/ha, and from 9.9 to 19.3 kg DM/cow per day with a pre-grazing pasture mass of 4900 kg DM/ha.

More recent research has studied the effect of PA on pasture DMI of high producing dairy cows with no supplementation. Pasture DMI of dairy cows grazing an orchardgrass pasture was 17.5 and 20.6 kg DM/cow per day at low (25 kg DM/cow per day) and high (40 kg DM/cow per day) PA, respectively (Bargo *et al*., 2002a). In two experiments that measured PA at a 5-cm cutting height (Delaby *et al*., 2001), pasture DMI increased from 11.3 to 13.0 kg/cow per day as PA increased from 12.1 to 15.8 kg of DM/cow per day, and from 12.9 to 15.0 kg/cow per day as PA increased from 16.5 to 21.0 kg DM/cow per day. Stockdale (2000a) reported an increase in pasture DMI from 14.3 to 19.3 kg/d when PA of a ryegrass pasture was increased from 26.7 to 53.5 kg DM/cow per day. Dalley *et al*. (2001) also reported an increase of pasture DMI from 13.6 to 17.9 kg/d as the PA of a ryegrass pasture increased from 40 to 65 kg DM/cow per day. Pasture DMI by high producing dairy cows in early lactation increased from 11.2 to 15.6 kg/d when PA of a ryegrass pasture was increased from 19 to 37 kg DM/cow per day (Wales *et al*., 2001).

In summary, over a range of PA from 20 to 70 kg DM/cow per day, pasture DMI increased 0.19 kg/kg of increased PA (range: 0.17 to 0.24 kg/kg). Data from seven studies (Peyraud *et al*., 1996; Dalley *et al*., 1999; 2001; Stockdale, 2000a; Delaby *et al*., 2001; Wales *et al*., 2001; Bargo *et al*., 2002a) were used to describe the relationship between pasture DMI and PA for dairy cows on pasture-only diets (Bargo *et al*., 2003). In those studies, cows ranged from 19 to 182 DIM and produced from 23.0 to 45.8 kg/d of milk at the start of the experiment, grazed at a PA from 12.1 to 70 kg DM/cow per day, and consumed 6.7 to 20.5 kg DM/cow per day of pasture. Observations were weighted as described by St-Pierre (2001) to account for unequal replications and variances of the means across studies. Pasture allowance and its quadratic term were considered as independent variables. Parameter estimates for the final equation were obtained using a mixed model approach (i.e., trial was considered a random effect) using the MIXED procedure of SAS (1999). The regression analysis for pasture DMI (**PDMI**, kg/d) resulted in a best-fit model that included terms for PA (kg DM/cow per day) and its quadratic term: PDMI = 7.79 (SE 1.49) + 0.26 (SE 0.06) PA - 0.0012 (SE 0.0007) PA^2; $R^2 = 0.95$. Based on this equation, the optimum PA to maximize pasture DMI (21.9 kg/d) is reached at 110 kg DM/cow per day, and pasture DMI increased 0.26 kg/kg of increase in PA up to 110 kg DM/cow per day. If the goal is to maximize pasture DMI of high producing dairy cows, management must ensure unrestricted pasture quality and quantity, which is only found for short periods of time during the spring. Unrestricted pasture conditions (i.e., high PA) also implies low pasture utilization (pasture DMI/PA < 50%; McGilloway and Mayne, 1996). The use of very high PA might also result in deterioration of pasture quality as the season progresses because of the increase in residual pasture height (Peyraud and Delaby, 2001).

The studies reviewed by Bargo *et al*. (2003) indicate that maximum pasture DMI is achieved when PA is between 3 to 5 times the DMI, which is in agreement with the regression described above. However, even under unrestrictive pasture conditions, total DMI amounts achieved by high producing dairy cows are lower than those by cows consuming TMR (Kolver and Muller, 1998) or pasture plus supplements (Bargo *et al*., 2002a, 2002b). Because of low pasture utilization and deterioration of pasture quality at high PA, a practical recommendation is to provide a PA of 2 times the expected pasture DMI or 25 kg DM/cow per day of PA when cows are also fed supplements (Bargo *et al*., 2002a).

Methods and Equations to Estimate Dry Matter Intake in Grazing Cows

Estimation of DMI in grazing cows is more difficult and less accurate when compared with the determination of DMI by cows on confinement systems. An extensive review of the different methods and techniques to estimate DMI in grazing cows was published by Leaver (1982). Techniques may be classified as either pasture or animal-based (Meijs *et al*., 1982). An extensive review of pasture measurement techniques can be found in Mannetje (2000). The main disadvantage of pasture-based techniques is that pasture DMI is estimated as a group and not individually. The most common animal-based technique used is based on the estimation of fecal production and diet digestibility (Le Du and Penning, 1982; Peyraud, 1998): DMI = fecal production/ (1 − digestibility of the diet). Fecal production is estimated using markers such as chromium oxide (Peyraud, 1998) and alkanes (Dove and Mayes, 1991; Dove and Mayes, 1996). A comparison between those two methods has been reported by Mallossini *et al*. (1996), who concluded that estimation of pasture DMI was similar if a 95.5% recovery is assumed for chromium oxide.

Because estimation of DMI by grazing cows demands the use of labor-intensive and indirect techniques that have several sources of error, equations based on animal and pasture characteristics have been developed to predict DMI of grazing cows (Caird and Holmes, 1986; Vazquez and Smith, 2000). Caird and Holmes (1986) used data from nine experiments conducted with cows grazing ryegrass, consuming 1.2 kg/d of concentrate, and producing 21.5 kg/d of milk on average to predict total DMI. Animal variables included total OM intake (**TOMI**, kg/d), herbage OM intake, concentrate DMI (**CDMI**, kg/d), BW (kg), milk yield (**MY**, kg/d), herbage OM digestibility, and week of lactation. Pasture variables included herbage mass (**HM**, tonne of OM/ha), PA (kg OM/cow per day), and sward height (**SHT**, cm). For rotationally grazed cows the best equation (R^2 = 0.68) was: $TOMI = 0.323 + 0.177MY + 0.010BW + 1.636CDMI - 1.008HM + 0.540PA - 0.006PA^2 - 0.048PA \times CMDI$.

Vazquez and Smith (2000) used data from 27 grazing studies with dairy cows to obtain regression equations to predict total and pasture DMI. Mean milk production and supplementation amount were 15.9 and 1.9 kg/d, respectively. Independent variables included 4% FCM (kg/d), days since calving, PA (kg DM), NDF in pasture available (**NDFp**, % DM), NDF in pasture selected (**NDFs**,%DM), percentage of legumes in pasture (**LEG**, %), amount of concentrate supplemented (kg DM), amount of forage supplemented (kg DM), total supplementation (**SUP**, kg DM), PA and total supplementation interaction (**PASUP**), BW (kg), and change in BW (**CBW**, kg/d). The best equation (R^2 = 0.95) for total DMI (**TDMI**) estimation was: $TDMI = 4.47 + 0.14FCM + 0.024BW + 2.00CBW + 0.04PA + 0.022PASUP +$

0.10SUP − 0.13NDFp − 0.037LEG. The best equation to estimate PDMI (R^2 = 0.91) was: PDMI = 4.47 + 0.14FCM + 0.024BW + 2.00CBW + 0.04PA + 0.022PASUP − 0.90SUP − 0.13NDFp − 0.037LEG.

Equations developed by Caird and Holmes (1986) and Vazquez and Smith (2000) differ from the equation presented by NRC (2001) to estimate DMI. While those equations included pasture and supplement variables, the NRC (2001) equation is based only on animal variables such as FCM (kg/d), BW (kg), and week of lactation (**WOL**): DMI = (0.372 × FCM + 0.0968 × BW0.75) × (1 − e (−0.192 × (WOL + 3.67))). We used a dataset of 56 measures from Bargo *et al*. (2002b), who measured DMI four times during the grazing season using Cr_2O_3 as a fecal marker in dairy cows that grazed an orchardgrass pasture and were supplemented with 8.7 kg/d of a corn-based concentrate. Cows, pasture, and supplement information reported in that study (Bargo *et al*., 2002b) were used to estimate DMI with the equations of Caird and Holmes (1986), Vazquez and Smith (2000), and NRC (2001). Total DMI estimated by the equations of NRC (2001) (21.9 kg/d) or Caird and Holmes (1986) (21.2 kg/d) did not differ from DMI measured by Cr_2O_3 (21.6 kg/d) (P > 0.05), but estimation of DMI by the equation of Vazquez and Smith (2000) (24.4 kg/d) was higher than measured DMI (P < 0.05). This indicates that estimation of DMI using the equations of Caird and Holmes (1986) and NRC (2001) was accurate for this particular dataset with high producing dairy cows, with the advantage that the NRC (2001) equation is simpler and requires only animal factors.

Grazing Behavior and Pasture Dry Matter Intake

Pasture DMI of grazing cows can be expressed as the product of grazing time (min/d), biting rate (bites/min), and bite mass (g DM/bite; Hodgson and Brookes, 1999; Rook, 2000). Few grazing behavior studies have been conducted with high producing dairy cows under practical or production conditions, probably because of methodological limitations. Bite mass can be measured directly by using esophageally fistulated animals or indirectly dividing pasture DMI by the total bites/d (Forbes, 1988; Rook, 2000). Because use of esophageally fistulated animals is expensive, and may compromise animal welfare and normal behavior, bite mass is often calculated indirectly (Rook, 2000). Both biting rate and grazing time can be measured visually or automatically (Forbes, 1988). Visual estimation of biting rate requires the recording of head movements and sound associated with pasture prehension. Automatic methods for biting rate are based on recording jaw and sometimes head movements. Visual grazing time measurements are based on recording grazing activity at different intervals (e.g., 5 to 10 min) with the disadvantages of being labor intensive and limited by daylight (Rook, 2000). Traditionally, automatic grazing time measurements are conducted using vibracorders (Forbes, 1988). Recently, an automatic method for grazing behavior estimation was developed (Rutter *et al*., 1997), which has several advantages such as fewer people required, less operator-associated errors, and more detailed behavior information (Champion *et al*., 1998).

Grazing Behavior on Pasture-Only Diets. Among the three grazing behavior variables, bite mass has the greatest influence on pasture DMI (Forbes, 1988; McGilloway and Mayne, 1996). Although bite mass is also affected by the animal's anatomy characteristics (e.g., mouth; Rook, 2000), it is principally determined by pasture-related characteristics (Hodgson and Brookes, 1999), such as pasture height (Phillips, 1993; McGilloway *et al*., 1999) and density (Rook, 2000). Pasture height is the major constraint on bite mass in temperate pastures, with the effect primarily on bite depth rather than on bite area (Rook, 2000).

Dairy cows consistently remove around one-third of the height of pasture, regardless of pasture height (Wade *et al*., 1989). Bite mass decreases with a reduction in pasture height both in unsupplemented (Gibb *et al*., 1997; McGilloway *et al*., 1999) and supplemented (Rook *et al*., 1994) dairy cows. In many grazing behavior studies, pasture height is expressed as sward surface height, which refers to the height of the top surface of the leaf canopy on an undisturbed sward (Hodgson and Brookes, 1999). Gibb *et al*. (1997) reported that for dairy cows continuously grazing ryegrass, bite mass decreased from 0.31 g OM/bite at 7 or 9 cm to 0.23 g OM/bite at 5 cm, whereas neither biting rate (76 bites/min) nor grazing time (604 min/d) were affected by sward surface height. McGilloway *et al*. (1999) found that bite mass decreased from 1.28 to 0.85 g DM/bite in one experiment with reductions in sward surface height (from 21 to 7 cm) and from 1 to 0.66 g DM/bite in a second experiment with reductions in sward surface height (from 11 to 6 cm), while biting rate was not affected (56 bites/min in experiment 1; 62 bites/min in experiment 2). In a third experiment, an interaction was found between sward surface height and density; bite mass was reduced with reductions in sward surface height more at low pasture density (from 1.02 to 0.47 g DM/bite) than at high pasture density (from 0.97 to 0.63 g DM/bite; McGilloway *et al*., 1999).

Grazing time and biting rate are influenced by animal-related characteristics such as genetic merit and milk production. Both grazing time and biting rate act as compensatory mechanisms to avoid reductions in pasture DMI when bite mass decreases. However, these compensatory mechanisms have a limit. The upper limit of grazing time to compensate for a reduction in bite mass is determined for the time required for other activities such as ruminating (Rook, 2000). Under poor pasture conditions (e.g., very short pasture), all three variables decline (Hodgson and Brookes, 1999). High genetic cows had higher grazing time and biting rate than low genetic cows supplemented with concentrate (Bao *et al*., 1992). High genetic cows grazed a ryegrass pasture for longer time (218 vs. 204 min, measured visually for a period of 7 h) and at a higher biting rate (64 vs. 61 bites/min) than low genetic cows. Two recent studies (Pulido and Leaver, 2001; Bargo *et al*., 2002b) reported that high producing cows had greater grazing time, number of bites per day, and rate of intake than low producing cows. Bargo *et al*. (2002b) found a positive relationship between MY (kg/d) and the number of bites per day (**TB**, bites/d) for cows producing more than 25 kg/d of milk grazing a orchardgrass pasture and supplemented with 8.7 kg/d of concentrate: MY = 14.1 + 0.0005 TB (R^2 = 0.74), which indicates an increase of 5 kg/d of milk for every 10,000 bites/d (Bargo *et al*., 2002b).

Effect of Supplementation on Grazing Behavior. Increasing the amount of concentrate reduced grazing time but did not affect biting rate (Arriaga-Jordan and Holmes, 1986; Kibon and Holmes, 1987; Rook *et al*., 1994; Bargo *et al*., 2002a; Gibb *et al*. 2002). Arriaga-Jordan and Holmes (1986) reported that grazing time was reduced 11 min/kg of concentrate in continuous grazing and 8 min/kg of concentrate in rotational grazing, while biting rate was not affected by the amount of supplementation. Rook *et al*. (1994) reported that concentrate supplementation, but not pasture height, reduced grazing time 20 min/kg of concentrate. Bite mass decreased as pasture height decreased, while the supplementation amount had no effect on bite mass (Rook *et al*., 1994). Amount but not type of energy supplement (cereal vs. beet pulp) reduced grazing time 8 to 12 min/kg of concentrate by dairy cows grazing ryegrass at two pasture heights (Kibon and Holmes, 1987).

Biting rate was not affected by supplementation amount, type of supplement or pasture height, while bite mass was lower at the low pasture height (Kibon and Holmes, 1987). Recently, Sayers (1999) found that total bites per day and grazing time were higher when cows were supplemented with a fiber-based concentrate than when cows were supplemented with a starch-based concentrate, whereas bite mass was not affected. When the amount of concentrate was increased from 5 to 10 kg/d, total bites/d decreased from 22,023 to 16,933 and grazing time decreased 16 and 20 min/kg of fiber-based or starch-based concentrate, respectively (Sayers, 1999). Bargo *et al*. (2002a) reported that supplementation with 7.9 kg/d of a corn-based concentrate reduced grazing time by 75 min/d at low PA and by 104 min/d at high PA. Neither biting rate nor bite mass were affected by treatments. Gibb *et al*. (2002) reported that as the amount of concentrate supplementation increased from 1.2 to 6.0 kg/d grazing time of dairy cows grazing a ryegrass pasture decreased numerically from 591 to 572 min/d. Supplementation with 2 kg/d of soybean meal did not change any grazing behavior variables of dairy cows grazing a ryegrass pasture fertilized with 0 or 60 kg of N/ha (Delagarde *et al*., 1997). Bite mass was higher when cows grazed the fertilized pasture (Delagarde *et al*., 1997). Sayers (1999) studied the effect of amount and CP content of concentrate supplementation on grazing behavior of dairy cows on a ryegrass pasture. None of the grazing behavior variables were affected by the CP content of the concentrate. Total bites per day and grazing time were reduced as the amount of concentrate was increased, but neither the bite mass nor the biting rate changed (Sayers, 1999).

Data from the studies reviewed by Bargo *et al*. (2003) show that concentrate supplementation (mean: 4.1 kg/d; range: 2 to 8 kg/d) did not affect biting rate (mean: 58 bites/min; range: 45 to 78 bites/min) or bite mass (mean: 0.46 g of DM/bite; range: 0.27 to 0.64 g of DM/bite) but reduced grazing time by 34 min/d (SE 9 min/d, range: −212 to 25 min/d compared with controls; Student's *t*-test, significantly different from zero, $P < 0.01$) and total bites per day by 2291 (SE 534, range: −6672 to 2833 compared with controls; Student's *t*-test, significantly different from zero, $P < 0.01$). Regression analysis, accounting for the random effect of each study (St-Pierre, 2001), resulted in a negative relationship between grazing time (**GT**, min/d) and CDMI (kg/d): GT = 578 (SE 23) − 12 (SE 2) CDMI (R^2 = 0.88). Average grazing time for unsupplemented cows is 578 min/d and grazing time is reduced by 12 min/d for every kilogram of concentrate.

Substitution Rate

When grazing cows are fed supplements, pasture DMI usually decreases, which is known as substitution rate (**SR**; Kellaway and Porta, 1993). Substitution rate is calculated as: SR (kg/kg) = (pasture DMI in unsupplemented treatment − pasture DMI in supplemented treatment)/supplement DMI. A SR < 1 kg/kg means that total DMI on the supplemented treatment is higher than total DMI on the unsupplemented treatment. A SR = 1 kg/kg means that total DMI on the supplemented treatment is the same than total DMI on the unsupplemented treatment.

Substitution rate is one of the main factors explaining the variation observed in milk response (**MR**) to supplementation (Kellaway and Porta, 1993; Stockdale, 2000a; Bargo *et al*., 2003). Milk response to supplementation is expressed as kg milk/kg supplement, but it can be defined as: 1) overall MR or the increase in kilograms of milk per kilogram of supplement DMI calculated relative to an unsupplemented treatment; and 2) marginal MR or the increase in kilograms of milk per kilogram of incremental increase in supplement DMI calculated for different amounts of supplement. There is usually a negative relationship between SR and MR. When SR is large, resulting in a small increase in total DMI, the MR is low. Milk response in the short-term determines whether supplementation is profitable based on milk and concentrate prices. However, additional long-term factors should also be considered in any economic evaluation, including increase in stocking rates on the farm, improvement in pasture utilization, positive effects on BCS and reproduction, increase in lactation length, and positive effects on milk composition (Kellaway and Porta, 1993). Because SR and MR are closely related, factors affecting these two variables are commonly discussed together (Bargo *et al*., 2003). Substitution rate and MR to supplementation are affected by several pasture, animal, and supplement factors (Stockdale, 2000a; 2000b). The most important pasture-related factors are PA, pasture height, pasture species, pasture mass, and pasture quality. The most important supplement-related factors are amount and type of supplementation, and the most important animal-related factors are genetic merit of cows, production level, and stage of lactation.

Effect of Pasture Allowance on Substitution Rate

Many studies have reported that SR increases as PA increases (Meijs and Hoekstra, 1984; Stockdale and Trigg, 1985; Stakelum, 1986a, 1986b; Grainger and Mathews, 1989; Robaina *et al*., 1998; Bargo *et al*., 2002a). Many of these studies were conducted with low producing cows supplemented with less than 5 kg DM/d of concentrate; only the study of Bargo *et al*. (2002a) reported high producing cows fed more than 7 kg DM/d of concentrate. When stratifying the treatments in those studies as either low PA (<25 kg DM/cow per day; range: 7.6 to 25 kg DM/cow per day) or high PA (>25 kg DM/cow per day; range: 25 to 42.3 kg DM/cow per day), SR averaged 0.20 kg pasture/kg concentrate (range: 0 to 0.31 kg pasture/kg concentrate) at low PA, and 0.62 kg pasture/kg concentrate (range: 0.55 to 0.69 kg pasture/kg concentrate) at high PA. Considering the study effect as random (St-Pierre, 2001), a significant regression was found between SR (kg pasture/kg concentrate) and PA (kg DM/cow per day): SR = −0.55 (SE 0.13) + 0.05 (SE 0.009) PA −0.0006 (SE 0.0002) PA^2 (R^2 = 0.94).

Grazing studies evaluating the effect of PA on SR and MR of high producing dairy cows reported that SR increased and MR decreased as PA increased. All those studies showed a negative relationship between MR and SR. Considering the variation due to each study (St-Pierre, 2001), the data from those experiments showed a negative relationship between MR (kg milk/kg concentrate) and SR (kg pasture/kg concentrate): MR = 1.71 (SE 0.29) − 2.01 (SE

0.66) SR (R^2 = 0.43), indicating that the lower the SR the higher the MR expected. This is in agreement with Stockdale (2000b), who summarized data from 20 grazing experiments and reported that MR was negatively related with SR. Higher SR observed when cows grazed at high PA may be partially explained by the higher quality of pasture actually consumed (Dixon and Stockdale, 1999). Because cows grazing at high PA have the opportunity to be more selective, pasture actually eaten has higher digestibility than at low PA (Mayne and Wright, 1988).

Causes of Substitution Rate

It has been hypothesized that SR is caused by negative associative effects in the rumen (Dixon and Stockdale, 1999), or reduction in grazing time (McGilloway and Mayne, 1996). When concentrate supplements are included in pasture diets, associative effects may occur if digestive and metabolic interactions between them change the intake of energy (Dixon and Stockdale, 1999). An increase in total digestibility may be expected with the inclusion of concentrates in the diet because they are usually higher in digestibility than pasture. However, interactions between the digestion of concentrates and pasture may reduce fiber digestion (Dixon and Stockdale, 1999). The energy provided by the concentrate (fermentable carbohydrates) may lead to reductions in ruminal pH, which may decrease the activity or number of cellulolytic bacteria, reduce the rate of fiber digestion of pasture, and therefore pasture DMI (Dixon and Stockdale, 1999). Based on this hypothesis, small amounts of concentrate supplementation or supplementation with concentrates with a slow rate of degradation would result in lower SR (Kellaway and Porta, 1993). However, studies on the effect of amount of concentrate supplementation on SR did not show a clear trend to lower SR with small amounts of concentrate, probably because of the small number of studies. Under the same hypothesis, concentrates that are more slowly degraded in the rumen (e.g., fiber-based concentrates) would minimize SR compared with concentrates that are more rapidly degraded in the rumen (e.g., starch-based concentrates) because ruminal pH would be higher with fiber-based concentrates. However, the effect of the type of concentrate showed inconsistent results, which may be related to the different sources and proportion of starch and fiber that determines the rate of ruminal degradation. More information is needed related to the type and amount of concentrate supplementation and their interaction on SR of high producing dairy cows on pasture. The second hypothesis proposed to explain SR is related to grazing time. It has been suggested that reductions in grazing time by supplementation would explain SR (Mayne and Wright, 1988; McGilloway and Mayne, 1996). A significant negative relationship was presented and discussed above between grazing time and concentrate DMI, which indicates a reduction of 12 min/d per kilogram of concentrate.

Bargo *et al*. (2002a) studied ruminal digestion and grazing time of high producing dairy cows grazing at low and high PA to test both hypotheses on SR. Substitution rate was higher (0.55 vs. 0.26 kg pasture/kg concentrate) when supplemented cows grazed at higher PA (40 vs. 25 kg of DM/cow per day), and it was related to both negative associative effects in the rumen and reduction in grazing time. Supplementation with 7.9 kg/d of a corn-based concentrate reduced ruminal pH, ruminal degradation rate of pasture, and fiber digestibility at both PA (Bargo *et al*., 2002a). Grazing time was reduced 75 min/d, with supplementation at the low PA, which explained nearly all of the 2.0 kg/d reduction in pasture DMI measured by Cr_2O_3 (75 min/d × 55 bites/min × 0.55 g of DM/bite = 2.3 kg/d). At the high PA, concentrate supplementation reduced grazing time 104 min/d and explained 80% of the 4.4 kg/d reduction in pasture DMI (104 min/d × 56 bites/min × 0.60 g of DM/bite = 3.5 kg). The remaining 20% may be related to negative associative effects in the rumen; for example, the decrease in apparent digestibility of NDF by concentrate supplementation was greater at the high PA than at the low PA (4.3 vs. 1.1 percentage points, respectively; Bargo *et al*., 2002a).

Effect of Supplementation on Dry Matter Intake of Grazing Dairy Cows

Level of Energy Supplementation

Studies conducted with high producing dairy cows on pasture that have evaluated the effect of amount of concentrate supplementation on DMI were reviewed by Bargo *et al*. (2003). Overall, pasture DMI decreased and total DMI increased by increasing the amount of concentrate. Pasture DMI was numerically (Arriaga-Jordan and Holmes, 1986; Dillon *et al*., 1997) or significantly (Spörndly, 1991; Robaina *et al*., 1998; Sayers, 1999; Reis and Combs, 2000b; Walker *et al*., 2001; Bargo *et al*., 2002a) reduced when amount of concentrate increased, which is related to the SR.

For the range of concentrate supplementation (1.8 to 10.4 kg DM/cow per day), pasture DMI decreased 1.9 kg/d (SE 0.3 kg/d, range: −0.1 to −4.4 kg/d; Student's *t*-test, significantly different from zero, $P < 0.01$) or 13% compared with pasture DMI of pasture-only diet treatments (14.8 kg/d). When corrected for the random effect of study (St-Pierre, 2001), a significant negative relationship was found between pasture DMI reduction (**PDMIr**, kg/d) and CDMI (kg/d): PDMIr = 0.26 (SE 0.54) − 0.39 (SE 0.07) CDMI ($R^2 = 0.82$). Total DMI was numerically (Arriaga-Jordan and Holmes, 1986) or significantly (Spörndly, 1991; Dillon *et al*., 1994; Robaina *et al*., 1998; Sayers, 1999; Reis and Combs, 2000b; Walker *et al*., 2001; Bargo *et al*., 2002a) increased 3.6 kg/d (SE 0.5 kg/d, range: 1.0 to 7.5 kg/d; Student's *t*-test, significantly different from zero, $P < 0.01$) or 24% compared with total DMI of pasture-only diet treatments. When corrected for the random effect of study (St-Pierre, 2001), a significant positive relationship was found between total DMI increase (**TDMIi**, kg/d) and CDMI (kg/d): TDMIi = 0.08 (SE 0.73) + 0.52 (SE 0.08) CDMI ($R^2 = 0.91$).

Type of Energy Supplementation (Starch vs. Fiber-based concentrates; Processed grain). Studies comparing starch or fiber-based concentrates for high producing dairy cows on pasture were reviewed by Bargo *et al*. (2003). Some of those were grazing studies (Meijs, 1986; Sayers, 1999; Delahoy *et al*., 2003), and others were confinement studies with cows fed fresh-cut forage (Garnsworthy, 1990; Valk *et al*., 1990; Spörndly, 1991; Schwarz *et al*., 1995). Sources of starch included corn (Schwarz *et al*., 1995; Valk *et al*., 2000; Delahoy *et al*., 2003), barley (Spörndly, 1991), cassava (Meijs, 1986), or the combination of barley, wheat, and corn (Garnsworthy, 1990; Sayers, 1999). Sources of fiber included oatfeed (Garnsworthy, 1990), and beet pulp either alone (Spörndly, 1991; Schwarz *et al*., 1995; Valk *et al*., 2000) or combined with soy hulls (Meijs, 1986; Delahoy *et al*., 2003) or citrus pulp (Sayers, 1999). Because starch sources are more commonly used to supplement dairy cows on pasture than fiber sources, results of these studies were summarized as the effect of fiber-based concentrate compared to starch-based concentrates (Bargo *et al*., 2003).

In the grazing studies, pasture and total DMI were increased 0.7 (Meijs, 1986) and 0.8 kg/d (Sayers, 1999) when fiber-based concentrates replaced starch-based concentrates for early lactation cows grazing ryegrass pastures. For late-lactation cows grazing orchardgrass, pasture and total DMI were similar with both types of concentrates (Delahoy *et al*., 2003). Confinement studies reported similar fresh-cut forage DMI (Spörndly, 1991; Schwarz *et al*., 1995; Valk *et al*., 2000) and similar (Spörndly, 1991; Schwarz *et al*., 1995) or lower (Valk *et al*., 2000) total DMI. The low number of studies do not allow for strong conclusions, but compared with starch-based concentrates, fiber-based concentrates increased pasture DMI 0.7 kg/d (range: −0.1 to 1.4 kg/d) in grazing studies, and reduced pasture DMI 0.45 kg/d (range: −0.3 to −0.7 kg/d) in confinement studies. Overall, fiber-based concentrates slightly increased pasture DMI 0.13 kg/d, with a large variation among studies (range: −0.7 to 1.4 kg/d).

The number of studies in which fiber-based concentrates replaced starch-based concentrates is too small to make strong conclusions, and half of the studies were conducted in confinement. Inconsistency in the results can also be attributed to differences in the source of starch or fiber used in the concentrate, type of pasture, and other components in the diet, all factors that may affect the rate of degradation of concentrates in the rumen. Meijs (1986) suggested that supplementing a highly degradable pasture with a starch-based concentrate might reduce ruminal pH and pasture ruminal digestion, increase retention time of feed in the rumen, and decrease pasture DMI. Replacing starch-based concentrates with fiber-based concentrates would maintain higher pH in the rumen, enhance pasture digestion, and result in higher DMI. In the studies of Meijs (1986) and Sayers (1999) both pasture (ryegrass) and starch (cassava or barley plus wheat) were highly degradable in the rumen and could explain the response in DMI with fiber-based concentrate. In the study of Spörndly (1991), the inclusion of hay in the diet may have maintained a higher pH in the rumen and therefore explain similar DMI even with highly degradable starch source such as barley. The use of a starch source with lower degradability than barley such as corn (Schwarz *et al*., 1995; Delahoy *et al*., 2003) may not be as detrimental to ruminal pH and may explain similar pasture DMI observed in those studies with cows grazing a slowly degradable pasture of orchardgrass (Delahoy *et al*., 2003).

Processing methods for grains used for dairy cows have been extensively reviewed (Theurer *et al*., 1999); however, that review focused on cows fed TMR diets in confinement. Studies evaluating the effect of processed grains such as corn or sorghum on DMI of dairy cows on pasture were reviewed by Bargo *et al*. (2003). Seven of those eight studies were grazing studies (Bargo *et al*., 1998; Pieroni *et al*., 1999; Reis and Combs, 2000a; Soriano *et al*., 2000; Alvarez *et al*., 2001; Wu *et al*., 2001; Delahoy *et al*., 2003), and one was conducted in confinement with fresh-cut forage (Reis *et al*., 2001). Results were summarized as the effect of forms of processing compared with unprocessed (dry) forms (Bargo *et al*., 2003). Forms of processing included high moisture corn (Soriano *et al*., 2000; Alvarez *et al*., 2001; Reis *et al*., 2001; Wu *et al*., 2001), steam-flaked corn with a density of 290 (Bargo *et al*., 1998) or 360 g/L (Delahoy *et al*., 2003), steamrolled corn with a density of 591 g/L (Reis and Combs, 2000a), and steam-flaked sorghum with a density of 480 g/L (Pieroni *et al*., 1999).

Four of the five studies did not report differences in pasture or total DMI when dry corn was replaced by processed corn (Reis and Combs, 2000a; Alvarez *et al*., 2001; Reis *et al*., 2001; Delahoy *et al*., 2003). For sorghum grain, however, Pieroni *et al*. (1999) reported higher pasture and total DMI with steam-flaked grain than with dry ground grain.

Rumen Undegradable Protein (RUP) Supplementation

The use of RUP sources for dairy cows has been extensively reviewed by Santos *et al*. (1998); however, that review focused on TMR fed in confinement. Supplementation with RUP might be necessary for high producing dairy cows on pasture because the basal diet of pasture has a high ruminal CP degradability (>70%), and therefore provides smaller amounts of RUP compared with cows on TMR diets. The effect of supplementation with isonitrogenous concentrates based on various sources of rumen degradable protein (RDP) or RUP on DMI of high producing dairy cows on pasture was reviewed by Bargo *et al*. (2003). All the studies were conducted with cows in early lactation (<75 DIM) supplemented with isonitrogenous concentrates that ranged from 14 to 24% CP, where RDP sources such as soybean meal (Hongerholt and Muller, 1998; McCormick *et al*., 1999, 2001a, 2001b; Schor and Gagliostro, 2001), sunflower meal (Schroeder and Gagliostro, 2000; Bargo *et al*., 2001), and urea or rapessed meal (Tesfa *et al*., 1995) were replaced by RUP sources such as animal protein blend (Hongerholt and Muller, 1998), corn gluten meal (McCormick *et al*., 1999; 2001a), expeller soybean meal (McCormick *et al*., 2001b), blood meal (McCormick *et al*., 2001a; Schor and Gagliostro, 2001), feather meal (Bargo *et al*., 2001), heat-treated rapeseed meal (Tesfa *et al*., 1995), and fish meal (Schroeder and Gagliostro, 2000).

Pasture DMI was not affected by replacing RDP sources with RUP sources in five of seven studies (Tesfa *et al*., 1995; Hongerholt and Muller, 1998; McCormick *et al*., 1999, 2001a; Bargo *et al*., 2001). McCormick *et al*. (2001b) reported a 0.8 kg/d lower pasture DMI with cows fed annual ryegrass in confinement when supplemented with a high RUP concentrate. In contrast, Schor and Gagliostro (2001) found that replacing RDP by RUP sources in the concentrate resulted in higher DMI for cows grazing a perennial ryegrass/red clover pasture.

Forage Supplementation (Corn silage and Hay)

The effect of corn silage supplementation on animal performance of high producing cows on pasture was reviewed by Bargo *et al*. (2003). In one of the studies (Stockdale, 1994), cows were supplemented only with corn silage; while in the other studies, cows were supplemented with corn silage plus low (3.2 kg/d; Valk, 1994) or high (8.7 kg/d; Holden *et al*., 1995) amounts of concentrates. Two of those studies were grazing studies (Stockdale, 1994; Holden *et al*., 1995), and one study was in confinement (Valk, 1994).

Response to corn silage supplementation depends on the amount of pasture offered, which determines the SR and total DMI (Phillips, 1988). Corn silage supplementation had positive effects on production when the amount of pasture offered was low (Stockdale, 1994). When PA was high, the supplementation with 2.3 kg DM/d of corn silage reduced pasture DMI and resulted in a similar total DMI (Holden *et al*., 1995). Valk (1994) conducted two experiments in confinement with high producing dairy cows fed fresh-cut forage and supplemented with corn silage at different times of the day or mixed with the pasture. Corn silage fed at night did not increase total DMI compared with diets containing only fresh-cut forage (Valk, 1994). However, when corn silage was mixed with the fresh-cut forage, total DMI increased (Valk, 1994).

Studies on hay supplementation to high producing dairy cows on pasture were reviewed by Bargo *et al*. (2003). Four of those were conducted with cows in early lactation supplemented also with high (> 8 kg DM/d; Rearte *et al*., 1986a, 1986b; Reis and Combs, 2000) or low (< 8 kg DM/d, Wales *et al*., 2001) amounts of concentrate, and only one (Stockdale, 1999b) with cows receiving hay as the only supplement. Hay was supplemented in different forms including long hay (Rearte *et al*., 1986a; Reis and Combs, 2000a), chopped hay added to the concentrate (Rearte *et al*., 1986a), or pellets and cubes of hay (Wales *et al*., 2001). Amount of hay supplemented varied from 0.9 (Rearte *et al*., 1986a) to 3.9 kg DM/d (Stockdale, 1999b). Different forms and amounts of hay supplementation reduced pasture DMI, with an overall reduction averaging 3.5 kg/d (range: 0.8 to 5.6 kg/d).

The effect on total DMI depended on the SR. In the study of Reis and Combs (2000a), hay supplementation resulted in a SR from 0.81 to 0.97 kg pasture/kg hay, which resulted in similar total DMI. In contrast, in the study of Stockdale (1999b), hay supplementation determined a SR of 0.33 kg pasture/kg hay and increased total DMI. Rearte *et al*. (1986b) reported no effect of hay supplementation on pasture or total DMI. Hay supplemented in a pellet or a cube form, either alone or added to the concentrate, decreased pasture DMI compared with a pasture-only diet treatment (Wales *et al*., 2001).

Fat Supplementation

Research on the effect of fat supplementation on DMI of high producing dairy cows on pasture was reviewed by Bargo *et al*. (2003). Some of the studies supplemented cows with concentrates with fat sources that partially replaced some of the concentrate ingredients (Garnsworthy, 1990; Gallardo *et al*., 2001) or were added to a basal amount of concentrate (King *et al*., 1990; Agenäs *et al*., 2002; Schroeder *et al*., 2002). Sources of fat included ruminally inert sources such as hydrogenated fish fat (Gallardo *et al*., 2001), Ca-salts of long-chain fatty acids (Garnsworthy, 1990), high melting point fatty acids (King *et al*., 1990; Schroeder *et al*., 2002); or non-ruminally inert sources such as full fat rapeseed (Murphy *et al*., 1995), and soybean oil (Agenäs *et al*., 2002). The amount of fat supplemented ranged from 200 (Gallardo *et al*., 2001) to 1000 g/d (Schroeder *et al*., 2002).

Only three studies (Gallardo *et al*., 2001; King *et al*., 1990; Schroeder *et al*., 2002) measured pasture DMI. Two of the studies reported no differences in DMI when fat partially replaced concentrate ingredients (Gallardo *et al*., 2001) or was added to the basal amount of concentrate (King *et al*., 1990). Schroeder *et al*. (2002) reported a linear reduction in pasture DMI as the amount of fat added to the basal concentrate increased from 0 to 1 kg/d. The large amount of fat supplementation may have affected physiological mechanisms of intake regulation (Schroeder *et al*., 2002). Total DMI was not affected by fat supplementation in any of the studies because fat supplement either did not reduce pasture DMI when partially replaced concentrate ingredients (Gallardo *et al*., 2001), or reduced pasture DMI when added over a basal amount of concentrate (King *et al*., 1990; Schroeder *et al*., 2002). Overall, fat supplementation did not affect total DMI (−0.3 kg/d, SE 1.3 kg/d, range: −0.8 to 10.6 kg/d; Student's *t*-test, significantly different from zero, P = 0.83) compared with the no-fat treatments. However, caution should be used in this conclusion because of the low number of studies with cows producing less than 30 kg/d.

Conclusions

Total DMI of dairy cows on pasture-only diets is lower than total DMI of dairy cows consuming TMR or pasture plus supplements, indicating that high producing cows on pasture-based diets need to be supplemented to achieve their genetic potential for DMI. Substitution rate, or the reduction in pasture DMI per kilogram of supplement, is a major factor explaining the variation seen in MR to supplementation. There is a negative relationship between SR and MR; i.e., when SR is large (small increase in total DMI), the MR is low. Compared with pasture-only diets, increasing the amount of concentrate supplementation increased total DMI 24%.

References

Agenäs, S., K. Holtenious, M. Griinari, and E. Burstedt. 2002. Effects of turnout to pasture and dietary fat supplementation on milk fat composition and conjugated linoleic acid in dairy cows. Acta Agric. Scand., Sect. A, Anim. Sci. 52:25–33.

Alvarez, H. J., F. J. Santini, D. H. Rearte, and J. C. Elizalde. 2001. Milk production and ruminal digestion in lactating dairy cows grazing temperate pastures and supplemented with dry cracked corn or high moisture corn. Anim. Feed Sci. Technol. 91:183–195.

Arriaga-Jordan, C. M., and W. Holmes. 1986. The effect of concentrate supplementation on high yielding dairy cows under two systems of grazing. J. Agric. Sci. (Camb.) 107:453–461.


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Bao, J., P. S. Giller, and J. J. Kett. 1992. The effect of milk production level on grazing behaviour of Friesian cows under variable pasture conditions. Irish J. Agric. Food Res. 31:23–33.

Bargo, F., G. A. Pieroni, and D.H. Rearte. 1998. Milk production and ruminal fermentation of grazing dairy cows supplemented with dry-ground corn or steam-flaked corn. J. Dairy Sci. 81(Suppl. 1):250.

Bargo, F., D. H. Rearte, F. J. Santini, and L. D. Muller. 2001. Ruminal digestion by dairy cows grazing winter oats pasture supplemented with different levels and sources of protein. J. Dairy Sci. 84:2260–2272.

Bargo, F., L. D. Muller, J. E. Delahoy, and T. W. Cassidy. 2002a. Milk response to concentrate supplementation of high producing dairy cows grazing at two pasture allowances. J. Dairy Sci. 85:1777–1792.

Bargo, F., L. D. Muller, J. E. Delahoy, and T. W. Cassidy. 2000b. Performance of high producing dairy cows with three different feeding systems combining pasture and total mixed rations. J. Dairy Sci. 85:2948–2963.

Bargo, F., L. D. Muller, E. S. Kolver, and J. E. Delahoy. 2003. Invited Review: Production and digestion of supplemented dairy cows on pasture. J. Dairy Sci. 86:1–42.

Beever, D. E., and C. L. Thorp. 1997. Supplementation of forage diets. Page 419 in Milk Composition, Production and Biotechnology. R. A. S. Welch, D. J. W. Burns, S. R. Davis, A. I. Popay, and C. G. Prosser, eds. CAB International, Oxon, UK.

Caird, L., and W. Holmes. 1986. The prediction of voluntary intake of grazing dairy cows. J. Agric. Sci. (Camb.) 107:43–54.

Champion, R. A., S. M. Rutter, and R. Delagarde. 1998. Recent developments with the IGER Behaviour Recorder. Pg 31 in Techniques for Investigating Intake and Ingestive Behaviour by Farm Animals. M. J. Gibb, ed. Proc. IXth European Intake Workshop. IGER, North Wyke, UK.

Dalley, D. E., J. R. Roche, C. Grainger, and P. J. Moate. 1999. Dry matter intake, nutrient selection and milk production of dairy cows grazing rain fed perennial pastures at different herbage allowances in spring. Aust. J. Exp. Agric. 39:923–931.

Dalley, D. E., J. R. Roche, P. J. Moate, and C. Grainger. 2001. More frequent allocation of herbage does not improve the milk production of dairy cows in early lactation. Aust. J. Exp. Agric. 41:593–599.

Delaby, L., J. L. Peyraud, and R. Delagarde. 2001. Effect of the level of concentrate supplementation, herbage allowance and milk yield at turn-out on the performance of dairy cows in mid lactation at grazing. Anim. Sci. 73:171–181.

Delagarde, R., J. L. Peyraud, and L. Delaby. 1997. The effect of nitrogen fertilization level and protein supplementation on herbage intake, feeding behaviour and digestion in grazing dairy cows. Anim. Feed Sci. Technol. 66:165–180.

Delahoy, J. E., L. D. Muller, F. Bargo, T. W. Cassidy, and L. A. Holden. 2003. Supplemental carbohydrates sources for lactating dairy cows on pasture. J. Dairy Sci. 86: 906-915.

Dillon, P., S. Crosse, and B. O'Brien. 1997. Effect of concentrate supplementation of grazing dairy cows in early lactation on milk production and milk processing quality. Irish J. Agric. Food Res. 36:145–159.

Dixon, R. M., and C. R. Stockdale. 1999. Associative effects between forages and grains: consequences for feed utilization. Aust. J. Agric. Res. 50:757–773.

Dove, H., and R. W. Mayes. 1991. The use of plant wax alkanes as marker substances in studies of the nutrition of herbivores: a review. Aust. J. Agric. Res. 42:913–952.

Dove, H., and R. W. Mayes. 1996. Plant wax components: a new approach to estimating intake and diet composition in herbivores. J. Nutr. 126:13–26.

Doyle, P. T., C. R. Stockdale, and A. R. Lawson. 1996. Pastures for dairy production in Victoria. Agriculture Victoria, Australia.

Forbes, J. M. 1995. Voluntary food intake and diet selection in farm animals. CAB International, Oxon, UK.

Forbes, T. D. A. 1988. Researching the plant-animal interface: The investigation of ingestive behavior in grazing animals. J. Anim. Sci. 66:2369–2379.

Gallardo, M. R., S. E. Valtorta, P. E. Leva, H. C. Castro, and J. A. Maiztegui. 2001. Hydrogenated fish fat for grazing dairy cows in summer. Int. J. Biometeorol. 45:111–114.

Garnsworthy, P. C. 1990. Feeding calcium salts of fatty acids in high-starch or high-fibre compound supplements to lactating cows at grass. Anim. Prod. 51:441–447.

Gibb, M. J., C. A. Huckle, R. Nuthall, and A. J. Rook. 1997. Effect of sward surface height on intake and grazing behaviour by lactating Holstein Friesian cows. Grass Forage Sci. 52:309–321.

Gibb, M. J., C. A. Huckle, and R. Nuthall. 2002. Effects of level of concentrate supplementation on grazing behaviour and performance by lactating dairy cows grazing continuously stocked grass swards. Anim. Sci. 74:319–335.

Grainger, C., and G. L. Mathews. 1989. Positive relation between substitution rate and pasture allowance for cows receiving concentrates. Aust. J. Exp. Agric. 29:355–360.

Hodgson, J. and I. M. Brookes. 1999. Nutrition of grazing animals. Page 117 in Pasture and Crop Science. J. White, and J. Hodgson, eds. Oxford University Press, Auckland, N.Z.

Holden, L. A., L. D. Muller, G. A. Varga, and P. J. Hillard. 1994. Ruminal digestion and duodenal nutrient flows in dairy cows consuming grass as pasture, hay, or silage. J. Dairy Sci. 77:3034–3042.

Holden, L. A., L. D. Muller, T. Lykos, and T. W. Cassidy. 1995. Effect of corn silage supplementation on intake and milk production in cows grazing grass pasture. J. Dairy Sci. 78:154–160.

Hongerholt, D. D., and L. D. Muller. 1998. Supplementation of rumenundegradable protein to the diets of early lactation Holstein cows grazing grass pasture. J. Dairy Sci. 81:2204–2214.

Kellaway, R., and S. Porta. 1993. Feeding concentrates supplements for dairy cows. Dairy Research and Development Corporation, Melbourne, Australia.

Kibon, A., and W. Holmes. 1987. The effect of height of pasture and concentrate composition on dairy cows grazed on continuously stocked pastures. J. Agric. Sci. (Camb.) 109:293–301.

King, K. R., C. R. Stockdale, and T. E. Trigg. 1990. Influence of high energy supplements containing fatty acids on the productivity of pasture-fed dairy cows. Aust. J. Exp. Agric. 30:11–16.

Kolver, E. S., and L. D. Muller. 1998. Performance and nutrient intake of high producing Holstein cows consuming pasture or a total mixed ration. J. Dairy Sci. 81:1403–1411.

Le Du, Y. L. P., and P. D. Penning. 1982. Animal based techniques for estimating herbage intake. Page 37 in Herbage Intake Handbook. J. D. Leaver, ed. Br. Grassl. Soc., Hurley, UK.

Leaver, J. D. 1982. Herbage Intake Handbook. British Grassland Society, Hurley, UK.

Leaver, J. D. 1985. Milk production from grazed temperate grassland. J. Dairy Res. 52:313–344.

Mannetje, L. and R. M. Jones. 2000. Field and laboratory methods for grassland and animal production. CABI Publishing, Oxon, UK.

Mayne, C. S., and I. A. Wright. 1988. Herbage intake and utilization by the grazing dairy cow. Page 280 in Nutrition and Lactation in the Dairy Cow. P. C. Garnsworthy, ed. Butterworths, London.

McCormick, M. E., D. D. French, T. F. Brown, G. J. Cuomo, A. M. Chapa, J. M. Fernandez, J. F. Beatty, and D. C. Blouin. 1999.

Crude protein and rumen undegradable protein effects on reproduction and lactation performance of Holstein cows. J. Dairy Sci. 82:2697–2708.

McCormick, M. E., J. D. Ward, D. D. Redfearn, D. D. French, D. C. Blouin, A. M. Chapa, and J. M. Fernandez. 2001a. Supplemental dietary protein for grazing dairy cows: effect on pasture intake and lactation performance. J. Dairy Sci. 84:896–907.

McCormick, M. E., D. D. Redfearn, J. D. Ward, and D. C. Blouin. 2001b. Effect of protein source and soluble carbohydrate addition on rumen fermentation and lactation performance of Holstein cows. J. Dairy Sci. 84:1686–1697.

McGilloway, D. A., and C. S. Mayne. 1996. The importance of grass availability for the high genetic merit dairy cow. Page 135 in Recent Advances in Animal Nutrition. P. C. Garnsworthy, J. Wiseman, and W. Haresign, eds. Nottingham University Press, UK.

McGilloway, A. Cushnahan, A. S. Laidlaw, C. S. Mayne, and D. J. Kilpatrick. 1999. The relationship between level of sward height reduction in a rotationally grazed sward and short-term intake rates of dairy cows. Grass Forage Sci. 54:116–126.

Meijs, J. A. C., R. J. K. Walters, and A. Keen. 1982. Sward methods. Page 11 in Herbage Intake Handbook. J. D. Leaver, ed. Br. Grassl. Soc., Hurley, UK.

Meijs, J. A. C. 1986. Concentrate supplementation of grazing dairy cows. 2. Effect of concentrate composition on herbage intake and milk production. Grass Forage Sci. 41:229–235.

Meijs, J. A. C., and J. A. Hoekstra. 1984. Concentrate supplementation of grazing dairy cows. 1. Effect of concentrate intake and herbage allowance on herbage intake. Grass Forage Sci. 39:59–66.

Murphy, J. J., J. F. Connolly, and G. P. McNeill. 1995. Effects on cow performance and milk fat composition of feeding full fat soybeans and rapeseeds to dairy cows at pasture. Livest. Prod. Sci. 44:13–25.

National Research Council. 2001. Nutrient Requirements of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, DC.

Peyraud, J. L. 1998. Techniques for measuring faecal flow, digestibility and intake of herbage in grazing ruminants. Page 39 in Techniques for Investigating Intake and Ingestive Behaviour by Farm Animals. IXth European Intake Workshop. IGER, North Wyke, UK.

Peyraud, J. L., and L. Delaby. 2001. Ideal concentrate feeds for grazing dairy cows responses to supplementation in interaction with grazing management and grass quality. Page 203 in Recent Advances in Animal Nutrition. P. C. Garnsworthy and J. Wiseman, eds. Notthingham University Press, UK.

Peyraud, J. L., E. A. Comero´n, M. H. Wade and G. Lemaire. 1996. The effect of daily herbage allowance, herbage mass and animal factors upon herbage intake by grazing dairy cows. Ann. Zootech. 45:201–217.

Peyraud, J. L., L. Astigarraga, and P. Faverdin. 1997. Digestion of fresh perennial ryegrass fertilized at two levels of nitrogen by lactating dairy cows. Anim. Feed Sci. Technol. 64:155–171.

Phillips, C. J. C. 1988. The use of conserved forage as supplement for grazing dairy cows. Grass Forage Sci. 43:215–230.

Phillips, C. J. C. 1993. Nutritional behaviour. Page 75 in Cattle Behaviour. C. J. C. Phillips, ed. Farming Press., UK.

Pieroni, G. A., F. Bargo, and D.H. Rearte. 1999. Dry-ground or steam flaked sorghum supplementation to lactating dairy cows grazing pasture. J. Dairy Sci. 82(Suppl. 1):44.

Poppi, D. P., T. P. Hughes, and P. J. L'Huillier. 1987. Intake of pasture by grazing ruminants. Page 55 in Livestock Feeding on Pasture. NZ Soc. Anim. Prod. Occ. Pub. No. 10. Ruakura Agric. Center, Hamilton, NZ.

Pulido, R. G., and J. D. Leaver. 2001. Quantifying the influence of sward height, concentrate level and initial milk yield on the milk production and grazing behaviour of continuously stocked dairy cows. Grass Forage Sci. 56:57–67.

Rearte, D. H., E. M. Kesler, and G. L. Hargrove. 1986a. Forage growth and performance of grazing dairy cows supplemented with concentrate and chopped or long hay. J. Dairy Sci. 69:1048–1054.

Rearte, D. H., E. M. Kesler, and G. L. Hargrove. 1986b. Response by dairy cows to hay supplement with early spring grazing or to delay in turning to pasture. J. Dairy Sci. 69:1366–1373.

Reis, R. B., and D. K. Combs. 2000a. Effects of corn processing and supplemental hay on rumen environment and lactation performance of dairy cows grazing grass-legume pasture. J. Dairy Sci. 83:2529–2538.

Reis, R. B., and D. K. Combs. 2000b. Effects of increasing levels of grain supplementation on rumen environment and lactation performance of dairy cows grazing grass-legume pasture. J. Dairy Sci. 83:2888–2898.

Reis, R. B., F. San Emeterio, D. K. Combs, L. D. Satter, and H. N. Costa. 2001. Effects of corn particle size and source on performance of lactating cows fed direct-cut grass-legume forage. J. Dairy Sci. 84:429–441.

Robaina, A. C., C. Grainger, P. Moate, J. Taylor, and J. Stewart. 1998. Responses to grain feeding by grazing dairy cows. Aust. J. Exp. Agric. 38:541–549.

Rook, A. J. 2000. Principles of foraging and grazing behaviour. Page 229 in Grass: Its Production and Utilization. A. Hopkins, ed. Blackwell Science, Boston, MA.

Rook, A. J., C. A. Huckle, and P. D. Penning. 1994. Effects of sward height and concentrate supplementation on the ingestive behaviour of spring-calving dairy cows grazing grass-clover swards. Appl. Anim. Behav. Sci. 40:101–112.

Rutter, S. M., R. A. Champion, and P. D. Penning. 1997. An automatic system to record foraging behaviour in free-ranging ruminants. Appl. Anim. Behav. Sci. 54:185–195.

Santos, F. A. P., J. E. P. Santos, C. B. Theurer, and J. T. Huber. 1998. Effects of rumen-undegradable protein on dairy cow performance: A 12-year literature review. J. Dairy Sci. 81:3182–3213.

SAS User's Guide: Statistics, Version 8.01 Edition. 1999. SAS Inst., Inc. Cary, NC.

Sayers, H. J. 1999. The effect of sward characteristics and level and type of supplement on grazing behaviour, herbage intake and performance of lactating dairy cows. Ph.D. Thesis. Queen's University of Belfast. The Agricultural Research Institute of Northern Ireland. Hillsborough.

Schor, A., and G. A. Gagliostro. 2001. Undegradable protein supplementation to early-lactation dairy cows in grazing conditions. J. Dairy Sci. 84:1597–1606.

Schwarz, F. J., J. Haffner, and M. Kirchgessner. 1995. Supplementation of zero-grazed dairy cows with molassed sugar beet pulp, maize or a cereal-rich concentrate. Anim. Feed Sci. Technol. 54: 247–258.

Schroeder, G. F., and G. A. Gagliostro. 2000. Fishmeal supplementation to grazing dairy cows in early lactation. J. Dairy Sci. 83:2899–2906.

Schroeder, G. F., G. A. Gagliostro, D. Becu-Villalobos, and I. Lacau-Mengido. 2002. Supplementation with partially hydrogenated oil in grazing dairy cows in early lactation. J. Dairy Sci. 85:580–594.

Soriano, F. D., C. E. Polan, and C. N. Miller. 2000. Milk production and composition, rumen fermentation parameters, and grazing behavior of dairy cows supplemented with different forms and amounts of corn grain. J. Dairy Sci. 83:1520–1529.

Spörndly, E. 1991. Supplementation of dairy cows offered freshly cut herbage ad libitum with starchy concentrates based on barley or fibrous concentrates based on unmolassed sugar beet pulp and wheat bran. Swedish J. Agric. Res. 21:131–139.

St-Pierre, N. R. 2001. Integrating quantitative findings from multiple studies using mixed model methodology. J. Dairy Sci. 84:741–755.

Stakelum, G. 1986a. Herbage intake of grazing dairy cows. 1. Effect of autumn supplementation with concentrates and herbage allowance on herbage intake. Irish J. Agric. Res. 25:31–40.

Stakelum, G. 1986b. Herbage intake of grazing dairy cows. 3. Effect of herbage mass, herbage allowance and concentrate feeding on the herbage intake of dairy cows grazing on mid-summer pasture. Irish J. Agric. Res. 25:179–189.

Stockdale, C. R. 1985. Influence of some sward characteristics on the consumption of irrigated pastures grazed by lactating dairy cows. Grass Forage Sci. 40:31–39.

Stockdale, C. R. 1994. Persian clover and maize silage. I. Silage as a supplement for lactating dairy cows offered herbage of different quality. Aust. J. Agric. Res. 45:1751–1765.

Stockdale, C. R. 1999a. The nutritive characteristics of herbage consumed by grazing dairy cows affect milk yield responses obtained from concentrate supplementation. Aust. J. Exp. Agric. 39: 379–387.

Stockdale, C. R. 2000a. Differences in body condition and body size affect the responses of grazing dairy cows to high-energy supplements in early lactation. Aust. J. Exp. Agric. 40:903–911.

Stockdale, C. R. 2000b. Levels of pasture substitution when concentrates are fed to grazing dairy cows in northern Victoria. Aust. J. Exp. Agric. 40:913–921.

Stockdale, C. R., and T. E. Trigg. 1985. Effects of pasture allowance and level of concentrate feeding on the productivity of dairy cows in late lactation. Aust. J. Exp. Agric. 25:739–744.

Stockdale, C. R., A. Callaghan, and T. E. Trigg. 1987. Feeding high energy supplements to pasture-fed dairy cows. Effects of stage of lactation and level of supplement. Aust. J. Exp. Agric. 38:927–940.

Tesfa, A. T., P. Virkajarvi, M. Tuoril, and L. Syrjala-Qvist. 1995. Effects of supplementary concentrate composition on milk yield, milk composition and pasture utilization of rotationally grazed dairy cows. Anim. Feed Sci. Technol. 56:143–154.

Theurer, C. B., J. T. Huber, A. Delgado-Elorduy, and R. Wanderley. 1999. Summary of steam-flaking corn or sorghum grain for lactating dairy cows. J. Dairy Sci. 82:1950–1959.

Valk, H. 1994. Effects of partial replacement of herbage by maize silage on N-utilization and milk production of dairy cows. Livest. Prod. Sci. 40: 241–250.

Vazquez, O. P., and T. R. Smith. 2000. Factors affecting pasture intake and total dry matter intake in grazing dairy cows. J. Dairy Sci. 83:2301–2309.

Valk, H., H. W. Klein Poelhuis, and H. J. Wentink. 1990. Effect of fibrous and starchy carbohydrates in concentrates as supplements in herbage-based diet for high yielding dairy cows. Neth. J. Agric. Sci. 38:475–486.

Wade, M. H., J. L. Peyroud, G. Lemaire, and E. A. Comeron. 1989. The dynamics of daily area and depth of grazing and herbage intake of cows in a five-day paddock system. Page 1111 in Proc. 16th Int. Grassland Congress, Nice, France.

Wales, W. J., P. T. Doyle, C. R. Stockdale, and D. W. Dellow. 1999. Effects of variations in herbage mass, allowance, and level of supplement on nutrient intake and milk production of dairy cows in spring and summer. Aust. J. Exp. Agric. 39:119–130.

Wales, W. J., Y. J. Williams, and P. T. Doyle. 2001. Effect of grain supplementation and the provision of chemical or physical fibre on marginal milk production responses of cows grazing perennial ryegrass pastures. Aust. J. Exp. Agric. 41:465–471.

Walker, G. P., C. R. Stockdale, W. J. Wales, P. T. Doyle, and D. W. Dellow. 2001. Effect of level of grain supplementation on milk production responses of dairy cows in mid-late lactation when grazing irrigated pastures high in paspalum (*Paspalum dilatatum* Poir.). Aust. J. Exp. Agric. 41:1–11.

Wu, Z., L. J. Massingill, R. P. Walgenbach, and L. D. Satter. 2001. Cracked dry or finely ground high moisture shelled corn as a supplement for grazing cows. J. Dairy Sci. 84:2227–2230.

STRATEGIES TO MAXIMISE INTAKE PER HA IN A PASTURE BASED SYSTEM

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Abstract

The Australian dairy industry demands systems able to produce more milk/ha from pasture. Current levels of pasture intake/ha are well below potential and appear as the greatest limitation to attain further improvements in milk production from pasture. A whole farm study conducted by Future Dairy showed that pasture intake/ha is determined by the pasture management rules applied, regardless from the stocking rate or mil yield/cow of the farm system. A further whole farm study evaluated the feasibility of a system including a triple forage crop rotation as an option to increase milk/ha from home grown feed beyond optimum levels of pasture intake/ha.

Background

A volatile international market for milk and grain prices is driving the Australian dairy industry to produce milk at low cost in order to stay competitive. Since pasture is still the cheapest source of feed, increasing the production of milk from pasture becomes the logic pathway to achieve this. Following this rationale, most dairy farmers in the past have attained productivity gains by expanding the size of their pasture based farm operating areas (Malcolm and Sinnett, 2007, ABARE, 2008). But today, with increasing prices of most of the land suitable for dairying, that option is increasingly limited or inexistent. In this context, there will be a greater need to increase output of milk per unit of land. In other words, the industry will increasingly need to focus on producing more milk/ha from pasture.

The amount of milk produced from pasture on a particular farm system is, from a simplistic point of view, the product of the total amount of pasture intake/ha (kg DM/ha/year) and its Feed Conversion Efficiency (FCE: L milk/kg DM). Then, improving either of these factors will lead to a higher amount of milk/ha from pasture. In the past, researchers have focused on the improvement of those two aspects. In this way it is possible to establish, for both parameters, the gap between the industry average and the potential target to be reached (represented by the results obtained at the research farms). In theory, there is room for improvement in FCE from 1.01 to 1.43 L/Kg DM (Kolver 2007) and in pasture intake/ha from ~7,000 to ~17,000 kg DM/ha/year (Garcia and Fulkerson, 2005). As a result, whereas the improvement in FCE could cause a potential increase in milk/ha of 40%, the improvement in pasture intake/ha has a potential to increase milk/ha by 140% compared to current industry level (Fig 1). Therefore it is clear that, if the objective is to produce more milk from pasture, there is a larger potential to be exploited from increasing pasture intake/ha.

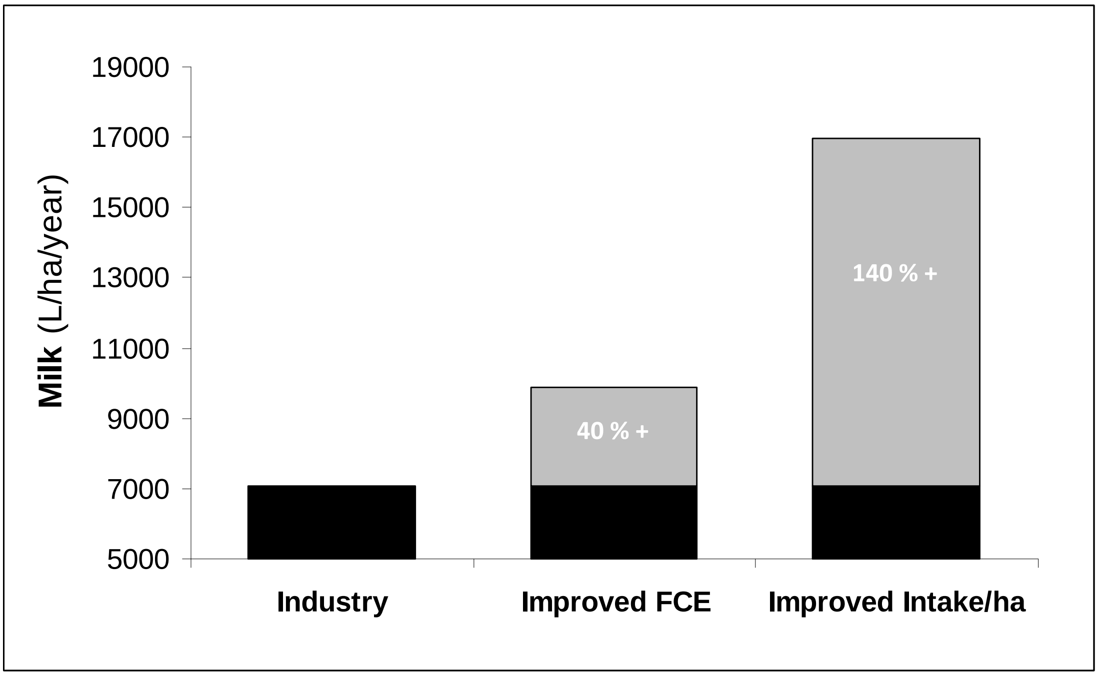

Figure 1 : Potential increase in milk production from pasture through the improvement of Feed Conversion Efficiency (FCE) or pasture intake/ha.

How feasible it is to reach this potential and which are the strategies to achieve this is something that has not been fully evaluated yet. Since there are hundreds of variables and interactions at play when one litre of milk is produced on a commercial dairy farm, whole farm studies become particularly necessary to test such concepts.

The objective of this paper is to evaluate different strategies that can be used to achieve more milk per hectare from pasture (or other sources of home grown feed). Results from whole farm studies conducted as part of the Future Dairy Project will be summarised for that purpose.

MORE MILK FROM PASTURE

To produce more milk/ha there are two logic pathways to follow: increase stocking rate (SR) or increase milk yield/cow (MY). Extensive work on pasture based systems has been done to assess these alternatives separately with diverse results. In summary, higher stocking rates have always been related to improvements in pasture utilisation but not without a negative impact on individual cow's performance (King and Stockdale, 1980, Holmes and Parker, 1992, Macdonald *et al*., 2008). In contrast, systems aiming at higher milk yield per cow have normally been associated with lower levels of pasture utilisation, but also with better reproductive performance and feed conversion efficiency (Beever and Doyle, 2007). However, none of the previous studies have compared the two strategies at the farm system level.

The farmlet study

A farmlet study was conducted at Elizabeth Macarthur Agricultural Institute, NSW DPI, Camden, from 2006 to 2008 evaluating the effect of a 50% increase in either SR or MY, or in both at the same time. The farmlets were set at 2 stocking rates (2.5 and 3.8 cows/ha) and 2 targets of milk per cow (6,000 and 9,000 L/cow/lactation). Each farmlet consisted of 30 cows grazing an area of either 6.5 or 9 ha (subdivided in ~10 paddocks each), for the high or low SR treatments, respectively. Those cows were fed either 19 or 23 kg DM/day for the low or high target of milk per cow, and Crude Protein (CP) and Metabolisable Energy (ME) of the ration for each group was formulated accordingly.

Results

After 2 years of study, the farmlet with a higher SR achieved 49% more milk/ha/year than the Control, while the farmlet fed to achieve a higher MY only produced 10% more than the Control. The combination of both strategies (farmlet High-High) led to an increase in milk/ha/year of 66% (Table 1).

Table1: Farmlets milk and milksolids production.

	unit	**Control**	**High SR**	**High MY**	**High-High**
Per ha	L Milk/year	20,895	31,143	22,975	34,583
	Kg. Milksolids/year	1,568	2,282	1,663	2,443
Per cow	L Milk/lactation (305 days)	6,991	6,895	7,759	7,501
	Kg.Milksolids/lactation (305 days)	526	506	571	522

In relation to this, cows fed to achieve a higher MY (farmlets High MY and High-High) failed to reach their target (Table 1). This was explained, in first place, by the ME content of the feed consumed, which was directly associated with the proportion of pasture in the diet. Such pasture was based on kikuyu (summer production), oversown with short rotation ryegrass in the autumn. The levels of ME (Fig. 3) declined drastically during summer, limiting milk response, whereas NDF% increased significantly during the same period, causing a reduction on dry matter intake (kg DM/cow/day) which, in turn, also affected milk production.

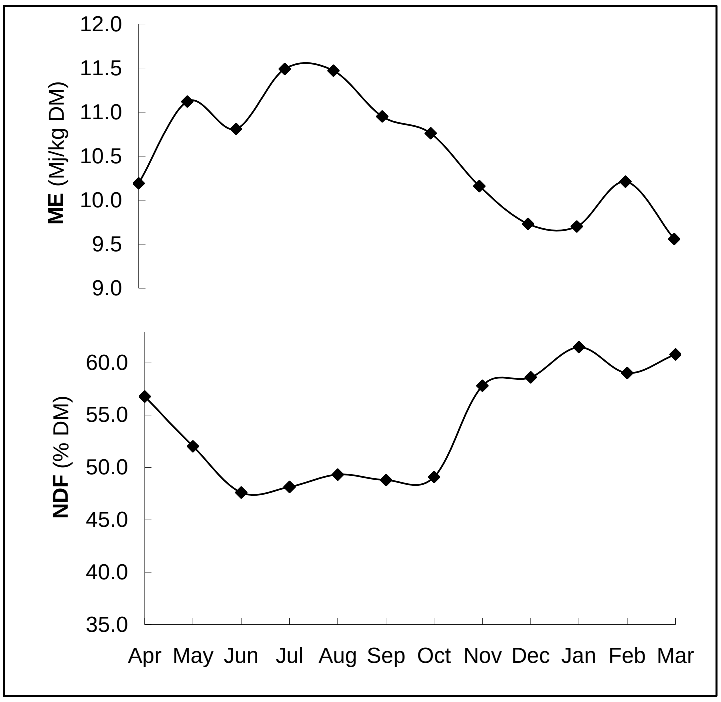

Fig. 3 –Metabolisable energy (ME; line above) and Neutral Detergent Fiber (NDF; line below) of pasture utilised average of all farmlets.

Interestingly, the farmlets where cows were fed to achieve a higher target of MY had a higher average of Body Condition Score (BCS) and Live Weight (LW) (data not shown). This suggests that in these farmlets, some proportion of the energy from the extra feed was used for the deposition of tissue instead of milk production. Reproductive performance was similar among all farmlets.

Pasture utilisation

Despite the contrasting characteristics of the four systems, the amount of pasture utilised/ha/year and its average nutritive value (Table 2) were similar for all of them.

Table 2: Total utilised pasture per year (grazed and conserved), and nutritive value for each farmlet.

		unit	**Control**	**High SR**	**High MY**	**High-High**
Utilisation	Grazed	(kg DM/ha)	9,754	11,005	9,458	10,655
	Conserved	(kg DM/ha)	1,321	99	1,730	561
	Total utilised	(kg DM/ha)	11,075	11,104	11,187	11,215
Nutritive Value	Metabolisable Energy	(Mj/kg DM)	10.5	10.6	10.4	10.5
	Crude Protein	(% DM)	25.4	25.9	25.4	25.6
	Neutral Detergent Fibre	(% DM)	54.0	55.0	54.4	53.1
	Acid Detergent Fibre	(% DM)	24.6	24.0	25.4	24.8

Furthermore, the four systems maintained similar levels of pre and post grazing pasture mass residuals throughout the year (Fig. 4).

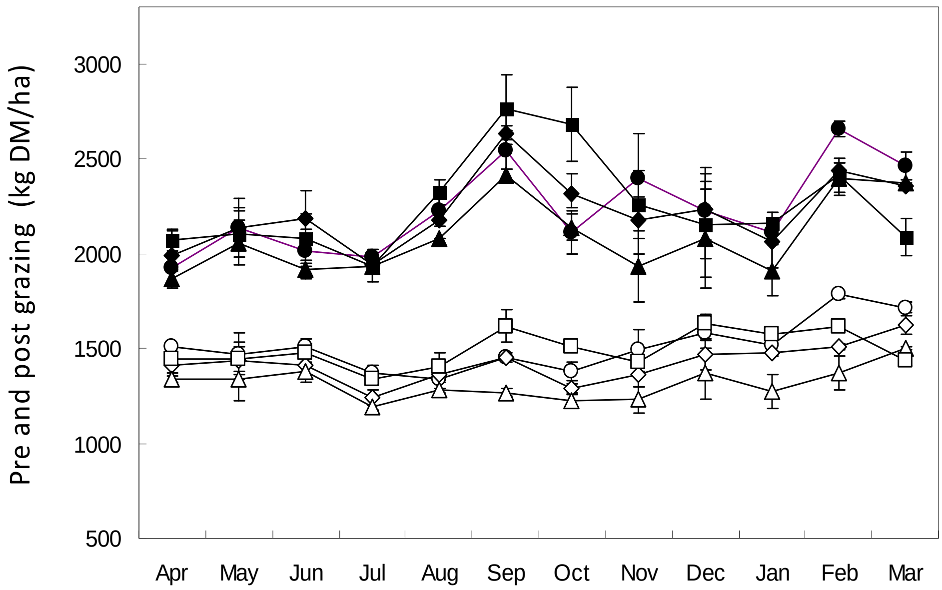

Fig 4: Pre (solid symbols) and post (open symbols) grazing residuals of pasture for the farmlets Control (◆ ;◇), High SR(▲;Δ), High MY(■;□) and High-High (●;○).

This similarity across farmlets was a direct consequence of the application of a set of rules based on two basic concepts:

1. Adjust rate of pasture consumption (Kg/ha/day) to pasture growth rate (Kg/ha/day).
2. Maintain a set target for pre and post-grazing pasture residuals (pre ~ 2400 and post ~1400 kg DM/ha in this case).

To implement these rules the pasture cover of the whole farm was monitored weekly and pasture growth rate was estimated from the difference in biomass between 2 consecutive weeks. Then intake of pasture/cow was set for the given week accordingly. Supplements were used to achieve target consumption (23 or 19 kgDM/cow/day for farmlets with high or low MY, respectively). If growth rate was exceeding cows maximum intake for a particular farmlet (typically during spring), a proportion of the area of the farmlet was cut and conserved as silage. Using this pasture management concepts it was possible to achieve a close match between pasture growth rate and pasture consumption rate in all farmlets (Figure 5).

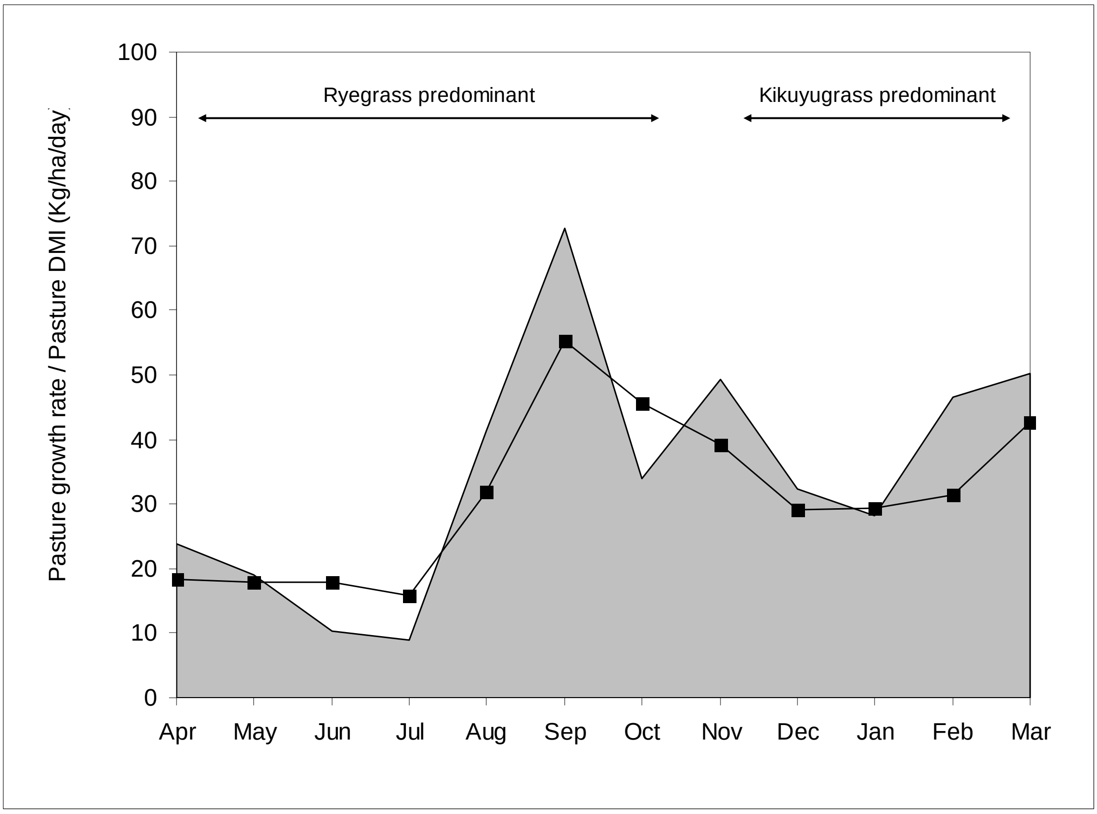

Fig. 5: Pasture growth rate (area) and pasture Dry Matter Intake (DMI; single line) per hectare per day average of the four farmlets.

Key outcomes

- The total pasture intake/ha is determined by the pasture management rules applied, not by the SR or target of MY chosen for the farm system.
- On a kikuyu based system, it is more effective to increase milk/ha through increased SR than MY.

HOW FAR CAN WE GO WITH PASTURE?

The total pasture utilised/ha in the farmlet study described above (~11 t DM/ha) did not reach its optimum due to water restrictions during summer. Besides this, Garcia *et al*. (2008) working under full irrigation in similar paddocks at the same experimental farm obtained more than 17 t DM/ha applying the same management rules. Considering that the latter is near the optimum of utilised pasture yield to be achieved, the next question was: Is there any further option if we wanted to keep increasing intake/ha of home grown feed?

MORE MILK FROM HOME GROWN FEED BEYOND PASTURE

Forage crops can be considered an option to complement pasture, both in quantity and quality, throughout the year. In this way the concept of Complementary Forages Rotation (CFR) was introduced as an option to be implemented on pasture based systems. The CFR comprises the use of three forage crops/year (maize for silage, followed by forage rape and a legume for graze) on the same area of land to produce above 40,000 kg DM/ha/year (Garcia *et al*., 2008). This massive production of DM was proved to be achieved with an average of 10.5 MJ ME/kg DM, and at a cost of 110 AU$/t DM, which is highly competitive to pasture grown under similar conditions.

From this original idea, the concept of Complementary Forage System (CFS) was developed. This concept focuses on the use of the CFR to complement pasture at the system level. It involves allocating a certain proportion of the farm area to the CFR. This CFR area would complement the forage production of the pasture area both in quantity and quality throughout the year. In this way, apart from the bulk of maize silage obtained from the CFR, its autumn-winter grazable forages would provide (very timely) high quality feed at a time of the year when pasture production alone could not sustain a high stocking rate and milk responses.

The whole farm study

A 2 year whole farm study was conducted to evaluate the feasibility of introducing the CFR on a pasture based dairy farm. A 21.5 ha experimental farm was set with 65% of the area on pasture and 35% of the area under the CFR crops, both under full irrigation. The farm was run with a 100 cows herd (peak milking), which were only fed the forage produced within the 21.5 ha (with the exception of ~1 t of concentrate/cow/lactation as the only bought in feed used).

The target of forage utilisation for the whole CFS study was 25 t DM/ha/year ([35%area x 40 t DM/ha] + [65%area x 17 t DM/ha]). With the use of that home grown forage plus 1 t

DM/cow of concentrate, the individual target per cow was set at 8,000 L/lactation, resulting in a total system objective of 30,000 L/ha/year of milk from home grown feed.

Results

As average of 2 years of study, a total utilisation of **25.1 t DM/ha** of home grown feed was achieved over the whole farm area. That average resulted from a net utilisation of 33.2 t DM/ha from the CFR area and 20.7 t DM/ha from the Pasture area. This level of forage utilisation was achieved applying the same principles of pasture management described above for the pasture farmlets at EMAI. As a result, on average of the 2 years, **27,703 L/ha/year from home grown feed** were produced. This was achieved with an average milk yield per cow (adjusted to 305 days in milk) of 7382 L, using only 1 t of concentrates/cow.

The CFR complemented the pasture area throughout the year both by increasing intake/ha of home grown feed and by balancing the diet at different times of the year (Figure 6). From this combination an average daily milk production of ~ 24 L/cow was achieved. Maintaining such levels of milk production through summer when the diet is mainly based on kikuyu pasture (with increased NDF %) remains a challenge.

The potential of milk from home grown feed

The results obtained in the 2 studies reviewed on this paper highlight the feasibility of obtaining higher yields of milk/ha at a whole farm level from an increased intake/ha of home grown feed. In Figure 7 the results of both studies are compared in relation to the current situation of industry.

FINAL COMMENTS

- The industry's largest potential to increase milk yield/ha from pasture lays on the potential to increase forage intake /ha.
- To maximise intake per ha in pasture-based systems the key is to manage pastures and other home grown forages according to growth rate and target residual. This applies for systems with higher or lower stocking rate and higher or lower milk yield/cow.
- It is possible to increase milk production/ha from home grown feed even after optimum levels of pasture intake/ha are reached.

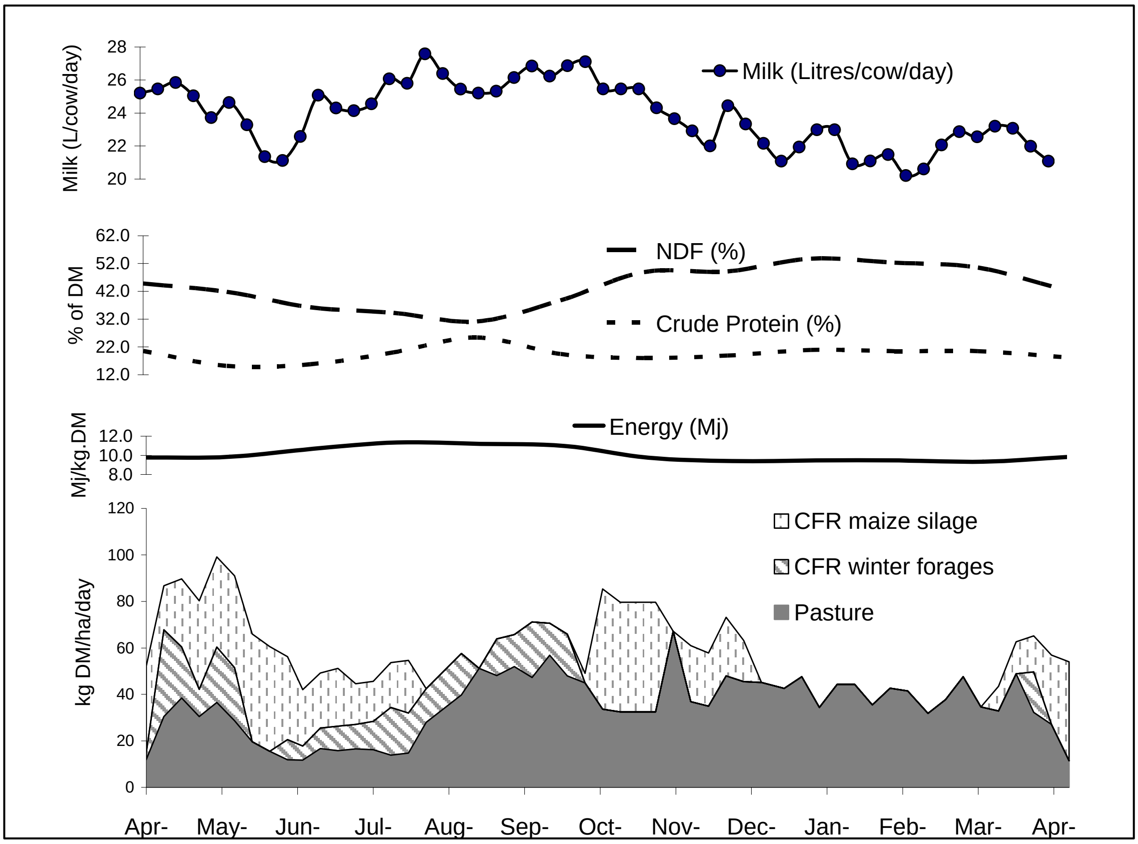

Fig. 6: Use of home grown forage (kg./ha.day), nutritive value (ME, CP and NDF) and milk production (L/cow.day) for the CFS whole farm study (year1)

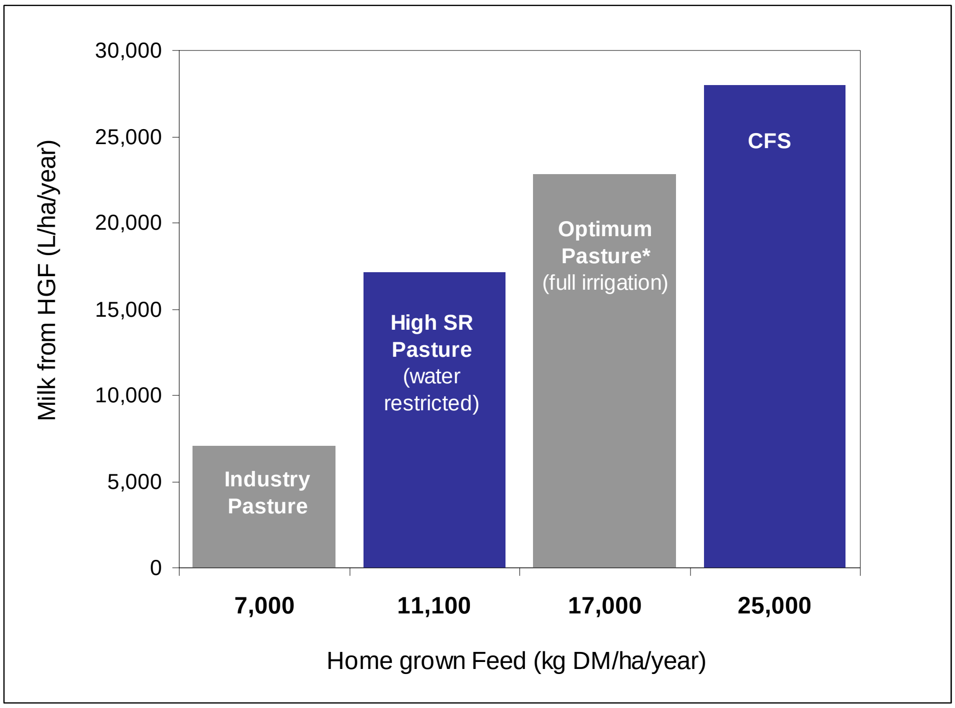

Fig. 7: Milk/ha from home grown feed at different levels of DM intake/ha.

References

ABARE. 2008. Financial performance of dairy farms, 2005-06 to 2007-08. Canberra.

Beever, D. E. and P. T. Doyle. 2007. Feed conversion efficiency as a key determinant of dairy herd performance: a review. Aust. J. Exp. Agric. 47(6):645-657.

Garcia, S. C. and W. J. Fulkerson. 2005. Opportunities for future Australian dairy systems: a review. Aust. J. Exp. Agric. 45(9):1041-1055.

Garcia, S. C., W. J. Fulkerson, and S. U. Brookes. 2008. Dry matter production, nutritive value and efficiency of nutrient utilization of a complementary forage rotation compared to a grass pasture system. Grass Forage Sci 63(3):284-300.

Holmes, C. W. and W. J. Parker. 1992. Stocking rate and its effects on dairy farm productivity. Pages 4-15 in 1992 Dairyfarming annual. Massey University, Palmerston North New Zealand.

King, K. R. and C. R. Stockdale. 1980. The effects of stocking rate and nitrogen fertilizer on the productivity of irrigated perennial pasture grazed by dairy cows. 2. Animal production. Aust. J. Exp. Agric. 20(106):537-542.

Macdonald, K. A., J. W. Penno, J. A. S. Lancaster, and J. R. Roche. 2008. Effect of Stocking Rate on Pasture Production, Milk Production, and Reproduction of Dairy Cows in Pasture-Based Systems. J. Dairy Sci. 91(5):2151-2163.

Malcolm, W. and A. Sinnett. 2007. Future Productivity and Growth in Dairy Farm Businesses in New Zealand: the Status Quo is not an option. Australian Agribusiness Perspectives: 2007.

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WHAT FORAGES DO COWS PREFER IF GIVEN CHOICE?

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Abstract

Pasture alone cannot fulfill the rising demand for dry matter in the dairy industry. The concept of complementary forage system (CFS) has been developed by FutureDairy to increase milk production from home grown feed. The objective of this study is to quantify the grazing preference of forages that can be used in the CFS. Four trials have been conducted with 25 different forage varieties. All species were grown at the same site, under the same climatic conditions and with soil moisture and nutrient availability being non-limiting to plant growth. All forage plots were laid out in a completely randomised block design with three replicate blocks. The treatment plots were set around the circumference of a circle, thus the grazing cows (3 cows at a time) had unbiased access to all the plots. Two observers recorded the cow preference as the time spent grazing on each forage species over 1 hour.

Trial 1 tested 14 forages (8 grass, 4 legumes and 2 herbs) for 2 years. The most preferred forage was prairie grass (11.6 min /h) and the least preferred was fescue (5.9 min/h). Among the legumes white clover and lucerne were the most preferred (9.6 and 9.0 min/h respectively). Cow preference time correlated (r=0.73) positively with water soluble carbohydrate content and negatively with the nitrate-nitrogen level. Cow preference also changed between seasons.

Trial 2, 3 and 4 were shorter trials thus avoiding the seasonal effect. Four forage field peas (leafless: Kaspa, Morgan, Yarrum and semi-leafless: Sturt) varieties were tested in Trial 2. Sturt was the most preferred pea variety (35.6%) mainly due to the convenience in prehension (less tendrils); Kaspa was the least preferred (17.3%). Trial 3 was focused on forage legumes during summer. Cowpeas, lablab and soybean were the forages trialed. Soybean cv. Intrepid had 65% preference over the other two legumes. The fourth trial is ongoing; three forage herbs (Brassica rape Winfred, forage turnip Hunter and forage radish Grazer) which can compensate the harsh autumn and winter weathers were selected with ryegrass white clover as a control. Preliminary results from the first grazing showed that forage rape was the most preferred followed by most leafy turnip and radish. These studies

demonstrate the importance of individual cows' preferences in relation to intake of grazed forages.

Introduction

The modern lactating dairy cows produce higher milk yield and are more demanding for dry matter than their ancestors. Australian dairy farming system relies mainly on pasture but with adverse weather conditions the persistence of the pasture is questionable (Fulkerson et. al. 2003). Even under normal weather conditions the amount of dry matter produced from pasture alone (average ~7 tDM/ha) is insufficient to fulfill the herd's requirements. Consequently, the Future Dairy project has introduced the use of complementary forage rotations (CFR) where forages complement each other and the whole system. These CFR have been shown to produce over 40 tDM/ha or twice as much the potential yield of pasture (Garcia et. al, 2008). The CFRs can be integrated with pasture into what has been called complementary forage systems (CFS) as described in a companion paper of this session (Farina et. al 2009). This CFS is designed to increase the amount of milk produced from home-grown forages providing with a more stable forage base all year round. However, this implies the use of a number of forages, which sometimes must be grazed 'simultaneously' (e.g. 3 different forages the same day).

Forage yield and quality are probably the most important factors to be considered when selecting forages to be included in the CFS, but other factors such as palatability or animal's preference may also be important. Cows have been shown to have marked preference for some forage more than others when given the choice (Horadagoda et. al 2009). However, why this happens is less clear.

Using forages with higher palatability (more preferred by the cows) may result in higher rates of dry matter intake and consequently higher milk yields. In addition, knowing which forages are more preferred by the cows will be of paramount importance in future pasture-based Automatic Milking Systems (AMS). In these systems cows move voluntarily from the paddock to the dairy and vice versa, meaning that the whole functioning of the system is based on ways to entice cows to move in and out of the paddocks in search of food. Clearly forages that are more preferred by cows could be used in these future systems to encourage cows to walk (e.g.) longer distance voluntarily. This topic is further covered in another session of this Symposium (Kerrisk *et. al* 2009).

Over the past few years we have undertaken a series of studies to compare the cow preference firstly (Horadagoda *et. al*., 2009) of the forages evaluated in a large comparative

study by Neal et. al (2006) and later to compare the preference of forages that had the potential to be used in "Future Dairy's complementary forage rotation system (Garcia *et. al*. 2008). This paper summarises the results of these studies.

What characters of a forage will make it more palatable to stock?

It has been established that cattle respond to the four primary taste groups: sweet, salty, sour and bitter (Nombekela *et.al,* 1994). Smell may have a role in palatability and preference, but is not usually considered to be as critical as taste. Also the sense of touch and feel of the feed in the mouth may alter feed intake and preference. Coarse materials may initially cause an undesirable sensation in the mouth and limit intake. Previous experience of the forage and adaptation by the stock to the forage are important factors in feed recognition, palatability and feed preference.

Preference Trials

Materials and methods

Four trials have been carried out at Camden between 2006 and 2009. In each trial all species were grown at the same site, and with soil moisture and nutrient availability being non-limiting to plant growth.

The plots layout was unique with plots located around the circumference of a circle (Figure 1) in such a way that the cows used in each test had unbiased access to all forage species within this circle. The treatment plots were laid out in a completely randomized block design within 3 replicates within the circle. Prior to the trials cows were accustomed to the forage species to be tested and made familiar with the testing procedure.

On each experiment, a total of 10-12 non-lactating Holstein Friesian cows of similar dominance were chosen from a large herd. During the experimental periods, 3 cows at a time were allowed to enter the circle and were observed every 10 second intervals for 1 hour. The forage they were grazing at each time was recorded.

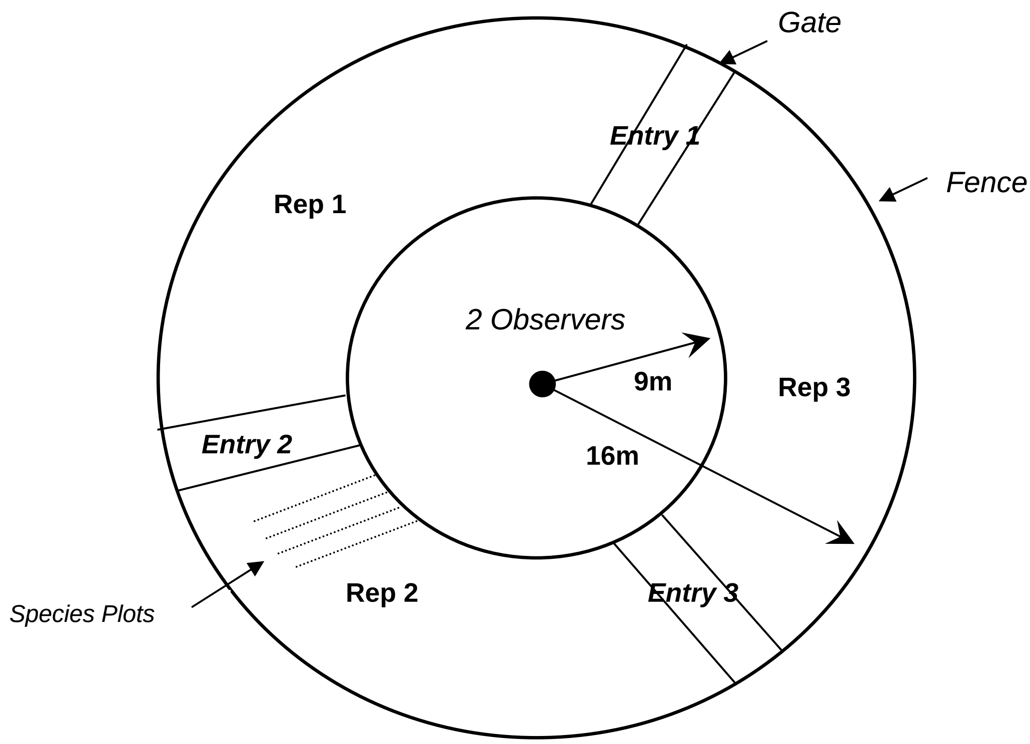


Figure 1: The experimental layout for the cow preference testing

In Trial 1, fourteen forage species (8 grass, 4 legume and 2 herb) were studied during 8 seasons over 2 years (Table 1). In Trial 2, four different field peas varieties were tested as field peas are an alternative winter crop constituent of the Future Dairy CFS. The pea types studied include 3 leafless (Kaspa, Morgan and Yarrum) varieties which were densely entangled with tendrils and one semi-leafless (Sturt) variety with lesser amounts of tendrils. In Trial 3, three summer legume species (soybean, lablab and cowpeas) were tested as alternative summer grazing options to maize. Many farmers do not have the equipment or expertise to grow maize nor do they want to have corn growing on a grazeable area close to the dairy. In this case, they are looking for forage options to boost the relatively low quantity and quality of pastures based on species (kikuyu or paspalum) adapted to subtropical environments, In Trial 4 three brassica species: forage rape cv. Winifred, turnips cv. Hunter, fodder radish cv. Grazer were evaluated with Ryegrass-white clover pasture used as a control.

Table 1: The forage species tested in the 4 trials are listed with the common name, scientific name and variety.

Common name	*Botanical name (scientific name)*	*Variety*
Trial 1		
Cocksfoot	*Dactylis glomerata*	Kara H0265
Fescue	*Festuca arundinacea*	Advance Maxp.
Phalaris	*Phalaris tuberosa*	Holdfast
Prairie brome grass	*(Bromus willdenowii*	Matua
Perennial ryegrass	*Lolium perenne*	Bronsyn
Short rotation ryegrass	*Lolium multiflorum*	Concord
Kikuyu	*Pennisetum clandestinum*	Whittet
Paspalum	*Paspalum dilatatum*	Poir. Common
Lucerne	*Medicago sativa*	Sceptre
Persian clover	*Trifolium resupinatum*	Maral
White clover	*Trifolium repens*	Kopu II
Red clover	*Trifolium pratense*	Astred
Chicory	*Cichorium intybus*	Grouse
Plantain	*Plantago lanceolata*	Tonic
Trial 2		
Feild peas	*Pisum sativum*	Kaspar
		Morgan
		Yarrum
		Sturt
Trial 3		
Cowpea	*Vigna unguiculata*	Red Caloona
Soybean	*Glycine max*	Intrepid
Lablab	*Lablab purpureus*	Rongai
Trial 4		
Brassica rape	*Brassica rapa*	Winfred
Radish	*Paphamus sativos*	Grazer
Forage Turnip	*Brassica rapa cv. Rapa*	Hunter
Ryegrass	*Lolium perenne*	Aberdart

Results

Trial 1

The most preferred species over the whole year (see Figure 2) was prairie grass followed by kikuyu and then white clover, despite the fact that kikuyu was not available in winter. Fescue was the least preferred grass species (Figure 2). The mean grazing times for prairie grass and kikuyu during the 1 hour test periods of grazing was 11.6 and 10.5 minutes, respectively. White clover and lucerne were the most preferred legumes (9.6 and 9.0 minutes, respectively) while chicory and plantain were little consumed (3.5 and 3.2 minutes, respectively).

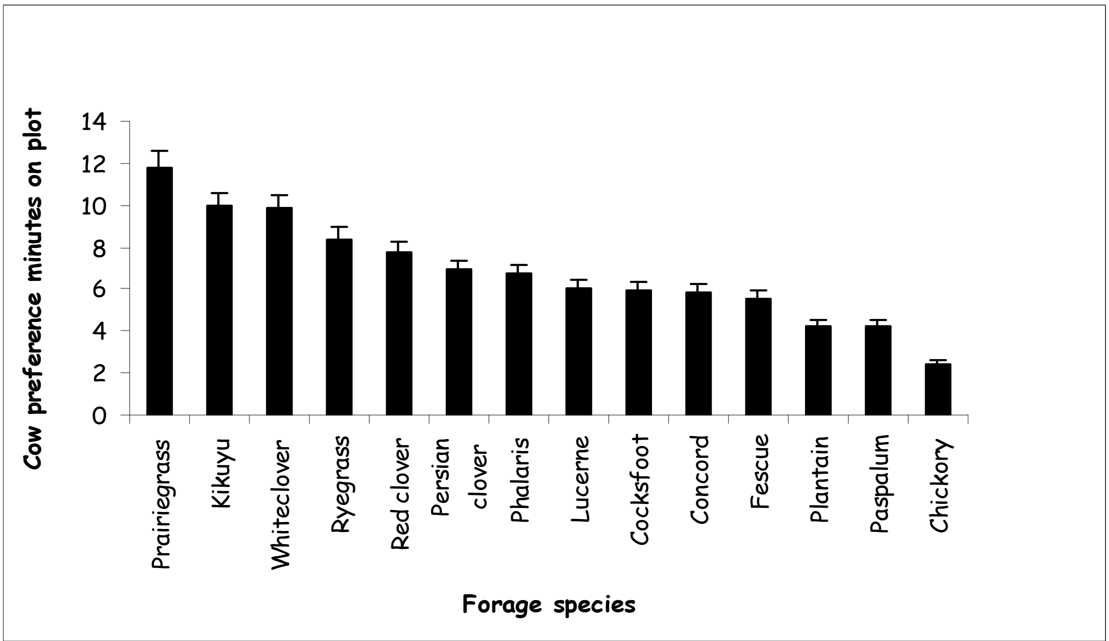


Figure 2: Time (min.) spent by cows on each forage species. Values are mean + SEM over the eight periods of testing replicates and cows.

The seasonal changes in cow preference, as a % of total preference test time, for all grass species tested are shown in Figure 3 and indicate a definite preference for particular species at certain times of the year. Kikuyu and phalaris were the preferred species in summer, with approximately 65% of the total time spent grazing these grasses. Prairie grass was preferred above all other species during the winter months with approximately 30% of total time spent on this species. Some grass species were not highly preferred in any season (paspalum) or were not present in summer (S.R. ryegrass). Perennial ryegrass had moderate preference during its vegetative state of growth from autumn to spring.

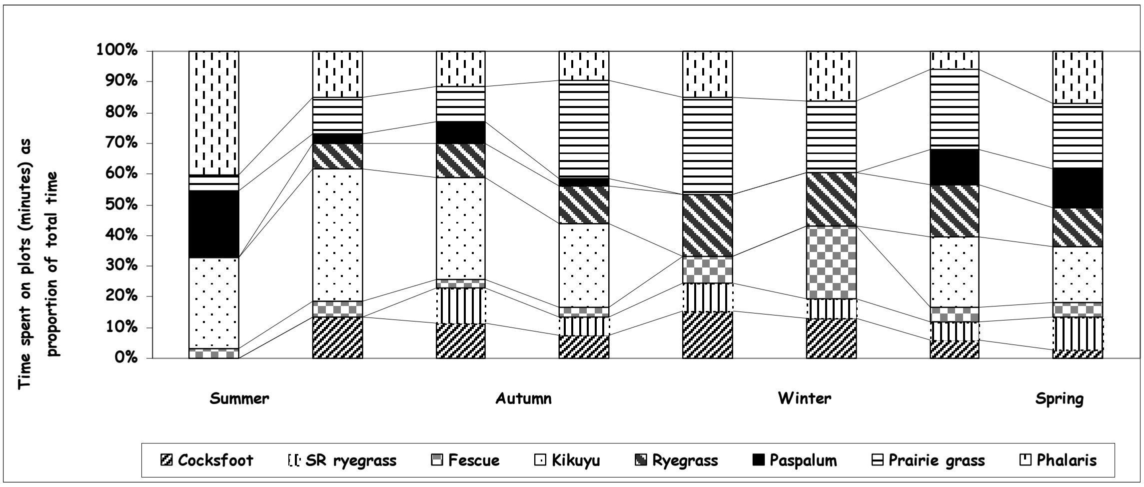


Figure 3. Seasonal changes in the cow preference [time (min.) spent on each plot as a proportion of total time of test] for grass species over replicates and cows.

The results for preference tests taken over seasons for herbs and legumes also showed very distinct variations between species (Figure 4).

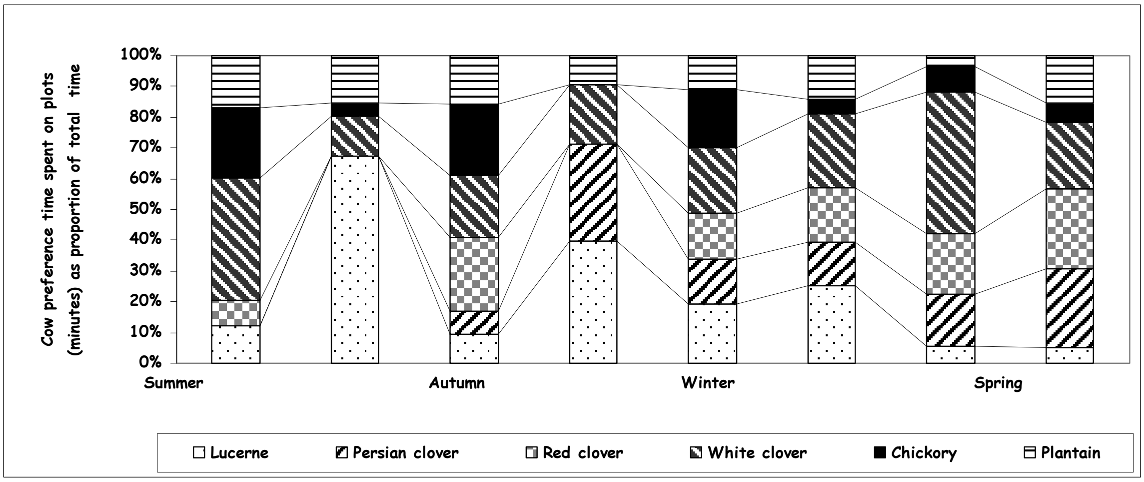
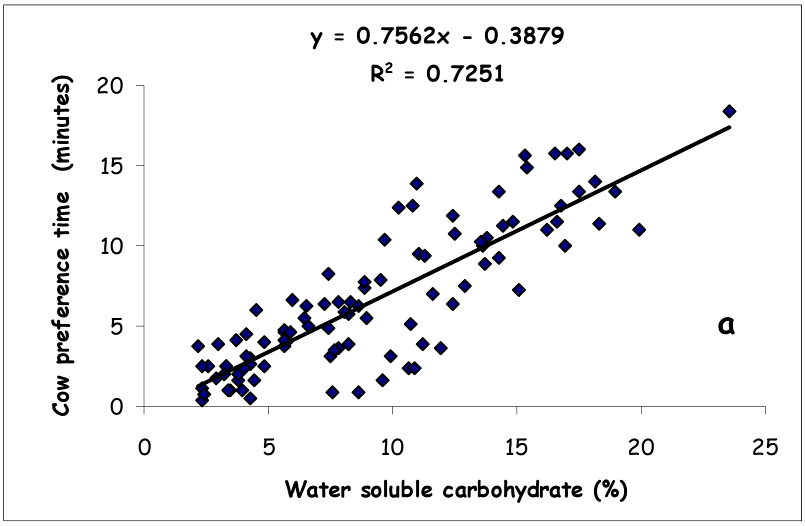


Figure 4. Seasonal changes in the cow preference [time (min.) spent on each plot as a proportion of total time of test] for legume and herb species over replicates and cows.

The relationship between WSC concentration and cow preference over all forage species showed the highest ($P < 0.001$) positive relationship (Figure 5a), with r2 = 0.73. The relationship between nitrate-nitrogen content and cow preference over all species was linear but significantly ($P < 0.001$) negative (Figure 5b).



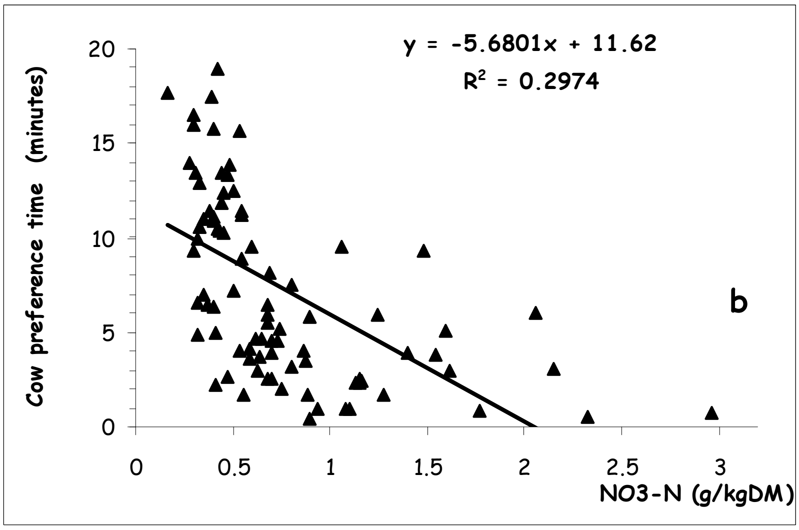


Figure 5. The relationship between the cow preference time (min.) and (a) the water soluble carbohydrate (%) in forages and (b) the nitrate nitrogen (NO3-N) concentration (g/kgDM) in forages

The relationship between cow preference and the neutral detergent fibre (NDF) and tensile strength were both negative (Figures 6a and 6b, respectively), meaning that cows avoided grazing forages with higher fibre content.

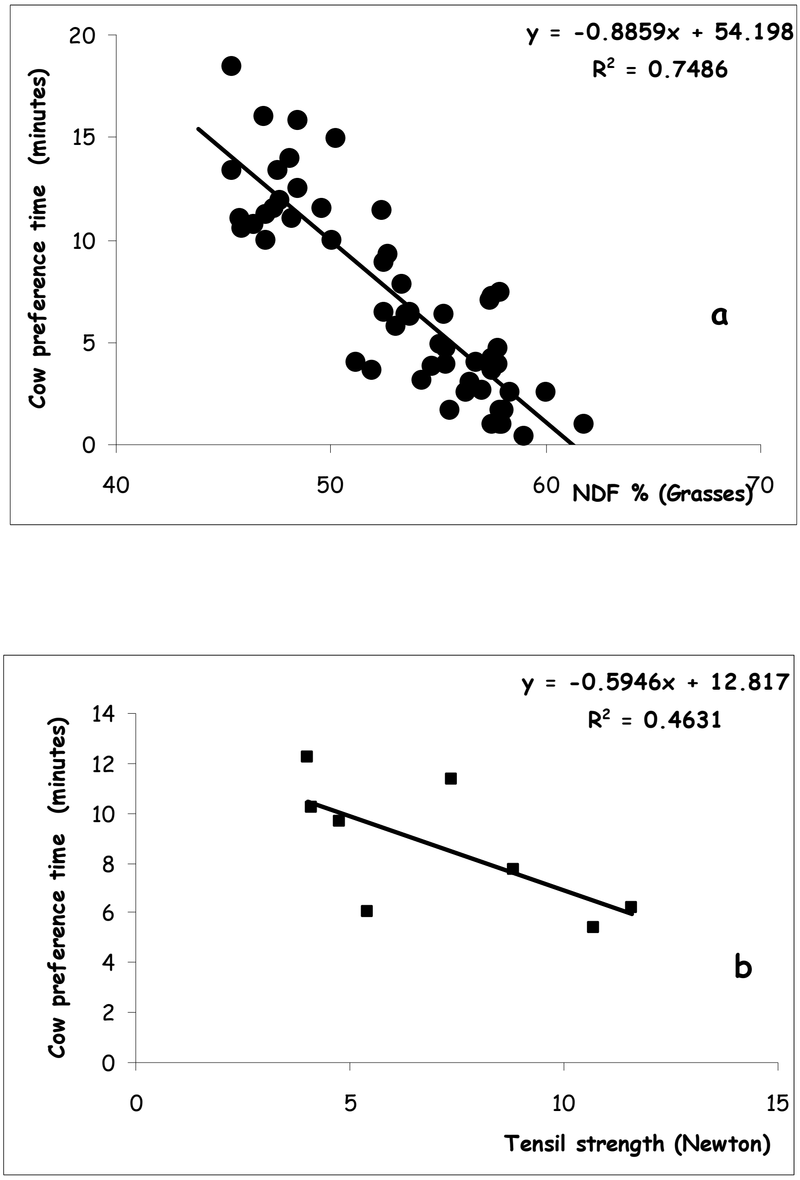


Figure 6: The relationship between cow preference time (min.) and the neutral detergent fibre (NDF) (a) and tensile strength of grasses (b)

Figure 7 shows the forage preference by 3 individual cows. Although there was some variation in forage preference among individual cows, in general the results were fairly consistent

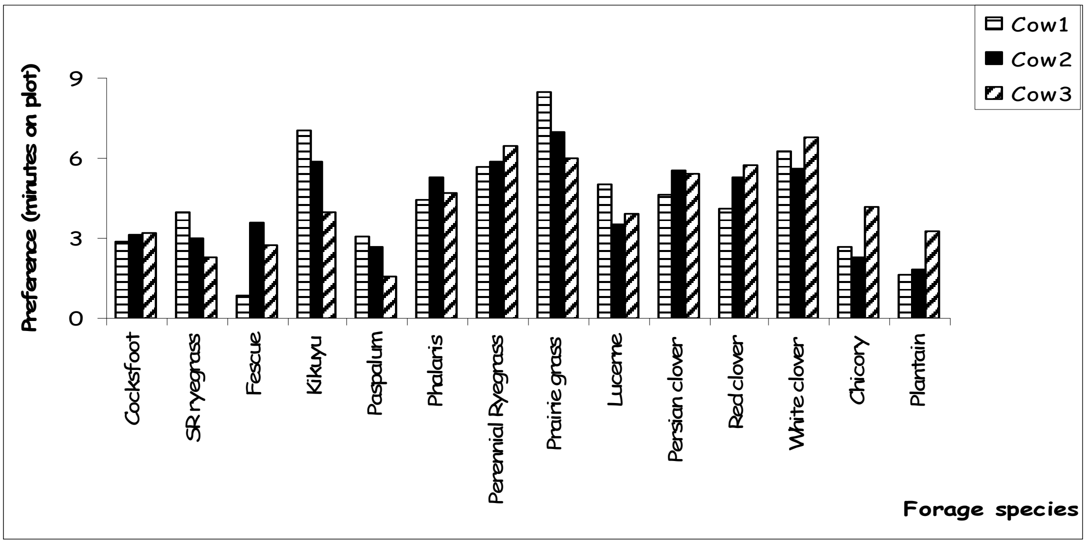


Figure 7: Preference for each forage species by a particular cow

Trial 2

In the Trial 2 four different field pea varieties were tested for preference to identify most palatable varieties. Until now field peas have always been used for silage. Thus having the option of grazing field peas would increase the flexibility of CFS. In this trial 10 cows were used to test preference.

The results clearly indicated that cows preferred to graze those peas with fewer tendrils Sturt (Figure 8a). Tendrils seem to make it difficult for cows to graze. Interestingly, once cows had finished with the leafy varieties of peas, they grazed the higher 'tendril' varieties (Figure 8b) without hesitation. The mean relative time spent grazing each variety is shown in Figure 9. The main disadvantage of grazing field peas was that the plants do not regrow after grazing as the apical growing points are removed.


(a)


(b)

Fi**gure 8: (a) Semi-leafless forage pea variety Sturt with white flowers and less tendrils.**

(b) Leaf-less forage pea variety Kaspa with higher tendrils

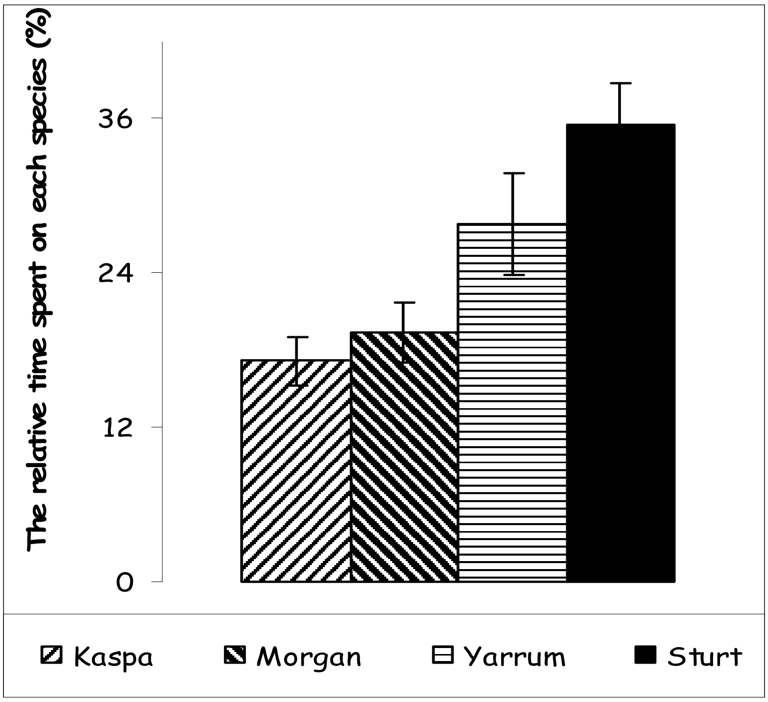


Figure 9: Preference time (min.) for the 4 field pea varieties.

Yarrum was the second most preferred variety it may be due to higher water soluble carbohydrate (WSC) or sugar levels and lower neutral detergent fibre (NDF) (Table 2).

Table 2: The nutritive value of the 4 field pea varieties tested in the preference test

Field pea variety	Nutrients							
	NDF %	ADF %	HC %	WSC %	N %	Ash %	DMD %	ME MJ/kgDM
Kasper	32	26.6	5.6	8.8	3.8	11.2	71.3	10.1
Morgan	35	30.9	3.9	11.6	3.5	10.3	70.8	9.9
Sturt	31	28.8	2.7	6.9	3.8	10.3	72	10.2
Yarrum	29	26.6	2.3	10.2	3.6	10.0	73	10.5

Trial 3

In Trial 3, the preference of cows for soybean, cow peas and lablab were tested. As shown in Figure 10, soybean was the most preferred species.

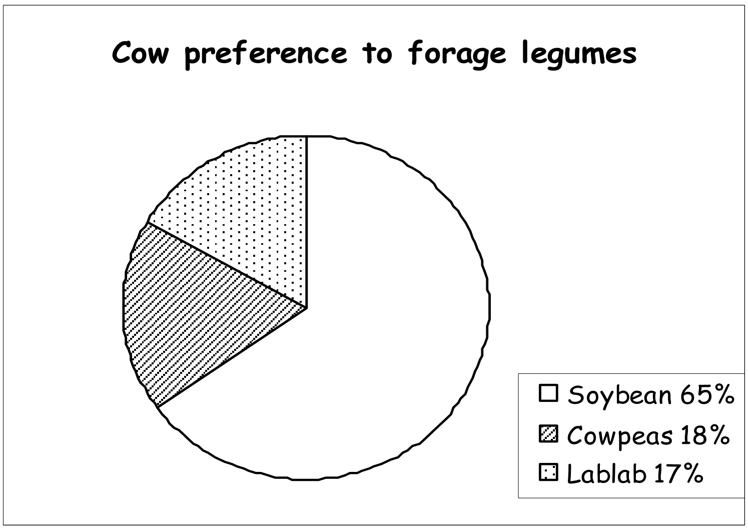


Figure 10: Proportion of time spent by 10 cows on each legume variety

The quality of the forage over the summer is shown in Figure 11 to account for different stages of maturity of the forages.

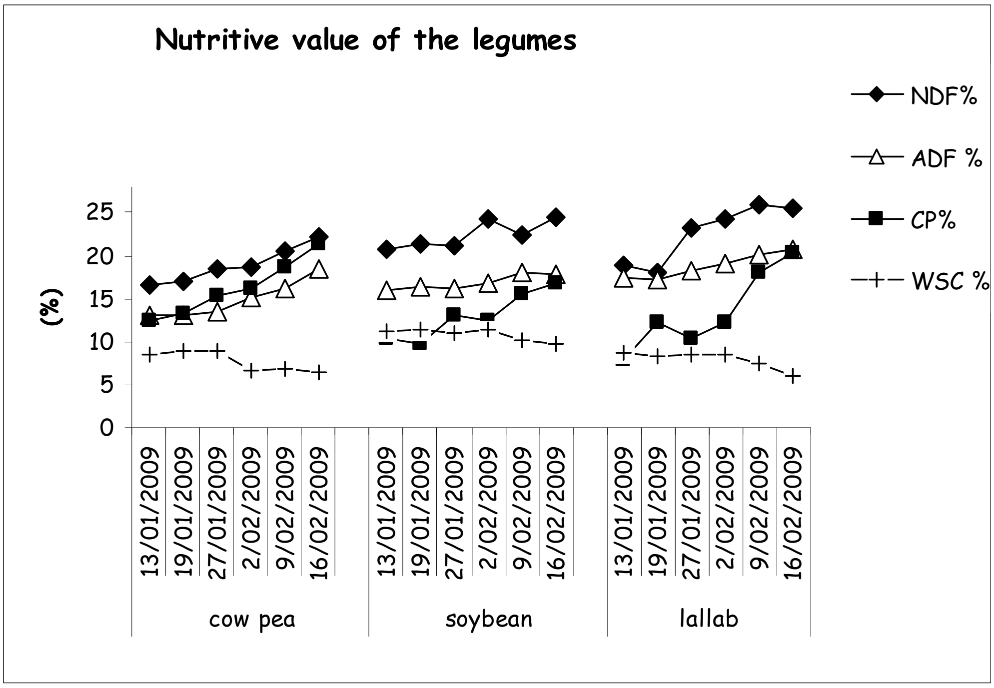


Figure 11: Nutritive value [neutral detergent fibre (NDF %), acid detergent fibre (ADF %), crude proteins (CP %) and water soluble carbohydrate (WSC %)] of legumes over the summer

Trial 4

Trial 4 is ongoing to evaluate forage rape, forage turnip and forage radish. Only one grazing has been completed by the time of writing this paper (Table 3). Forage rape was the most preferred forage brassica, followed by leafy turnip and lastly fodder radish but ryegrass white clover was preferred first.

Table 3: The nutritive value and the growth parameters of rape, turnip and forage radish.

	Brassica Rape Winfred	Turnip Hunter	Radish Grazer
# of plants/square M	135	119	103
Height after 10 weeks (cm)	120	80	70
Number of leaves	16	14	13
Dry matter content at 10 weeks (%)	10	9	8
Yield at10 weeks (t DM/ha)	6.5	5	4
N (%)	4.8	4.4	4
ADF (%)	18	17	16
NDF (%)	19	18	17
Cellulose (%)	11	11	14
Lignin (%)	5	4	3

As irrigation was limited, six weeks after sowing the plots turnips were affected by moisture stress followed by the radish, while forage rape coped the best. White cabbage butterfly infested the turnip but not the radish or the forage rape.

All fodders had high moisture content (10% dry matter or less) and all 3 crops had over 27% of crude protein content, compared to 22.5% in pasture.

Discussion

Trial 1 results showed preference for forages that were sweetest (higher water soluble carbohydrate contents) and less preference for forages with higher nitrate nitrogen content, which is associated with the bitterness of the forage. Both the NDF content and the tensile strength resistance of the forages had a negative effect on palatability. Season of the year played an important role in cow preference to forages. Trial 2 clearly demonstrated the physical barrier created by the peas with higher tendrils and how it interfered with the palatability. The white pea Sturt was preferred among the peas mainly due to convenience of prehension. In Trial 3 soybean was preferred over lablab and cow peas. Soybean leaves appear to be more palatable than stems and its erect growing nature made it more readily consumed than laterally growing lablab. Again the chemical constituents were very similar among the three species, suggesting that factors other than nutritive characteristics play an important role in terms of animal preferences. Trial 4 is ongoing but from the first grazing data it was clearly revealed that cows preferred the brassica rape over leafy turnips or radish. Again the erect stem may play a major role in palatability and also radish on the negative score had a higher nitrate nitrogen content which would increase bitterness compared to the other two forages. Cows also enjoyed grazing turnips as it was very crispy and prehension was much easier when compared to brassica rape, also post grazing residual was much lower in turnips.

These studies clearly show the importance of cow's preferences when grazing forages. In the future we envisage using this knowledge on cow preference to use it as 'rewards' or 'incentives' for cows managed in voluntary automatic milking or Robotic systems (AMS).

Conclusions

When there is an assortment of forages ruminants graze selectively. This means that when grazing animals get access to a number of palatable forages in a field, the animals may be selective and consume only certain forages. By introducing forages of higher palatability we could increase dry matter intake by the cows. This in turn would result in higher milk yield and increased benefits to industry.

In addition, these differences in feed selection by dairy cows may be an important factor in explaining differences in milk composition between individual cows. A hypothesis yet to be tested.

References

Farina, S.R., S. C. Garcia and W.J. Fulkerson, 2009. Strategies to maximize intake per ha in a pasture based dairy. Proceedings of 2009 DRF Annual Symposium

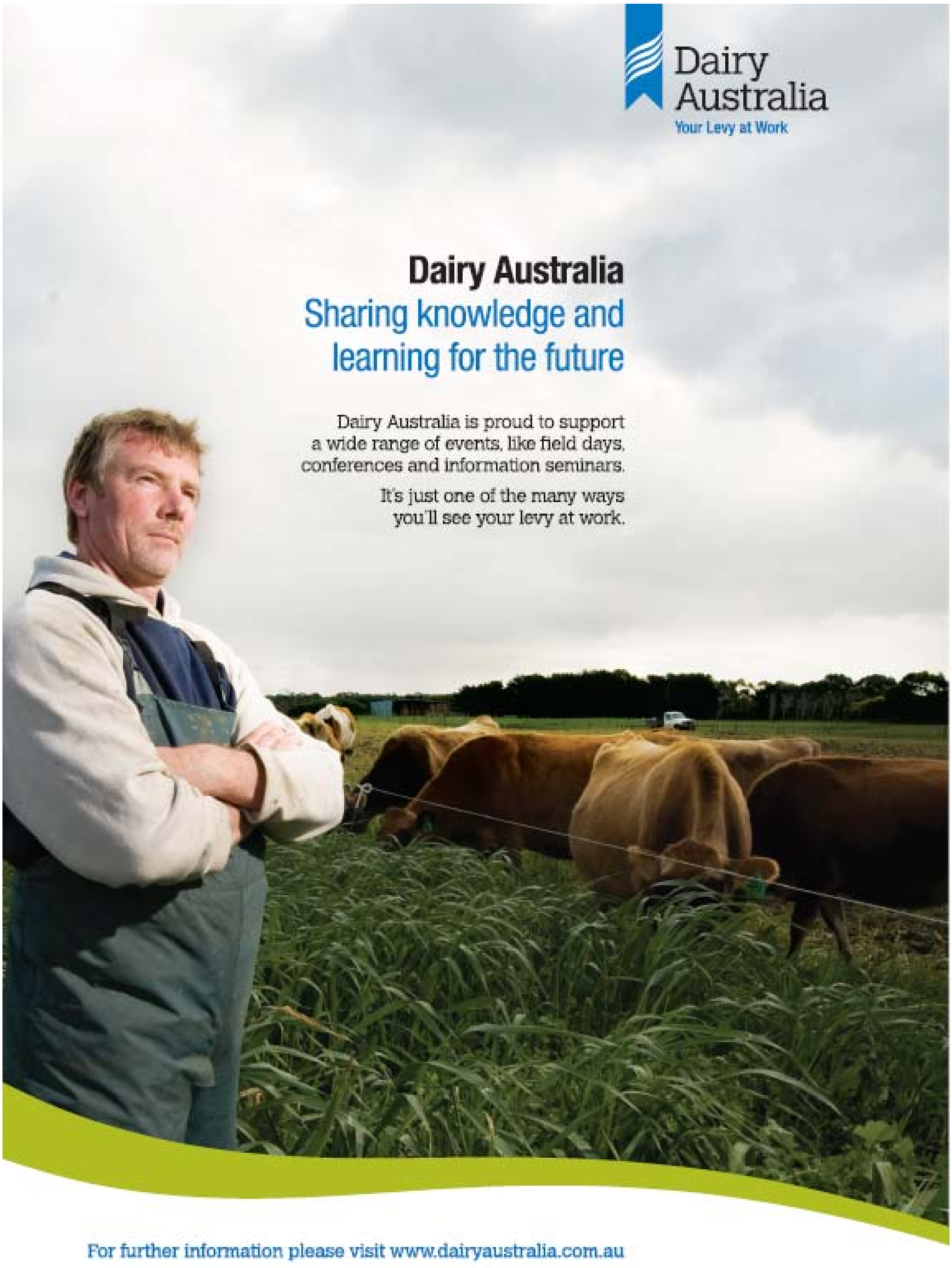
Fulkerson, W.J., K. Slack, R. Bryant, and F. Wilson, 2003. Selection for more persistent perennial ryegrass (*Lolium perenne*) cultivars for subtropical/warm temperate dairy regions of Australia. *Australian Journal of Experimental Agriculture*, **43,** 1083-1091.

Garcia, S.C., W.J. Fulkerson, and S.U. Brookes, 2008. Dry matter production, nutritive value and efficiency of nutrient utilization of a complementary forage rotation compared to a grass pasture system. *Grass and Forage Science,* **63,** 284-300.

Horadagoda, A., W. J. Fulkerson, K.S. Nandra, and I.M. Barchia, 2009. Grazing preferences by dairy cows for 14 forage species. *Animal Production Science,* 49, 586-594.

Kerrisk, K.D., Garcia, S.C> 2009. Feeding in an automated milking system. Proceedings of 2009 DRF Annual Symposium

Nombekela, S. W., M. R. Murphy, H.W. Gonyou and J. I. Marden, 1994. Dietary preferences in early lactation cows as affected by primary tastes and some common feed flavors. *Journal of Dairy Science* **77**, 2393-2399.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THE CONTEXT TO MAXIMISE THE BUSINESS: DAIRY INDUSTRY AND MARKET OVERVIEW

Joanne Bills

Manager, Strategy & Knowledge, Dairy Australia

Summary

- The global financial crisis and ensuing economic downturn has had a major impact on the dairy industry.
- The almost immediate fall in commodity prices has been quickly translated to sharply lower farmgate prices for three quarters of Australia's dairy farmers – concentrated in the southern exporting regions.
- Farmers supplying more domestically-focused processors under long term contracts have been insulated from these impacts, and the domestic market is still offering value growth.
- The current operating environment has polarised the industry's producers based on their milk supply arrangements, and the seasonal conditions they face.
- While there are already signs of recovery, market volatility will remain a feature of dairy markets, and when combined with climate variability presents an ongoing challenge for farm managers and production systems.

The industry in 2009

For the Australian dairy industry 2009 has been a year of almost unprecedented volatility and uncertainty in 2009. After a sustained period of buoyant international commodity prices, the global financial crisis and resultant economic downturn at the end of 2008 had an almost immediate negative impact on the Australian dairy industry (Figure 1).

Rapidly falling international commodity prices translated directly into lower farmgate prices for southern producers, with a step down in opening price – the first for 35 years -impacting around three quarters of dairy producers. The financial impact has been severe, particularly for a significant proportion of producers who – through climate-related necessity and encouraged by previous high farmgate prices – find themselves locked into high feed input systems with limited cost flexibility.

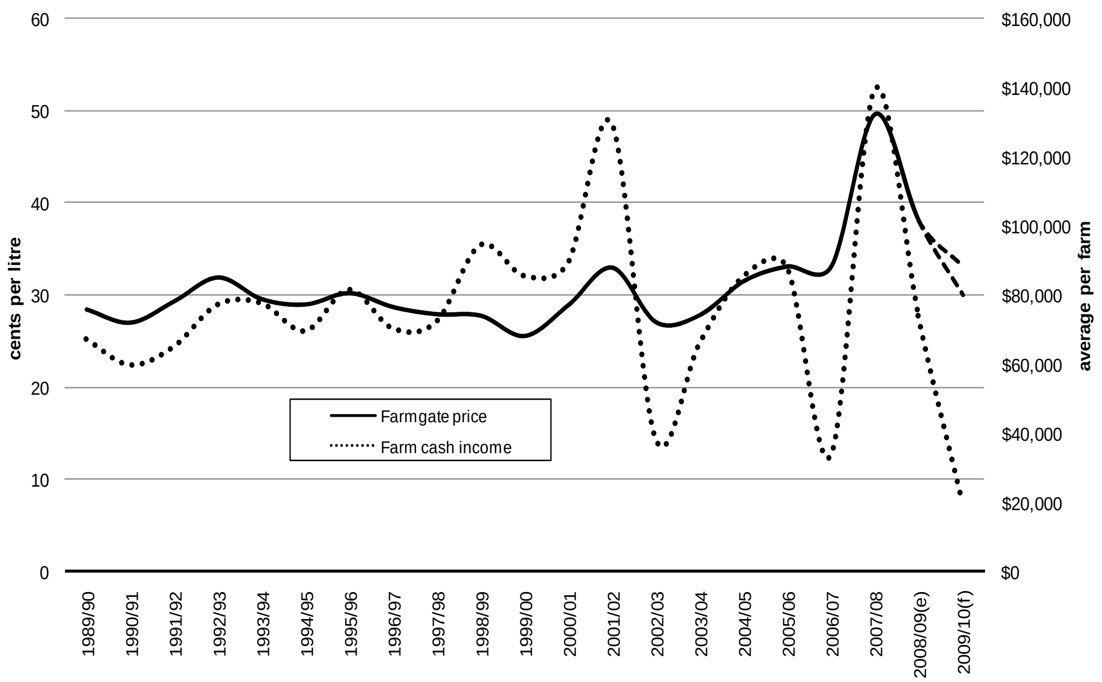
Farmers supplying domestically-focussed fresh milk processors have been insulated from the immediate impacts of the international downturn, as supply contracts negotiated in 2008 remain in force. In northern Australia, the higher contracted milk prices have coincided with a welcome improvement in seasonal conditions.

As a result, three distinct sectors have emerged from this polarisation in operating conditions farmers are facing, characterised by:

- the nature and security of milk supply arrangements; and
- the prevailing seasonal conditions and outlook.

They are summarised in the Table 1.

Figure 1: Average farmgate price and income - Australia



Source: Dairy Australia and ABARE

Table 1. Emerging sectors from polarisation in operating conditions farmers are facing

Segment	Price outlook	Input costs	Confidence
Southern pasture	Opening price down 30 to 35% for 2009/10, uncertain full year price	Scope to reduce costs given reasonable season	Impacted, but still mostly positive
Southern Murray Darling Basin	Opening price down 30 to 35% for 2009/10, uncertain full year price	Limited scope to reduce costs given increased debt levels and water allocation outlook	Most severely impacted of all regions, confidence at low levels
Fresh milk supply	Certainty offered by ongoing contracts featuring minimum price	In NNSW/SEQ, improved seasonal conditions have allowed for significantly lower feed costs	NNSW/ SEQ most positive region in Australia

Results from the 2009 National Dairy Farmer Survey (NDFS)[1] indicate the impact of the changed market outlook on confidence. After peaking in 2008 at 78%, the number of farmers stating they were positive about the future of the industry fell to 66%. Farmers in south east Queensland were most positive, while northern Victoria/Riverina recorded the lowest levels of confidence.

With significantly lower farmgate prices facing most southern dairy farmers in 2009/10, farmers will need to reduce costs in order to protect margins. The ability of farmers to achieve significant cost reductions will depend critically on their debt levels and their requirement for bought in supplementary feed.

[1] The National Dairy Farmer Survey (NDFS) is a survey of 1000 farmers across all dairying regions. In 2009 the survey was conducted between mid February and mid-March. This is the sixth year the NDFS has been conducted as part of Dairy Australia's Situation & Outlook process.

Results from the NDFS indicate that in 2009, 45% of farmers relied on supplementary feed entirely (i.e. did not graze) for some period over the preceding 12 months. In northern Victoria/Riverina the figure was 76%, and the average number of months for which herds did not graze in that region was over six months – compared to a national average of just under five months.

The DPIV Farm Monitor[2] for 2008/09 reports that the percentage of feed imported as a percentage of metabolisable energy requirement was 54% in northern Victoria, compared with 32% and 29% in south west Victoria and Gippsland respectively. This is a further indicator of the reliance of farms in the northern Victoria/Riverina region on supplementary feeding.

Market overview

The Australian industry exports around 45 to 50% of its annual milk production, accounting for around 11% of world dairy trade. In addition, the Closer Economic Relations (CER) agreement with New Zealand means that there is virtually unrestricted access to the Australian market for the world's largest dairy exporter. As a result, returns to the industry – particularly in the southern region – are greatly influenced by the international market for dairy products.

Only 7% of the world's milk production is traded internationally, making the international market for dairy products inherently susceptible to even small changes in supply and demand. Historically, the market has also featured significant government intervention, aimed at protecting domestic industries and balancing internal markets, often restricting and distorting international trade in the process.

World market conditions

In mid-2008, after two years of sustained high prices – it seemed the world dairy market was entering a new era (Figure 2). However, there were already indicators of a correction, with demand under pressure and increased supply, particularly from the US and New Zealand.

[2] DPIV Farm Monitor – an initiative of the Department of Primary Industries Victoria and Dairy Australia. 68 farms across Victoria' three dairying regions were interviewed in 2009.

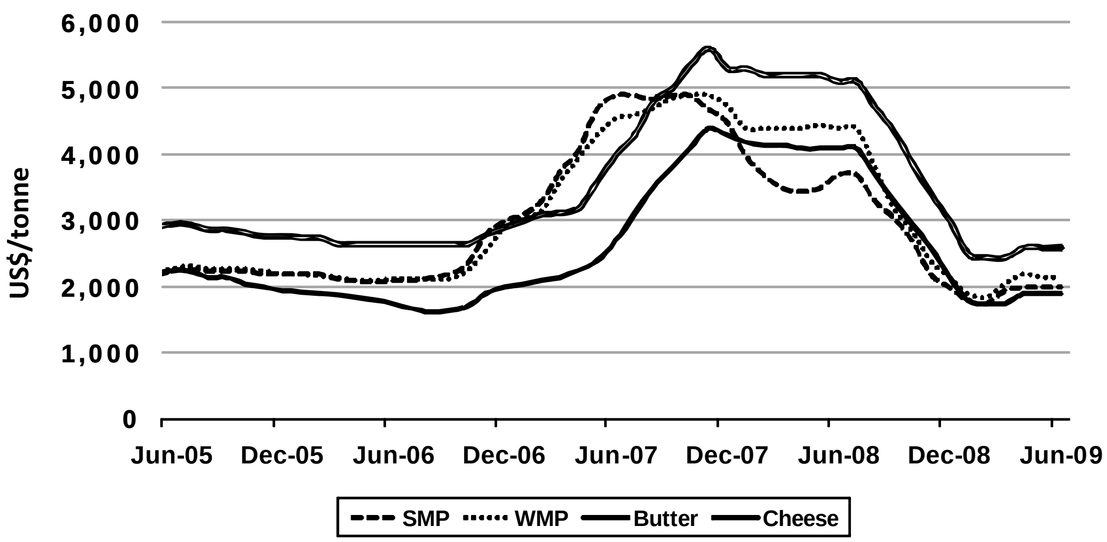


Figure 2: International dairy commodity prices

Source: Dairy Australia

Nevertheless, it would have been difficult to predict the impact of a global financial crisis, which after originating in the US, quickly spread to envelope both the developed and developing world. Trade in all commodities was impacted almost immediately as insurance and credit markets were paralysed by insolvency fears and increasingly volatile currency fluctuations.

Dairy commodity prices immediately went into a downward spiral as buyers reacted to initial falls and increasing economic uncertainty. Commercial supply pipelines emptied as buyers ceased purchases, preferring to run down high-priced inventories. As a result, supplier stocks rapidly built up, and intervention purchases by both the US and EU governments re-commenced in early 2009.

While government stocks built rapidly, they remain at significantly lower levels than in previous downturns. Nevertheless, the re-building of intervention stocks triggered the re-introduction of export subsidies, first by the EU as a temporary measure in January. Once the US followed suit in May, the EU retaliated extending the time frame and rate of subsidisation, and adding further to negative market sentiment. Most recently, the US announced an additional $US243 million in support for the industry, raising intervention prices and increasing the potential for government stockpiling.

The events of 2009 have seen an almost complete reversal of the factors that had previously driven the international commodity dairy price boom. Previously, the tight supply and demand balance, buoyant global economic conditions, virtually zero stocks, and the absence of government intervention had seen prices reach unprecedented levels in what was very much a “sellers market”.

At the commencement of the 2009/10 season, the world market situation is very much the reverse of a year ago, with buyers remaining cautious in their approach to any forward commitment given continuing economic uncertainty, and government stockpiles building, there has been limited upward pressure on prices, although by they appear to have bottomed.

The two key drivers of recovery in the world dairy market are a supply response and improved economic conditions to underpin demand growth. At the time of writing, there are some promising signs of both.

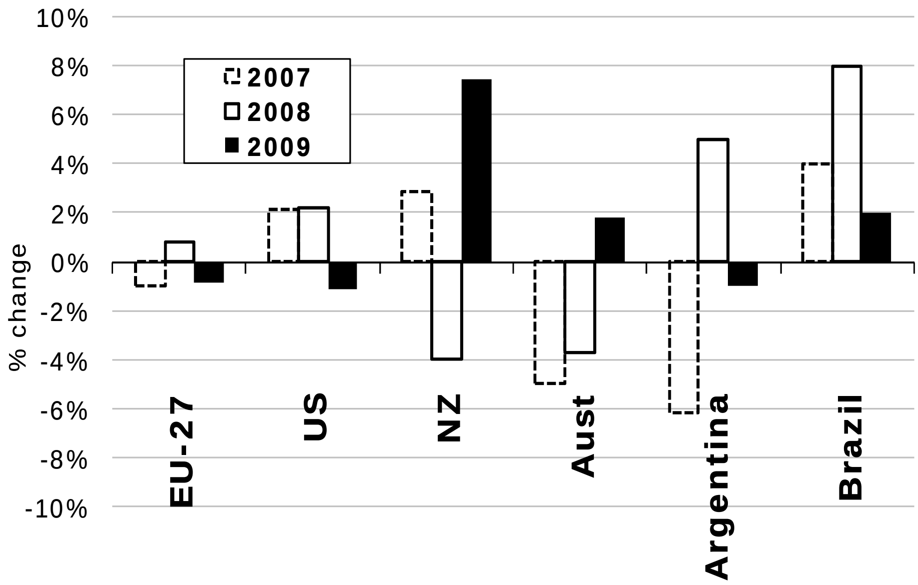


Figure 3: Major exporter production

Note: For NZ and Aust chart refers to 2008/09 season *Source: Dairy Australia*

The US had accounted for the major increases in export supplies following the booming commodity prices of the past couple of years. However, with collapsing domestic prices the milk to feed price ratio for dairy producers is at a record low. This combined with credit pressures - particularly in some of the larger, more export-focussed regions - is expected to result in falling in production over the remainder of 2009. However the expected contraction has been slow to materialise to date, as some US farmers, particularly in more traditional producing regions have enjoyed favourable seasonal conditions.

In the EU – despite a 1% increase in production quota and the return of market intervention - a similar fall in production is forecast, in response to severe cut in farmgate milk prices.

New Zealand production grew strongly over the 2008/09 season, fuelled by expectations of higher farmgate prices, and a high rate of farm conversions. With conversions likely to slow under the current circumstances, production growth will be constrained, but still grow by an estimated 2 to 3%. In Argentina, drought conditions have prompted large scale culling, limiting production over the coming 12 months.

On the demand side, economic conditions in key Asian and Middle Eastern markets are showing signs of recovery. Imports to south east Asia are recovering at lower commodity prices, and Middle Eastern markets have benefitted from lower prices and strong currencies making imports more affordable.

More generally, the global economy appears to have begun a recovery which will be led by developing economies in Asia. Many of these economies are still growing, albeit at a reduced rate than 12 months ago, and will be the key drivers of dairy demand.

While supply and demand trends are heading in the right direction, the ability for dairy markets to rebalance and prices to recover significantly in the short term will be hampered by government intervention. The presence of significant government stocks will overhang the market while they exist, and export subsidies limit the ability of price to move strongly upwards.

Australian market conditions

The Australian market is a mature one for dairy products, with total per capita consumption of dairy products estimated at around 300 litres each year – 104 litres as drinking milk, with the remainder as cheese and other products.

Supermarkets are the most important channel to consumers – accounting for an estimated 51% of the market by volume and 61% by value. While influenced by international commodity prices, retail prices for dairy products are inherently “sticky” as contract supply arrangements limit fluctuations.

Retail prices moved up slowly in response to higher commodity prices, but are currently sustaining value growth across all dairy categories in the supermarket channel, as pre-existing supply agreements have limited price falls.

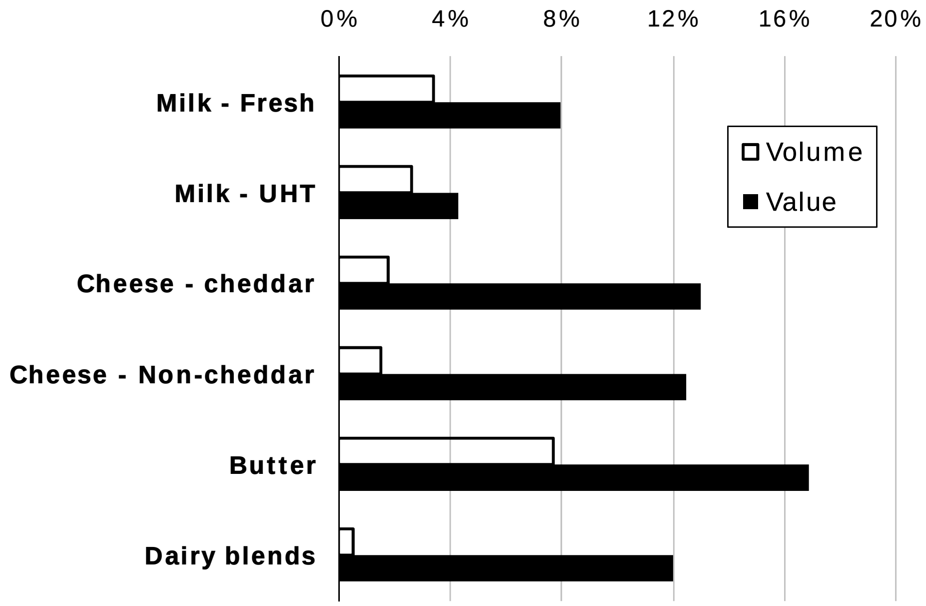


Figure 4: Supermarket sales - 12 months to May 2009

Source: Aztec and Dairy Australia

While dairy consumption has proved resilient to higher prices and a deteriorating economic outlook, there have been some shifts toward "trading down" or "economising". In the milk category, this has been most evident in shifts away from higher-priced branded and modified products to regular supermarket brand product. Shifts in pack sizes have also been evident as consumers to seek either "bulk" discounts or reduce the volume of their purchases to cut costs.

While the Australian market has offered good returns, any further deterioration in economic conditions is likely to accelerate these economising trends, eroding value growth across the dairy category. In addition, future contract negotiations are likely to result in retailers pushing for greater alignment with export market returns, particularly as manufacturers are likely to be increasingly focussed on domestic market opportunities while international returns are less attractive.

Conclusions and outlook

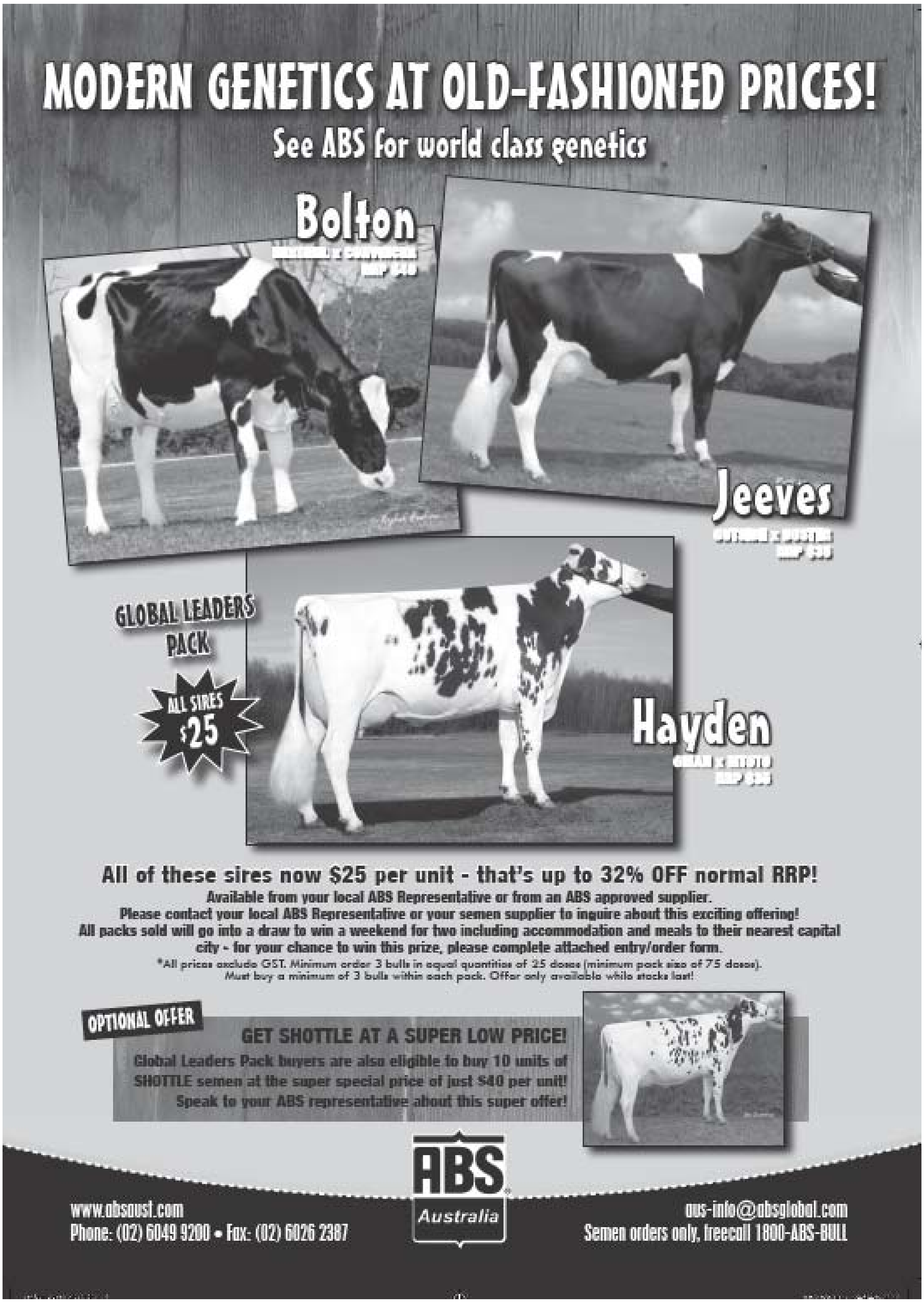
The events of the past 12 months have highlighted the volatility that characterises the international market for dairy products, heightened by the impact of a global financial crisis and economic downturn.

The Australian dairy industry is highly exposed to the international market, as both a major exporter, and importer of dairy products. The majority of dairy farmers in the southern export-focussed regions have felt the immediate impact of the downturn in international commodity prices. The outlook farmgate milk price for 2009/10 will depend on commodity prices and the strength of the Australian currency relative to the US currency. The ability for farmers to reduce production costs and protect margins will depend critically on their debt exposures and reliance on bought in feed.

Farmers supplying domestic fresh product markets requiring the security of year round milk production close to population centres have benefited from longer term supply contracts. Many have locked in relatively high prices for the next 12 months and beyond, in many cases.

Looking further ahead, the medium term outlook for the industry remains promising, with projected population growth and increased incomes in the developing world underpinning growing demand for dairy products. With supply constraints likely – particularly in traditional exporting regions – upward pressure will be maintained on dairy commodity prices. The Australian dairy industry is well placed to benefit from these trends as an established, reliable exporter of dairy products to key developing markets.

Nevertheless, volatility will remain a feature of dairy markets. The challenge for the industry into the future is to develop managers and dairy production systems that are flexible and responsive enough to handle both the variability inherent in the market place, and increased climate variability. Farmers have demonstrated their ability to adapt and change in the past, but will need access to the very best research, technology market intelligence and support to keep pace with the opportunities and challenges the future holds.



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UNDERSTANDING HOW FEEDING DECISIONS IMPACT ON PROFITABILITY

Basil Doonan

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Abstract

Understanding how feeding decisions impacts on farm profit is one of the keys to running a successful dairy business. Many farm business managers adopt an oversimplified approach to this, comparing input prices to milk price. This is totally misleading.

For the large majority of dairy businesses profitability is driven to the largest extent by the successful harvesting of pasture or home grown forages. The forage base is dynamic and consistently changing which means that any feeding decision needs to incorporate how it will interact with the entire system at that point in time rather than simply making decisions based on the ratio of input costs to milk price.

Farm managers have been shown to consistently and repeatedly get this process wrong, particularly in times of higher milk prices when they tend to farm how they would like rather than how they should. This leaves these businesses particularly exposed when milk price falls or costs rise sharply.

Adopting a whole of business or systems approach to the decision making process around feeding is one way of alleviating this. Even the simplest feeding decisions are set in this complex and leaky environment and can have significant impacts at the business level.

Introduction

Most farmers are committed at some level to profitable feeding decisions and so the major problem is not to convince farmers that it is important, but rather to convince them that "they" (as managers), are almost solely responsible for the profit derived from these feeding decisions.

In a large proportion of Australia, feeding decisions are complicated by the fact that they are based on utilising a high proportion of the pasture base. This feed is not a consistent commodity in either quality or quantity throughout the year and as a result management challenges arise.

To result in improved profit, feeding decisions should be based on the principle that profit will be maximised when we are operating at the point where the marginal cost (MC) of producing the last unit of product (milksolids) is equal to the marginal revenue (MR) received from producing it. This relationship is described in Figure 1 below, with Q representing the profit maximising position and ATC being average total costs.

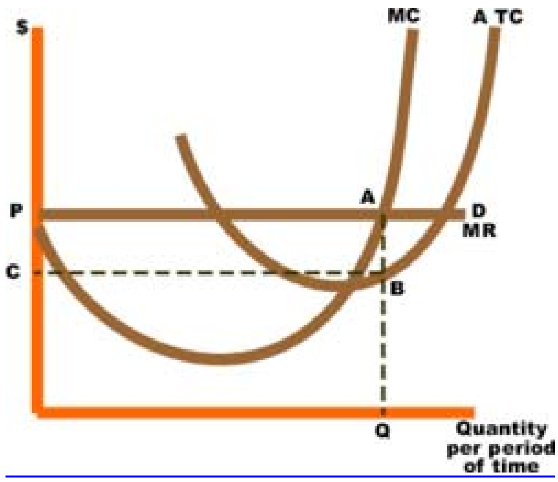

Figure 1: Profit maximisation

This relationship is the reason that as milk price increases we should expect to see an increase in the cost of production of the business. Analysis of benchmarking data clearly shows that as milk price fluctuates so too does the cost of production. This is illustrated in Figure 2, and taken on face value might suggest that farmers are reacting logically to increases or decreases in milk price. However this is not the case.

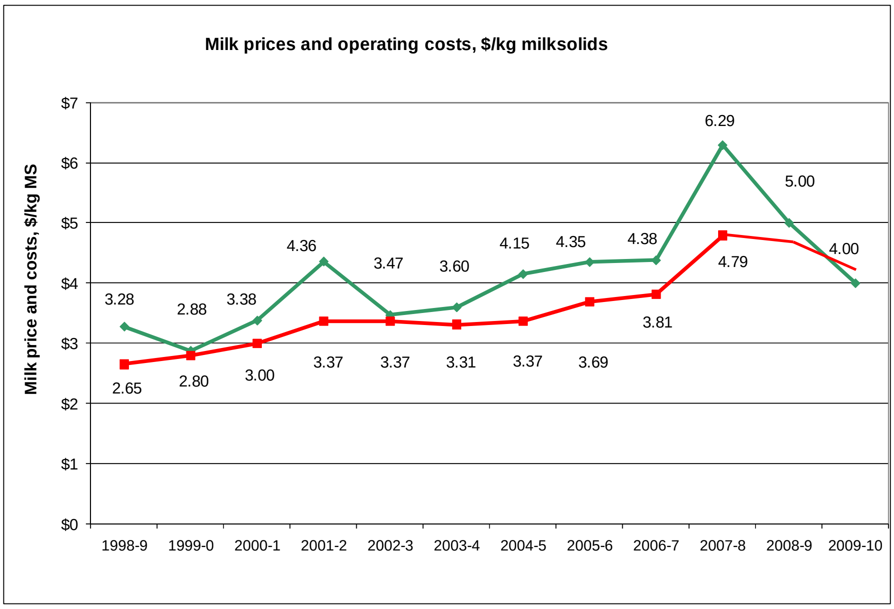

Figure 2: Relationship between milk price and cost of production of milksolids

The benchmarking data when paired with skills auditing information reveals an entirely different story and would suggest the following:

Firstly that most farmers lack the skills and knowledge to make profitable feeding decisions

That given an increase in milk price farmers will tend to farm the way they want rather than move towards profit maximisation.

The first point is illustrated below in Figure 3. The management of pastures is the key driver in making profitable feeding decisions. Yet on average most farmers have only a modest understanding of the principles associated with pasture management.

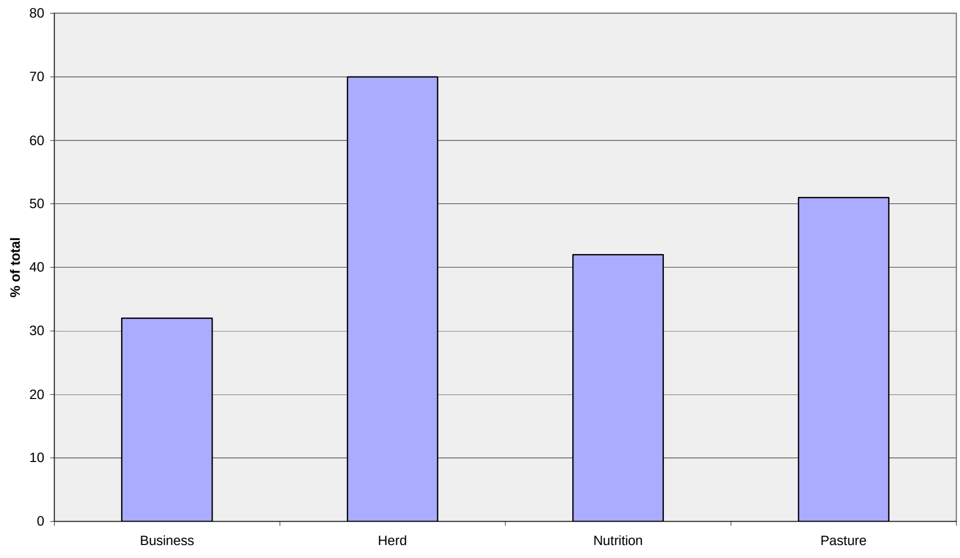

Figure 3: Average skill level of Tasmanian dairy farmers *DPIWE: 2004*[1]

Based on the extent that pasture management (or feeding decisions) drive profit and the fact that a return on capital year-in year-out of about 8% is required to cover interest on borrowed capital, in the order of 80% of managers do not have the necessary understanding of pasture management and feeding nutrition to make profitable decisions.

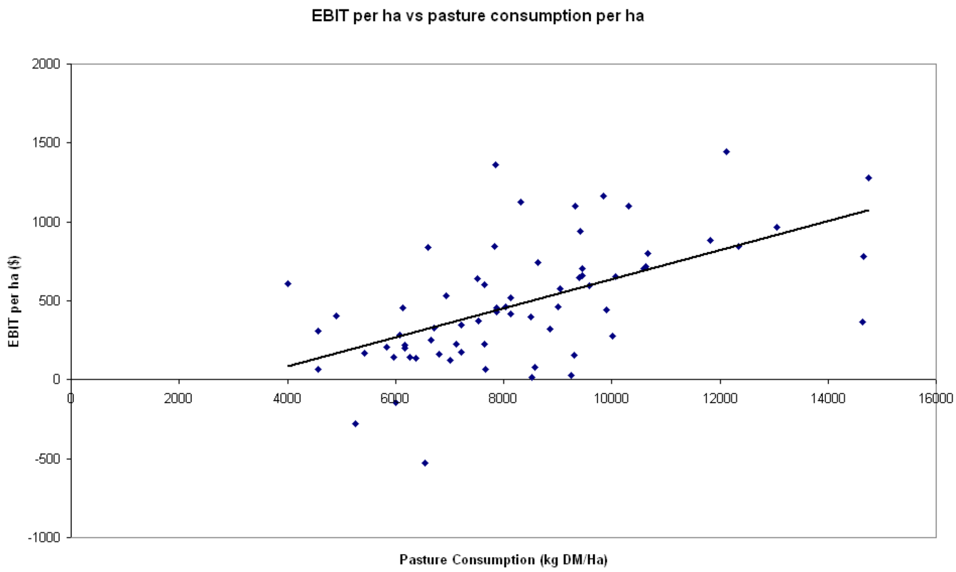

Figure 4: Relationship between gross margin and profit *DPIWE 2008*[3]

Figure 4 clearly illustrates that improving the utilisation of the resource base, that is, increasing pasture utilisation, increases profit (up to a point that most farmers are yet to achieve). It stands to reason then that those farmers with higher levels of skill in the area of pasture management and feeding will be more profitable.

If we look at the skill level of the top 10% of framers (based on return on capital) we find

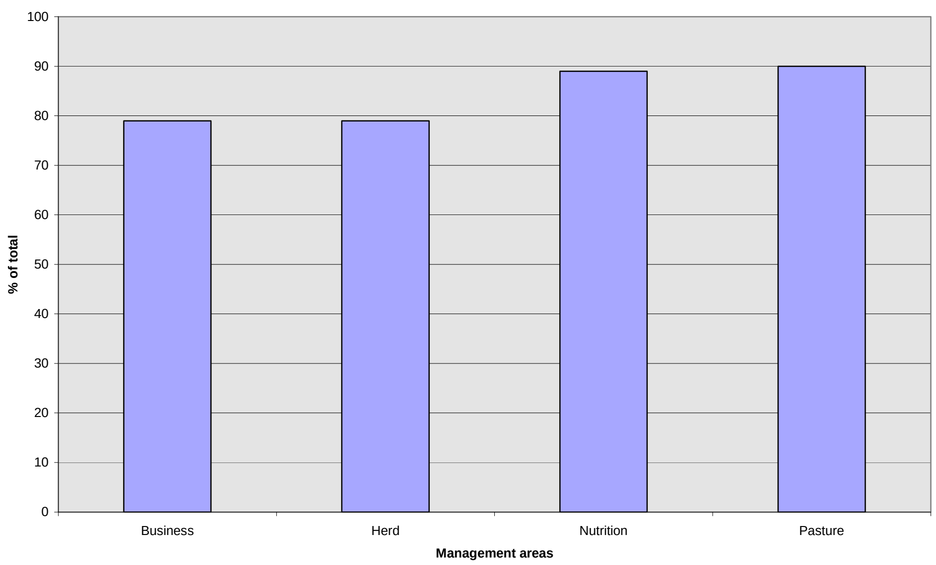

Figure 5: Skill level of the top 10% of Tasmanian dairy farmers *DPIWE 2004*[1]

that their skill profile is very different to that of the average farmer. In fact it is this higher level of skill that ultimately drives profit.

The second issue associated with feeding decisions is that farmers will tend to farm how the like to rather than how they should as milk solid price increases. Farmers have certain beliefs that are not always grounded in fact, as an example "that as the ratio of milk price to concentrate price improves we should/can feed more concentrates". This is very much an oversimplification of the MC: MR relationship.

The best illustration of the lack of understanding of the MC:MR relationship or the propensity for farmers to farm how they like to rather than farming for profit is a simple analysis of how the best farmers and the average group of farmers reacted to the increased (record high) milk price in the 2007-08 season. This relationship, along with some of the key drivers is described in Table 1 below.

Table 1: How two categories of farmers react to milk price changes

	2006-07		2007-08	
	Average*	Top 10%	Average*	Top 10%
Milk price	4.39	4.39	6.33	4.39
Increase in farm value			15%	35%
ROC	5%	12%	8%	16%
MS	151,000	165,000	172,000 (10%)	204,000 (24%)
N/ha	144	192	212 (47%)	232 (21%)
Grain	800	1100	1150 (44%)	1200 (9%)
Pasture harvested	9,210	11,290	9,320 (1%)	12,350 (10%)

* Excludes the top 10%

() is the percentage increase from 2008 to 2009

[3] DPIWE (2008), Dairy Business of the Year Benchmarking program

In response to the increase in milk price the best farmers spend more on inputs but use these inputs to increase overall profit. The average farmers spend much more (as a percentage) on inputs without an accompanying increase in production to offset these costs.

In fact 80% of the farmers in the average group would have been better off doing the same production as the previous season and not increasing costs. All of the additional money spent on feeding cows actually cost them money. Another way to think of this is that while turnover increased only people external to the business benefitted from this.

In contrast to this, in all cases the additional costs in feeding cows on the best farms resulted in an improved profit position over doing the same thing as the previous season. The result of this comparison is that the average farmer (the bottom 90%) on average is not capable of making profitable feeding decisions. The top farmers continue to make profitable feeding decisions despite seasonal, price and cost variations.

If farmers really want to improve profit from their feeding decisions they need to:

Increase their skills in the area of pasture management

Increase their understanding of animal and plant grazing relationships

Have an intimate knowledge of their system and how it responds as a whole to operational feeding decisions

1. PASTURE MANAGEMENT

Ultimately the management of the pasture resource should be aimed at achieving three things:

1. A high quality feed for the grazing animal
2. A large amount of this feed to reduce business overheads
3. Conditions that allow the pasture to persist.

Understanding how plants grow

It is important to understand plant morphology because this is what we use to establish the grazing interval (or rotation) and is strongly linked to plant physiology. In the past the grazing rotation has been set in a number of ways including drymatter accumulation, pasture height or average numbers for certain times of the year e.g. 20 days in spring. These are inappropriate because the will not necessarily help us achieve the grazing objectives set out above.

Plants such as ryegrass are a population of tillers. Each tiller has its own leaves and roots (see Figure 6) but they are interconnected and can share nutrients. Tillers live for about a year and as a result the management imposed on a pasture each year determines the survivability in subsequent years.

New tillers evolve from daughter tillers that develop from growing points at the base of a mature tiller. Because plants will naturally elongate, during seed-head formation, and large amounts of fibre accumulate during this process seeding is discouraged in most grazing systems. This is why vegetative reproduction is so important.

The daughter tiller is reliant on the parent plant until such time as it develops its own leaves and roots; this usually takes at least one grazing rotation. If either the parent tiller or daughter tiller is stressed during this time, the daughter tiller dies.

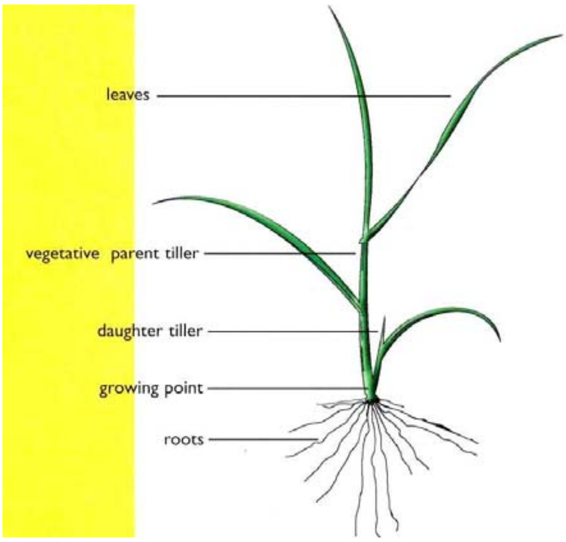

Figure 6: Vegetative ryegrass tiller with daughter tiller at the 3-leaf stage of growth

Energy production and use in tillers

Along with the nutrients obtained from the soil, plants need energy to grow. Plants use their leaves to catch sunlight and convert this to energy using a process called photosynthesis.

The end product of this process is water-soluble carbohydrates (WSC) which plants use to produce leaves, roots and daughter tillers. The WSC that are surplus to these requirements are stored in the base of the plant and are used to regrow immediately after defoliation when the plant has limited or no leaves.

Growth of pasture

After grazing, tillers will regrow the first new leaf from their energy reserves. This is often seen after grazing as the lime green regrowth that occurs within 24-48 hours. During this period the plant is unable to maintain root growth and new tiller formation from energy reserves so the plant effectively stops these.

As the first new leaf starts to photosynthesise it makes its own WSC, all of which is used for growth of the leaf, none is stored. It isn't until one full leaf has emerged that the plant begins to store WSC. At this point the plant starts to require nutrient in increasing amounts and the roots begin to grow again. The plant is very vulnerable to grazing at this stage because it has no stored WSC to regrow from. Pasture persistency is also being jeopardised because daughter tillers are still dependent on the parent plant.

Once the plant has grown its second leaf, WSC reserves have been recharged to the point where the plant can regrow after grazing. At this point no damage will be done to the parent tiller by grazing however the daughter tillers are susceptible to grazing.

As the tiller extends another leaf (3-leaf stage), root growth and tillering are now fully active and the daughter tillers are independent of the parent and can withstand repeated grazing. During this phase herbage accumulation is maximised and plants are ready to be grazed.

As the 4th leaf emerges, the oldest leaf starts to die, so that the tiller maintains 3 live leaves. At this stage, the quality of the feed on offer decreases as part of it consists of dead and decaying material of low nutritive value.

In order to maintain pasture persistency, ryegrass should be grazed at 2.5 to 3 leaves with the only acceptations being canopy closure, when disease occurs and in late spring when the plant is trying to produce seed heads.

1. Canopy closure is when the uppermost leaves of the pasture form a dense cover that prevents light penetration. Canopy closure takes precedence over the grazing physiology outlined above. The reason for this is that when canopy closure occurs, no more net growth will take place because light is limiting and the pasture is best harvested at this stage.

2. When the pasture is infested by disease such as rust, it is best to graze it and remove the infected pasture to prevent the disease spreading.

3. During peak growth in spring it may be beneficial to graze at 2 leaves in order to prevent the excessive elongation associated with seed head formation. This elongation results in high levels of fibre in the pasture and reduces the quality of the feed on offer and the animal’s ability to consume the feed.

Grazing Management

There are three aspects to grazing management including grazing interval, grazing intensity and grazing duration. All three are important considerations for the grazing manager.

Grazing interval

Deciding when to graze ryegrass dominant pastures should be based on the leaf-stage of plants for the reasons outlined earlier. The optimum time to graze is when ryegrass is at the 2.5-3-leaf stage.

Grazing interval and pasture production

Pasture has a sigmoid (s-shaped) growth pattern (Figure 7). After grazing, pasture growth is slow (Phase 1) with plants relying on reserves of energy to begin growing new leaves. As plants grow more leaf area, the growth rate increases (Phase 2) to a point where shading and decay of the plants resulting in a decreasing growth rate (Phase 3).

Obviously the optimum time to graze to optimise pasture production is towards the end of Phase 2, once maximum herbage accumulation has been achieved and before decay begins. A practical way to determine this is to monitor the grass plants and look for the first signs of decay. This will often coincide with 2-3 leaves per plant. Constantly monitoring LER and predicting changes in this will allow the rotation length to be adjusted to maximise pasture production.

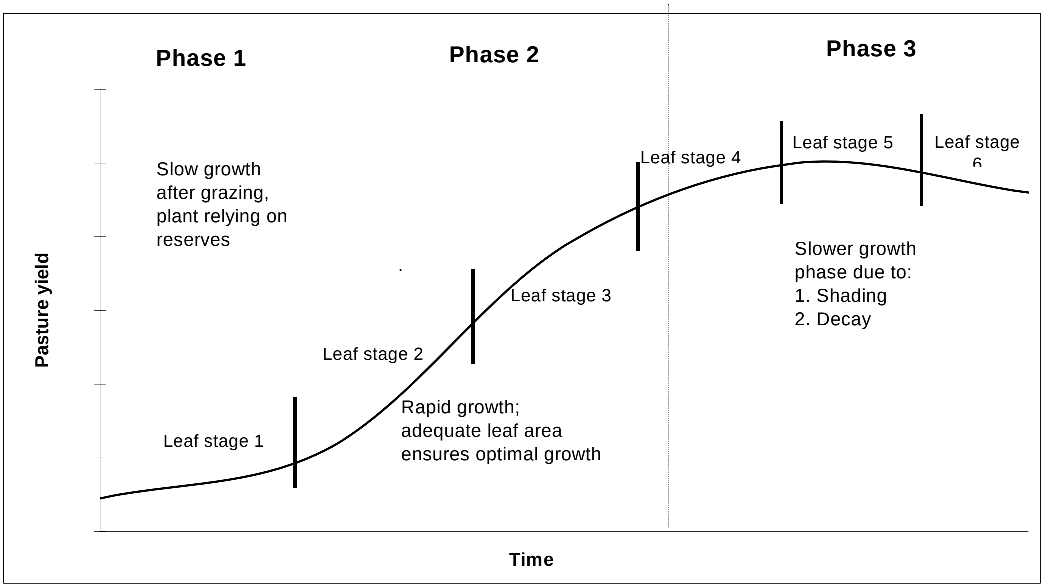

Figure 7: The growth pattern of pastures

The constant monitoring of pasture physiology is much more important than the accuracy of the measurement because the pasture is constantly changing. The rotation length should be adjusted for increasing or decreasing levels of moisture and temperature.

As an example of this, when grazing occurs at the appropriate grazing interval, approximately 50% of the feed grown in any given rotation occurs in the last 30% of the grazing rotation. This has huge implications for farm profit and is almost the sole reason as to why many farmers are so much more profitable than others. Pastures measured by Donaghy[4] in Tasmania exhibited the following growth pattern:

- 1 leaf stage = 10-20 kg DM/ha/day
- 2 leaf stage = 30-60 kg DM/ha/day
- 3 leaf stage = 90-110 kg DM/ha/day

As can be seen small errors in the rotation length can result in very large reductions in pasture accumulation. If this lost pasture has to be replaced by expensive supplements then the cost to the business is very large.

Similarly it is often the case that farmers will apply large amounts of nitrogen just to have canopy closure occur at 2 leaves. While these pastures can be extremely productive removing the nitrogen and increasing the rotation length to coincide with 2.5-3 leaves generally increases farm profit.

Grazing interval and pasture quality

Table 2 outlines changes in pasture quality with leaf stage. The levels of minerals change dramatically as growth progresses. Fortunately the nutritive value of ryegrass becomes better aligned with the animal requirement as we approach the appropriate grazing time based on leaf stage.

Table 2: Changes in the nutritive value of ryegrass at increasing leaf stages

Leaf stage	NSC/DIP	% RDP	Ca:P	K/(Ca+Mg)	Energy
1	1:2	35	1:1	8	1.3
2	1:1	25	1.5:1	-	2.5
3	2:1	24	2:1	2.5	3
Optimal	2:1	19	2:1	2.2	-

[4] Donaghy, D. (2007) Maximising pasture harvested and energy density to promote high levels of milk production. Redsky conference New Zealand

In addition to the changes in mineral content of the pasture, changes in both the energy and nitrogen level of the pasture are also more aligned with the animals' requirements.

One of the most common reasons given for running faster than appropriate grazing rotations is to reduce the proportion f fibre in the diet in order to increase intake and hence production. In fact there is only a very weak relationship between fibre levels of pastures and leaf stage. Figure 8 shows the relationship between fibre levels (measured as NDF) and leaf stage for a number of Tasmanian farms.

Increased fibre levels in pastures tends to be cause by increased stem elongation, (associated with reproduction or shading) and senescence. In addition to this rotation lengths of longer than 3 leaves will almost always result in increased fibre levels.

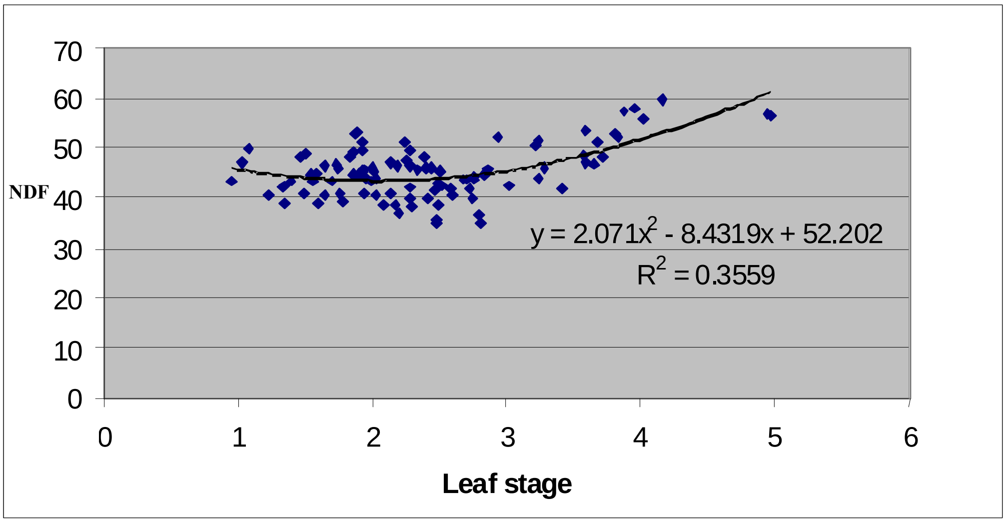

Figure 8: The relationship between fibre (NDF) and leaf stage Donaghy 2007[5]

Grazing intensity

Grazing intensity is how hard the pasture is grazed and is called the post-grazing residual. As the residual increases the intake of each individual animals increases and we can expect that production per animal will also increase. Post grazing residual is a useful guide to how well the animals are being fed and as to whether supplements should be made or fed.

The most pressing issue with respect to post grazing residual is to try to strike a balance between animal intake and plant regrowth and persistence. The ideal grazing residual from a plant perspective is in the order of 1500 kg DM/ha (or about 4 cm) because this means that all of the stored energy remains. Plants will regrow at their fastest rate. Higher post grazing

[5] Donaghy, D. (2007) Maximising pasture harvested and energy density to promote high levels of milk production. Redsky conference New Zealand

residuals would not increase regrowth but would increase animal intake. As a result animals must be used to manipulate grass and can never be fully fed (economically) on grass.

Residuals that are constantly too high result in the plant elevating its growing points above ground level where they are eventually grazed and the plant dies. Residuals that are constantly less than 4 cm have a less dramatic impact especially if plants are given time to recover. Constantly overgrazing will eventually result in a change in growth habit of the plant and they will tend to become smaller and grow sideways before elevating. This is commonly seen in sheep pastures.

When farm managers are forced to compromise between grazing to a lower residual and maintaining the appropriate grazing rotation, and increasing residual and running too fast a rotation they should graze down harder every time.

Setting the grazing rotation is therefore achieved by multiplying the LER by the target leaf stage at grazing.

Duration of grazing

Animals should not remain on a paddock longer than 3 days otherwise regrowth of the pasture suffers. If this increases to 5 days then large numbers of the tillers can be killed because their energy reserves and ability to regrow are compromised. Grazing for more than 5 consecutive days can result in the death of up to 50% of plants. Back-fencing can be used to stop cows grazing new growth in the paddock.

2. UNDERSTANDING ANIMAL AND PLANT INTERACTIONS

Growing large amounts of pasture will have limited impact on farm profit unless a large proportion of the feed is consumed by the grazing animals. There are a number of issues that farmers need to address in this area in order to optimise profit.

Matching feed supply and demand

In order to maximise the amount of pasture utilised, it is necessary to ensure the animals are being well fed while at the same time minimising the amount of pasture being wasted. Matching feed supply and demand as closely as possible does this.

Two tools that can help achieve this aim are a feed profile and a feed budget.

- Feed profile: a graph of pasture growth rates compared to animal requirements for a season. A feed profile can be used to best match stocking rate, calving date and spread and supplement policy to pasture growth.

- Feed budget: compares animal requirements with pasture growth rates. A feed budget is used to identify feed surpluses and shortfalls and determine when appropriate action needs to be taken to address these.

One of the most critical decisions made on a farm is the stocking rate that is set on the farm. The stocking rate determines the “mouth power” that is at the managers disposal to drive pasture utilisation and to capitalise on supplementary feeding decisions. Because stocking rate is the single most significant factor in pasture utilisation all feeding decisions should be made with this in mind. Often however this is not the case and decisions made in absence of this are likely to cost, rather than make money.

The fact that stocking rate is fixed at the start of the season means that there are factors other than input price to milk solid price that need to be considered. An example of this might be the use of nitrogen to produce milking feed. An average response might mean that the marginal cost of this feed is about 15c/kg DM and if utilised directly could result in an increase in profit.

On a similar farm where the stocking rate is lower the same feed produced from nitrogen may not be able to be grazed directly and may have to go through an ensiling process. By the time it is returned to the cow it may have fallen in quality by 10% and had up to 25% wastage resulting in a comparative cost based on energy of 43c/kg DM, and clearly unprofitable.

It is interesting that the same procedural operation can result in a very different outcome.

Pasture allocation

On a daily basis, pasture utilisation is determined by the amount of feed offered to the animals and the stocking rate we have at our disposal to consume it. The rotation length should be determined by the leaf-stage of the species in the sward. The amount of pasture in the paddock should determine how much is offered to the herd. Post-grazing residuals are a good indication of how well the cows are being fed. The aim is to leave a residual of 1,400-1,500 kg DM/ha.

If the herd is leaving more than this, and the rotation is matched to leaf emergence rate, paddocks may need to be removed from the rotation for hay/silage. If the cows are grazing below 1,400-1,500 and the rotation is matched to leaf emergence rate, there are several options: use nitrogen to grow more pasture, dry-off some cows, use a feed supplement, or accept lower milk production.

3. UNDERSTANDING YOUR FARM SYSTEM

The only way to truly understand an individual farming system is through benchmarking and economic analysis. Benchmarking is a 5 step process which involves:

1. Identify areas to improve
2. Identifying best practice
3. Understanding best practice
4. Adapting that practice to your system
5. Monitoring and continuously improving

Since less than 20% of farmers are engaged in benchmarking it is little wonder that less than 10% of farmers are able to achieve reasonable (above the cost of capital) returns.

Feeding decisions are complicated by the fact they have to be implemented in complex and leaky farming systems. Without a thorough understanding of the dairy business and of the businesses that technologies and strategies are being copied from it is understandable that profit is not guaranteed even if all of the right things are being done.

In more recent times we have seen a significant divergence in the resource bases used for dairy production. This means that comparative analysis, or comparing what one business is doing to another and copying what the best are doing is less likely to lead to improvements in profit. Feeding decisions are complicated by this and as a result analysis takes on increasing importance.

Many of the proponents of financial and economic decision making are now stating that even fundamental operational decisions associated with feeding need to be viewed from a whole farm perspective in order to improve the chance of a positive outcome.

Summary

If farmers are to make continuously sound feeding decisions they need to have a thorough understanding of grazing management including the relationship between animals and plants as well as a high level understanding of their business.

Recipe driven approaches are destined to fail with increasing certainty as the farming systems that evolve become more diverse and differentiated. It is however simple to obtain the skills required t make better feeding decisions and improve profit.


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FEEDING FOR PROFIT – FARMING FOR WEALTH

Ian Zandstra

Dairy Farmer, Nowra, NSW

Abstract

The two key factors impacting farm performance are the farming system and the business model. The core to our decisions is equity, as a goal and as a tool to grow our business for wealth creation. Our system is based on managing debt load and operating margin. We believe the whole farm rather than the cow is the factory and our system is on maximising milk production from relatively cheaper home grown feed. A successful system has to be repeatable our sharefarmer started with few cows in 2007 and is on his way to 800 head and machinery ownership.

Introduction

Profitable dairy farming is a combination of managing the technical (physical/operational) aspect efficiently and control over the financial costs. This simple division of the farm business (any business) can be extrapolated into the two most determining factors in farm performance:

- ***The farming system***. Systems co-ordinate the business for profit, the decisions about best use of resources. It is about 'decision-making', which is probably the main 'difference' between farm businesses. Systems are the physical or technical (farm operations) aspects of management of the farm.
- the biggest decision we make is our ***business model*** - scale, growth, assets, debt, skill, simplicity, complexity, labour, management, family farm, partners, share farming, corporate etc. – these things determine structure and durability and with this come farm aspirations, the vision for the business.

These are the frames around which we make our decisions. Either one can make or wreck the other, but both have to be good to deliver ***cash flow, profit and wealth creation***.

Most of my presentation will be about how these two building blocks are the cornerstone of our business and my discussion will focus on my understanding of the business of dairy farming. We all enter dairying for the operational aspects, clearly it takes a special person to want to do it, but for our farm the business side is the real focus. ***Equity*** (our own funds, our wealth, its use and further creation) is the key around which everything turns.

I like to divide farmers into two groups ***– either 'satisfisers' or 'optimisers'*** - just this thought puts a different perspective on attitudes to adoption of technology, investment, ROA, debt, wealth creation, even profit.

We farm as a partnership, Warnes and Zandstra at Pyree, near Nowra, NSW, on the Shoalhaven floodplain. Cheryl and I purchased our small first farm in 1982. We have 800 acres of land, about 660 pasture and arable. It is typical coastal dairying country and very wet at times. Our area has a town recycled water irrigation scheme and we have three centre pivots, with 170 acres irrigated. In the peak of a dry summer there is invariably a shortage of water. We have had a sharefarmer for two years who owns the cows and will milk 600 lactations this year. We share the monies after all feed related costs, including agistment. The sharefarmer pays for on-farm paddock work (except hay and silage making). We have supplied the machinery; he has started to buy some. It is a model based on margin over feed costs (MOFC). Milking hectares will be increased with heifers and dry cows grazed on another property.

The Business Model

There has been one feature that has always marked our business, – ***high debt loads***. This has been enabled by (or forced) management of ***high operating margins***. Since feed costs are the main variable, controlling margins and monitoring milk response has been the operating focus.

What have been the shapers of our business?

1. chance to borrow money and acquire productive pasture land
2. lots of debt
3. regulated pricing and the last litre response signal
4. also that "averaging" price during regulation was a false signal
5. the low prices post deregulation and volatile pricing

As you can see the shapers are financial – price, costs and the decisions we make, our economic choice of use of resources.

These have led to two important considerations:

- tight cost control over operations

- a watch on the cost of growth, yet growth has always been needed.

Dairying has so many segments, variables, (feed, fertiliser, land, labour, capital, management, etc) that farmers don't often know ***which spend creates which response.*** Spends at the time might be considered an ***input but in reality simply could become a burdensome cost*** – inputs are meant to create a positive response but who often knows what spend does what. Sometime the best approach is to do a ***'zero based budget'*** - calculate if you would be any worse off if you did not spend the money.

Spend can be assessed through financial analysis but our best test is to have the "tight and lean" thought process at all times, just always be on watch. Always ask what is the physical (and then financial) response to expenditure decisions. These things, in truth, are ***internal rates of return*** or ***marginal analysis***, but that's for accountants and consultants, for us it becomes gut feel, maybe a philosophy of farming.

Young farmers start up on the operational level (it's their interest) and don't get into the financials until they start running the accounts or running out of money. Then the issue is probably on ***segments or marginal analysis***, hopefully focusing on the few things that really make a difference. The main ones are milk response to feed costs and overcapitalisation. With marginal work it is not only identifying ineffective spends but maybe also a need to increase spends, so might not only be a matter of tightening some costs but also increasing cost where there is an effective response. The real test is not low cost but ***cost leadership*** in a segment and then whole farm, as cost effective as possible; this is productivity.

This has led to our business model and low cost farming system and I am not sure which come first but I think it is the 'tightness' of the farming system that has enabled the debt which has led to a business model of asset accumulation and wealth creation.

Debt drives our business because land assets for home grown feed drive our system. It is the simplest of equations – if margins on home grown fed are the greatest, use that margin to buy the resource. Equally if you have the asset, a farm, and it is worth a lot of money, use it. But if margins need to be high, a system to get high margins has to be employed - ***high pasture utilisation, grazing pressure, grass, cows and mouths and low purchased feed costs***

Farm Production

Year	**2005/06**	**2006/07**	**2007/08**	**2008/09**
Milk production (million litres)	2.2	1.9	2.22	2.8
Fat/Protein %	3.93/3.25	4.0/3.25	4.10/3.21	4.12/3.3
Milk solid (Kg x 1,000)	106	137.5	162	208
Milk price (cents per litre)	32	34.5	47	57
Number of cows	400	320	380	500
Previous Milk Prices	**2001/02**	**2002/03**	**2003/04**	**2004/05**
Cents per litre	32.15	28.15	33.4	30.4

Feeding philosophy

We believe dairying is not about cows but about feed; dry matter (DM), its availability, type, cost, seasonality, quality, (fibre, protein, energy) etc. In fact if a farmer wants to make as much as he can out of feed, the other costs associated with feed have to minimised as well; the lowest cost feed way is to graze, if that cannot be done 100% then the next best low cost way has to be used. It is too easy to get ***the 'iron disease'***, machinery, around the farm feeding regime. This could over capitalise the farm but unfortunately is not often calculated as a cost of feed, is often hidden in the farm debt. We would sooner invest in non-depreciable assets as hard assets are the cornerstone of a business, the productive base and the equity for gearing. We do not want our business to be a '***cash churner'***, consuming all the potential margin as operating spend, throwing the money at milk.

It is about ***whether the farm is the factory or whether the cow is***. Maximum productivity must come from the farm first and forage represents the highest farm yields but does not give peak cow yields. To achieve that any supplement to forage must not lead to substitution of home grown forage and hence less utilisation (of the feed and the farm). More digestible, lower fibre or higher DM conserved forages can be fed to increase DMI, hence milk production. This is the first option. Grain and concentrates increase DMI but substitution must be allowed for. High input/output systems are driven by energy concentration (MJ of metabolisable energy, ME) and the increased DMI that comes with concentrated feed, low fibre and high digestibility.

With a grazing system we focus on quality forage DMI and fully feed cows to appetite with minimal concentrate supplementation (we feed about just over 1 tonne per cow per annum). The concept is mainly DMI focused but also MJME with lots of total available MJME's from lots of forage into lots of cows, rather than high MJME per cow. This is where the ***cow system*** is very important for us, a part of keeping it simple – small cows, cross breeding, low maintenance per cow, important when home grown pasture is in short supply. Herd costs are not a major part of any farm expenses but cow inefficiencies can be major, especially in terms of stress on cow and farmer (calving troubles, fertility, temperament, feet troubles)

The cow model

This cows model is part of the feeding model – smaller, lower maintenance cows, especially important in low feed times and to enable plenty of willing mouths at good times. Our system is high farm production not high per cow production. The second would give higher production per hectare but the measure should be pasture utilisation per hectare as a first. Per cow production is 5,600 litres (cross breeds and high % heifers with expansion). Pasture utilisation is 14 tonnes DM per hectare, with a stocking rate of 4.5 cows per hectare on the grazing platform. Milk production per hectare is 21,500 litres. Cows have DMI of 3.1 tonne pasture, 1.1 tonne concentrate and 1 tonne conserved hay and silage with 50% of conserved feed (maize and grass silage) purchased at approx $210 per tonne DM. Conserved feed is used in DMI gaps and concentrate use decreases with forage ME increase. It is used in energy gaps.

The key is that if farmers want more milk from a cow then it is at cost greater than pasture or home grown forage. Cows can be well fed on grass alone but there is the need for:

- filling feed gaps,
- for supplementing nutrients (especially energy) and overcoming low pasture DMI
- profitable feeding to make more money but the feed price/ milk response is the key. Concentrated feeds cost more and are best effective at high milk prices or low grain prices

A farmer can get more litres per cow but at what price, allowing for all the costs. The ***economies of scale*** are hard to get, that the extra production attained from increasing size adds costs and ROA is often not enhanced. However scale economies can be perceived to be achieved by the simple process of purchased feed; the farmer buys more and better feed and production increases; the business has got bigger and better without any capital investment. – the revenue line has increased. This is the ***'dilution is the solution'*** model, especially if even more cows are added; the fixed cost are diluted by more output and although per unit margin might decrease from diminishing marginal returns, total farm margin increases.

This is an important concept in dairying and reflects that farmers might have no other way to grow so they must drive their assets harder. This is growth at the margin line – all else is paid for, ***('by sunk costs'),*** the response to a marginal spend (cost per feed unit), can be measured with its marginal return, litres of milk (and its value).

Although this growth in per cow production and farm revenue seems to happen at the margin line with a positive response it often has hidden extra costs:

1. Should not all the milk pay for the "sunk costs"
2. Many farms go down this path and grazing pressure backs off, pasture utilisation decreases – supplements are not used to full advantage
3. It is often instigated at good times and becomes entrenched and hard to back away from in droughts, low milk prices, high feed cost years. The variable cost becomes a fixed cost of the farm model.
4. It is therefore financially riskier
5. Is more complex right across the spectrum – cows, management, skill, labour

But there is another very valid but often denied fact – ***'the cost creep'*** (see Paul Bethane's article at the Symposium 2006). The further a farmer moves from a low cost grazing system then per unit costs increases. If the milk price stays the same the margin decreases. Are our farmers developing systems and infrastructure costs that add to the per unit cost of milk, systems that grow the farm and production with no improvement in productivity and efficiency. At high milk prices do farmers chew up margin with infrastructure and capital costs. Once again the test is margin over operating costs, feed being the main one, and all cost, including capital and labour, related to feed.

EBTDA – free cash flow – the financial choices

Our business is based on ***profit margin***, margin after operations (which is different from accounting profit). We now have as a target with the sharefarmer an MOFC of 60% to 70%.

MOFC was 65% in 07/08. This varies with the milk price. Other operating costs are then paid separately by the partners, but the next key cost has always been debt servicing. This can only be done from ***"free cash flow"*** – ***the EBITDA*** of a business (earning before interest, tax, depreciation, amortisation). This line is in all businesses and is really the line after all operating costs. This is the financial part of the business (apart from monitoring operating costs). Depreciation has to be monitored; it can be a useful tool or can reflect overcapitalisation and poor investment choices.

Decisions below the EBITDA line become a matter of choice, ***'discretionary 'decisions***, and it is here where the ***lifestyle***, business growth, durability and ***wealth creation*** decisions are made. New non depreciable assets can be expensive, but they add to the productivity of the farm. If they add to economies of scale through productivity and efficiency improvements (they should) the increase in scale and synergies pay their way and in time there is capital appreciation and wealth creation.

Sustainable and repeatable?

But the real valid test for any system is ***'is it repeatable'?*** Too many systems have all the bells, whistles and glory but are not repeatable. It is hard to get a start and buy some land today, but apart from that this system can create profits and although debt might be a financial risk a high operating margin system has less financial exposure. We have a sharefarmer; there is in our business something to share. He had 15 head of cattle in June 2007, he now has 800, and some machinery. He has some debt, which is not a bad thing, but considerable equity; he is on his way, based on cost control and operating profit.

We capture the margin, avoid over-capitalisation, invest in debt and cover for margin squeeze. We have grown through the many phases of the industry

- it is the mountains that inspire you but the valleys that make you
- never let a good crisis go to waste – when you lose don't lose the lesson
- good businesses are made in tough times
- profit has to be planned for, not just catching what falls out after expenses
- profit is the best risk management tool

It is all on the financial side of things – the operational matters we all have advice on, it is technical – the key is if it is profitable.

BOVINE MAMMARY STEM CELLS AND MILK PRODUCTION

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Bovine Mammary Stem Cells

A stem cell is an undifferentiated cell that does not possess any tissue-specific structures or perform specialised cellular functions. However stem cells have the ability to proliferate and supply cells that can later differentiate into specialised cells that maintain tissue integrity and function. Adult stem cells (as opposed to embryonic stem cells) are found in a wide range of tissues including the bovine mammary gland.

The differentiated cells of the bovine mammary gland include mammary epithelial cells (those that produce milk), myoepithelial cells (involved in milk secretion) and cells forming connective tissues. The declining milk yield throughout lactation, characterised by a classical lactation curve, is associated with changes in mammary epithelial cell number (Capuco *et al*., 2003, Stefanon *et al*., 2002). There is a dynamic turn-over of cells during lactation with the sum of cellular proliferation and differentiation rates vs. cell death (apoptosis) altering over time. It has been estimated that the majority of cells present in the mammary gland at the end of lactation are the products of cell renewal during lactation (Capuco *et al*., 2001)

Bovine Mammary Stem Cells and Production

Studying the biology of the stem cells present in the mammary glands of dairy cattle may provide an insight into the mechanisms governing two key attributes of mammary gland cellular biology a) the number of mammary epithelial cells present during lactation that may influence the level of milk production and b) the balance between cells that are replaced by mammary stem cell division during lactation compared to the number of cells that undergo cell death and affect the persistency of lactation (length of lactation at high levels of production).

A recent study has shown that infusion of a specific molecule into the bovine mammary gland may enhance the rate of cellular proliferation (Capuco *et al*., 2009) demonstrating the potential to manipulate the mechanisms of mammary epithelial cell renewal in vivo.

The ability to extend lactation with persistent high levels of milk production may provide advantages in relation to the requirement in most production systems for a concurrent pregnancy. In the systems where the proposed timing of conception may coincide with a period of negative energy balance due to high or peak levels of milk production, impacts on fertility have been observed. The relationships between lactation, energy balance and fertility have been extensively reviewed (Macmillan *et al*., 1996).

Increasing the persistence of lactation by manipulating mammary stem cell populations may allow additional management opportunities reducing the necessity for a concurrent pregnancy and lactation until a time of decreased metabolic demand and/or increased availability of feed. This may moderate the energy balance of the dairy production animal and has the potential to alleviate production related disorders such as decreased fertility.

Bovine Stem Cells in Milk

Interestingly, putative stem cells have been identified in human breast milk (Cregan *et al*., 2007) and maternal cells have been found in neonatal tissues (Srivatsa *et al*., 2003). This suggests that the passage of cells, including stem cells, from the mother to the baby may play a role in human neonatal development. The idea that stem cells may be present in bovine milk raises questions about the role that these cells may have in calf health and development.

Bovine Mammary Stem Cell Research

We have commenced a research program to identify those cells that exhibit stem cell like characteristics present in the mammary gland through pregnancy and lactation or that are observed in milk throughout lactation. Further research will allow isolation of putative mammary stem cell populations from both mammary tissue and milk and investigate the molecular regulation of these cells that enable their potential for replication. It is hoped that elucidation of the molecular characteristics of these cells may provide opportunities for animal selection or other interventions that could enable flexibility in management of dairy production systems.

Conclusions

An understanding of the activity of bovine mammary stem cell populations during lactation and their influence on lactation persistency has not yet been well characterised. Elucidating the cytodynamics of bovine mammary stem cells may lead to opportunities to alter the lactation cycle and indirectly influence reproductive efficiency and animal welfare by alleviating the metabolic demands on high producing dairy cows.

References

Capuco, A.V., Wood, D.L., Baldwin, R., McLeod, K., Paape, M.J. 2001. Mammary cell number, proliferation, and apoptosis during bovine lactation: relation to milk production and effect of bST. J. Dairy Sci. 84: 2177-2187.

Capuco, A.V., Ellis, S.E., Hale, S.A., Long, E., Erdman, R.A., Zhao, X., Paape, M.J. 2003. Lactation persistency: insights from mammary cell proliferation studies. J. Anim. Sci. 81: Suppl 3: 18-31.

Capuco, A.V., Evock-Clover, C.M., Minuti, A., Wood, D.L. 2009. In vivo expansion of the mammary stem/ progenitor cell population by xanthosine infusion. Exp. Biol. Med. 234: 475-482

Cregan, M.D., Fan, Y., Appelbee, A., Brown, M.L., Klopcic, B., Koppen, J., Mitoulas, L.R., Piper, K.M.E., Choolani, M.A., Chong, Y.S., Hartmann, P.E. 2007. Identification of nestin-positive putative mammary stem cells in human breastmilk. Cell Tissue Res. 329: 129-136.

Macmillan, K.L., Lean, I.J., Westwood, C.T. 1996. The effects of lactation on the fertility of dairy cows. Aust. Vet. J. 73: 141-7

Srivatsa, B., Srivatsa, S., Johnson, K.L., Bianchi, D.W. 2003. Maternal cell microchimerism in newborn tissues. J Pediatr.142:31-35.

Stefanon, B., Colitti, M., Gabai, G., Knight, C.H., Wilde, C.J. 2002. Mammary apoptosis and lactational persistency in dairy animals. J. Dairy. Res. 69: 37-52.

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RUMEN DEGRADATION KINETICS OF FORAGE RAPE (*BRASSICA NAPUS*) AT DIFFERENT WEEKS OF MATURITY

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Introduction

Forage rape (*Brassica napus*) can be used to fill the autumn feed gap in a pasture-based system due to its rapid growth and high quality (Garcia *et al*., 2008). Forage rape has a high metabolisable energy (ME), crude protein (CP) and nitrate content but low neutral detergent fibre (NDF) content (Fulkerson, 2008). However, to develop effective grazing management, information on changes in nutritive value of forage rape with growth is needed. The changes in the forage quality results primarily from a decrease in leaf:stem ratio and increased proportion of cell wall and lignification. Therefore, the objective of the present study was to determine the rumen degradation kinetics of leaf, petiole and stem fractions of forage rape during its growth.

Materials and methods

Forage rape (cv. Goliath) was harvested 10-15 cm from ground level at 6 weeks after sowing (when older leaves had started to senesce) and then at weekly intervals to 13 weeks. Plants were separated into leaf, petiole and stem fractions, with the separated fractions pooled and chopped into 1 to 2 cm pieces and refrigerated (4°C) immediately. Rumen-fistulated sheep were used to measure the rumen degradation parameters of dry matter (DM), nitrogen and neutral detergent fibre (NDF) of the three fractions using *in sacco* nylon bag technique. The *in sacco* degradability data obtained from each sheep were fitted according to the exponential equation of Orskov and McDonald (1979). Statistical analysis was carried out by linear mixed models (REML procedure of GENSTAT 11, Laws Agricultural Trust, 2008).

Results and Discussion

The DM disappearance curves for week 1, 3, 5 and 7 (weeks 2, 4 and 6 were omitted for clarity) are presented in Figure 1. In general, degradation of DM, N and NDF decreased with maturity. However, the rate of degradation of DM was higher

(P<0.001) for leaves compared to petioles and stem. The degradation of N was rapid among all the plant fractions; >80% N was degraded within 12 h for leaves and petioles; and within 24 h for the stem component.

The rate of fibre degradation of leaf (mean = 0.13/h) was faster (P<0.001) than petioles (0.06/h) and stem (0.03/h). This was reflected in higher NDF content in stem (mean = 323 g/kg DM), which was 60% and 26% higher than leaf (mean = 130 g/kg DM) and petiole (mean = 239 g/kg DM), respectively. However, the mechanical stability of the stems was due to larger stem diameter, and not primarily due to lignifications of vascular ring (Evans *et al*., 2003) as evident in ryegrass pastures (Chaves *et al*., 2006).

Further, the quality of forage rape is higher than ryegrass with a higher DM degradation rate from day 22 until day 112 (0.11 to 0.04/h, Chaves *et al*., 2006) compared to forage rape leaf (0.26 to 0.08/h), petioles and stem (0.13 to 0.03/h) from day 49 to day 91. This higher nutritive value of forage rape fractions (except stem in the later stages) over weeks 7 to 13 of maturity, compared to perennial ryegrass pasture is an important feature of forage rape.

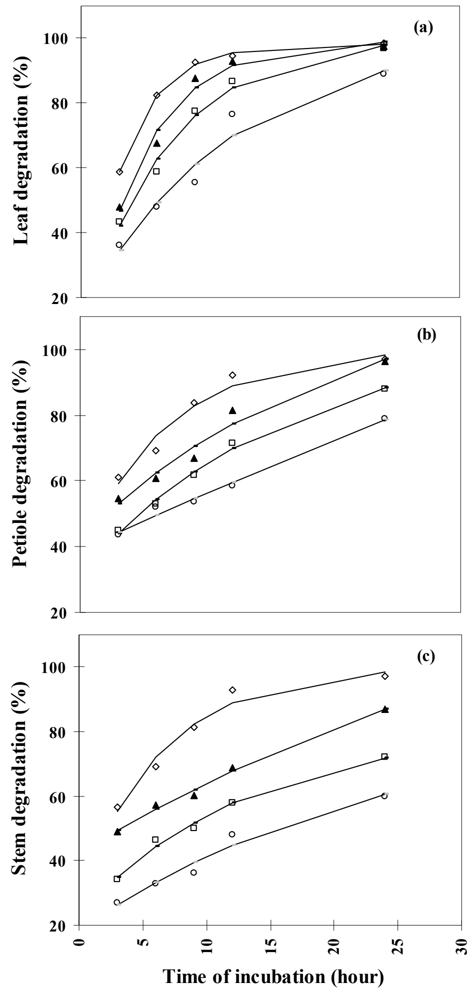

Figure 1: Dry matter (DM) degradation of leaves (a), petioles (b), and stem (c) at week 1 (◊), week 3 (▲), week 5 (□) and week 7 (○).

The practical implications are that nutritive value of forage rape (particularly leaf and petiole fractions) remained higher from week 7 until week 13, which gives more flexibility as to when to graze the crop.

References

Chaves, A.V., Waghorn, G.C., Brookes, I.M., Woodfield, D.R. 2006. Effect of maturation and initial harvest dates on the nutritive characteristics of ryegrass (*Lolium perenne L.*). Animal Feed Science and Technology 127, 293-318.

Evans, B.W., Snape, C.E., Jarvis, M.C. 2003. Lignification in relation to the biennial growth habit in brassicas. Phytochemistry 63, 765-769.

Fulkerson, W.J. 2008. Growing forage rape in autumn. Technical note, Futuredairy p. 1-6.

Garcia, S.C., Fulkerson, W.J., Brookes, S.U. 2008. Dry matter production, nutritive value and efficiency of nutrient utilization of a complementary forage rotation compared to a grass pasture system. Grass and Forage Science 63, 284-300.

Lawes Agricultural Trust, 2008. Genstat 11.1 (PC/Windows). VSN International Limited, UK.

Orskov, E.R., McDonald, I. 1979. The estimation of protein degradability in the rumen from incubation measurement weighted according to the rate of passage. Journal of Agricultural Science 92, 499-503.

PEPTIDES CONTAINED IN MILK AND FERMENTED MILK AS A POTENTIAL SOURCE OF REGULATORS OF BIOACTIVITIES

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Introduction

Milk contains components that provide nutritive elements, immunological protection and biologically active substances. Bioactive peptides can be generated during enzymatic proteolysis from bovine caseins and whey proteins, as in the case of gastro–intestinal digestion or during food processing (FitzGerald and Meisel, 1999; Hayes, Ross *et al.*, 2007; Meisel, 2004). Among the bioactive peptides, those manifesting anti-hypertensive, opioid and immuno-modulatory activities are extensively studied and frequently exploited in the production of foodstuff formulated to provide putative health benefits (Meisel, 2004).

Here we present the results of two studies aiming to demonstrate the immunomodulatory activity of peptides derived form milk proteins, and the intestinal absorption of an intact long chain peptide.

Material and Methods

In Exp. 1 we assessed the immunomodulatory activity of milk fermented by Enterococcus faecalis TH653 or Lactobacillus delbrueckii subsp. bulgaricus LA2 isolated from Italian traditional dairy products and selected among a panel of dairy acid lactic bacteria strains on the basis of their proteolytic activity. The bacteria were used to ferment sterilized skim milk. The obtained fermented milks were centrifuged and filtered and the fraction with molecular weight lower than 5 KDa (low MW fraction) was retained for further assays. The 5 KDa fractions obtained from fermented milks or the α-lactoalbumin-derived peptide Tyr-Gly-Gly (YGG peptide) were administered at different concentrations to bovine lymphocytes (BPBL) to evaluate their effect on cellular proliferation. In Exp. 2 we assessed the intestinal absorption of β-CN(193-209) peptide, a 17 residues peptide derived from C-terminal end of β-Casein (1881 Da). The peptide was obtained by enzymatic treatment as described by (Bouhallab, Molle *et al.*, 1993). β-CN (193-209) was administered to the in vitro Caco-2 cell model for the intestinal epithelium. Caco-2 cell monolayers were grown on semipermeable filters and β-CN(193-209) peptide (2 mM) was added to the apical compartment (120 min incubation) in presence or not of selective inhibitors of peptide transport to investigate the pathway of transepithelial transport of β-CN(193-209). The β-CN(193-209) peptide was quantified by mass spectrometry.

Results

Experiment 1

Only the low MW fraction obtained from the milk fermented by L. delb. burgaricus LA2 and administered to the lymphocytes with conA significantly (P < 0.01) decreased BPBL proliferation. An inhibitory effect of YGG peptide was observed only in presence of the mitogen concanavalin A (conA), and the response was affected also by new-born calf serum (NCS) concentration in the culture medium (Fig. 1).

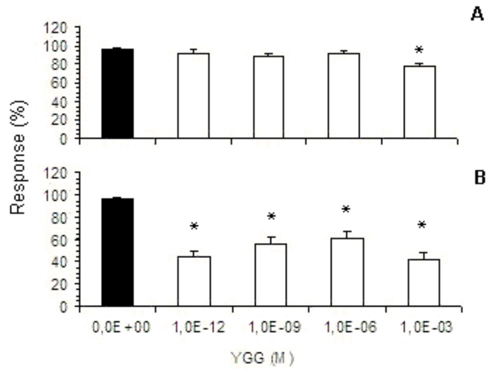

Figure 1: Effect of synthetic YGG on cellular proliferation in different culture conditions (A: 10% NCS with conA; B: 2.5% NCS with conA). The response is expressed as the percentage of the maximum absorbance observed and compared with the control (black box).

Experiment 2

After the incubation, β-CN(193-209) appeared in basolateral compartment at the micro molar range and its transport was inhibited by wortmannin, indicating that it is transported across the monolayer by transcytosis (Fig. 2).

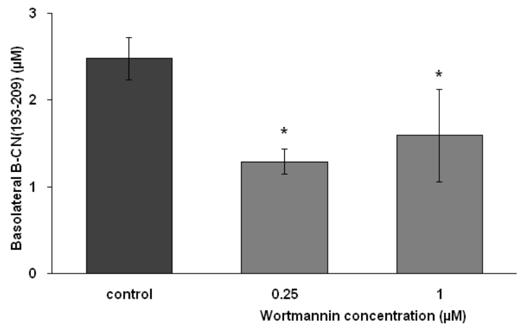

Figure 2: Effect of different concentrations of wortmannin (an inhibitor of transcytosis) on transport of β-CN (193-209) peptide across the Caco-2 cell monolayers.

Discussion

The hypothesis that milk and milk derived products contain peptides with an hormone-like activity is well accepted (Hayes, Ross *et al*., 2007; Meisel, 2004). Bioactive peptide generation occurs during the production of cheeses and fermented milks or during gastro-intestinal digestion. We demonstrated that milk fermented by the lactic acid bacteria L. delb. bulgaricus can decrease the proliferation of conA-activated bovine lymphocytes. This strains is normally used for yogurt production, thus it is possible that during yogurt making immunomodulatory peptides are generated. To identify the mechanisms of action responsible of this immuno-modulatory activity, we evaluated the effect of the milk-derived peptide YGG on bovine lymphocytes proliferation. YGG is an immuno-active peptide that could be generated from milk proteins by bacterial enzymes (Kayser and Meisel, 1996). Our results suggested that it negatively affected lymphocytes proliferation. Finally, the milk-derived peptide β-CN(193-209) is transported by trans-cytosis trough a Caco-2 monolayer, a well known in vitro model for the intestinal epithelium. So, even large peptides could be potentially available to influence biological functions. Further studies are needed to clarify if these activities are retained in vivo.

References

Bouhallab, S., Molle, D., Leonil, J. 1993. Continuous Hydrolysis of Beta-Casein in A Membrane Reactor - Preparation of A Bioactive Peptide. Biotechnology Letters, 15, 697-702.

Fitzgerald, R.J., Meisel, H. 1999. Lactokinins: Whey protein-derived ACE inhibitory peptides. Nahrung-Food, 43, 165-167.

Hayes, M., Ross, R.P., Fitzgerald, G.F., Stanton, C. 2007. Putting microbes to work: dairy fermentation, cell factories and bioactive peptides. Part I: overview. Biotechnol. J., 2, 426-434.

Kayser, H., Meisel, H. 1996. Stimulation of human peripheral blood lymphocytes by bioactive peptides derived from bovine milk proteins. Febs Letters, 383, 18-20.

Meisel, H. 2004. Multifunctional peptides encrypted in milk proteins. Biofactors, 21, 55-61.

THE EFFECT OF YERBA MATE (*ILEX PARAGUARIENSIS)* SUPPLEMENTATION ON THE PERFORMANCE OF DAIRY CALVES

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Introduction

The use of herbs as additives in livestock nutrition, as an alternative to other chemical compounds, is becoming a new goal in livestock production (Makkar *et al*., 2007). It is known that Yerba Mate (YM) tea (Ilex Paraguarensis) exerts antioxidant activity due to its content of several compounds such as polyphenols (Heck and De Mejia, 2007). The use of alternative feedstuff like YM, in ruminant nutrition represents a novel management tool that is green, clean, ethical (Martin and Kadokawa, 2006) and extremely easy to use. The effect of YM supplementation in ruminants has received little attention and thus, the role and the activity of natural antioxidants not commonly present in the diets of ruminants warrants investigation. Preliminary observations have shown that YM could be recommended as a natural novel feed supplement with the potential for improving feed intake and wool growth in lambs (Celi and Raadsma, 2009). The hypothesis of this study was that the supplementation of YM tea in calves' diet will improve their growth rate. We proposed to test this hypothesis by supplementing calves' diet with YM, and to monitor their oxidative and metabolic status and productive performances.

Material and Methods

The study was conducted at the Corstorphine Dairy Farm of the Camden campus, Faculty of Veterinary Science. We used 48 Holstein calves that were randomly allocated to two groups: one group (n = 24) was fed with fresh milk (control) and one group (n = 24) was fed the fresh milk with 50g of finely ground YM. Feeding was carried out twice each day where calves were fed fresh milk from communal calf feeders with dividers to ensure each calf received their allocated ration. Calves received the dietary treatments for a total of 10 weeks and were monitored weekly for live weight (LW). Blood samples were taken from all calves, at Week 0 (before the start of the administration of the dietary treatments) and then every fortnight. Blood samples were centrifuged and plasma was analysed for total antioxidant capacity (TAC), advanced oxidation protein products (AOPP), protein, urea, albumin, non-esterified fatty acids (NEFA), ß-hydroxybutyric acid (BHBA), triglycerides and cholesterol. Changes in LW and plasma concentration of metabolites were analysed by means of REML linear mixed model. The effect of age, sex and treatment group and their combined effects were analysed. Live weight data was analysed after a logarithmic (base e) transformation.

Results and Discussion

This study demonstrated that supplementation of YM to dairy calves had statistically significant effects on their metabolic and oxidative status which eventuated in lower LW (P<0.01) end of the trial (Table 1). We observed that TAC was significantly influenced by age, sex and treatment (P=0.011), however, no clear trend was evident as no group had a consistently high or low TAC levels over various ages or between sexes. This is most likely due to the complex regulation of endogenous antioxidant expression. Since the maintenance of redox homeostasis is modulated by various substances that form the antioxidant defense system (Lykkesfeldt and Svendsen 2007) the possibility that an overabundance of one type of antioxidant could be counterbalanced by down-regulating the expression of others is a likely possibility (Celi *et al.* 2008).

The metabolic parameters assayed determined that supplemented calves had elevated triglycerides in the plasma (P<0.05) and lower plasma albumin

Table 1: Live weight in calves supplemented with Yerba Mate or Control.

	Week									
	1	2	3	4	5	6	7	8	9	10
Control	42 ± 4	44 ± 4	46 ± 4	50 ± 4	56 ± 4	61 ± 5	65 ± 5a	72 ± 4A	78 ± 5A	83 ± 5A
Yerba Mate	42 ± 2	44 ± 4	47 ± 2	50 ± 3	54 ± 4	59 ± 4	63 ± 5b	68 ± 5B	74 ± 5B	79 ± 5B

Different small and capital letters within column indicate statistical difference at P<0.05 and P<0.01.

(P<0.01). These results suggest that supplemented calves were utilising adipose reserves rather than storing fat. The levels of protein, urea and cholesterol were within physiological range suggesting that this is most likely due to an increased demand for energy rather than malabsorption and this is supported by the lower growth rates of supplemented calves. One possibility for our observations is an upregulation of thermogenesis. It has been found that caffeine, particularly in combination with polyphenols can function by increasing resting energy expenditure and fat oxidation by increasing thermogenesis (Lee and Kim, 2009). It was beyond the scope of this study to establish the mechanism by which YM exerts an effect but our results suggest that further research on its effect on thermogenesis and the effects on long term production performances are warranted. These studies can lead to the development of new feeding strategies that can exploit the beneficial effects of YM. If we can increase thermogenesis in young calves with YM supplementation we can hypothesise that the supplemented calves will have higher cold tolerance and thus higher chances of survival.

References

Celi, P., A. Di Trana, and A. Quaranta. 2008. Metabolic profile and oxidative status in goats during the peripartum period. Australian Journal of Experimental Agriculture 48: 1004-1008.

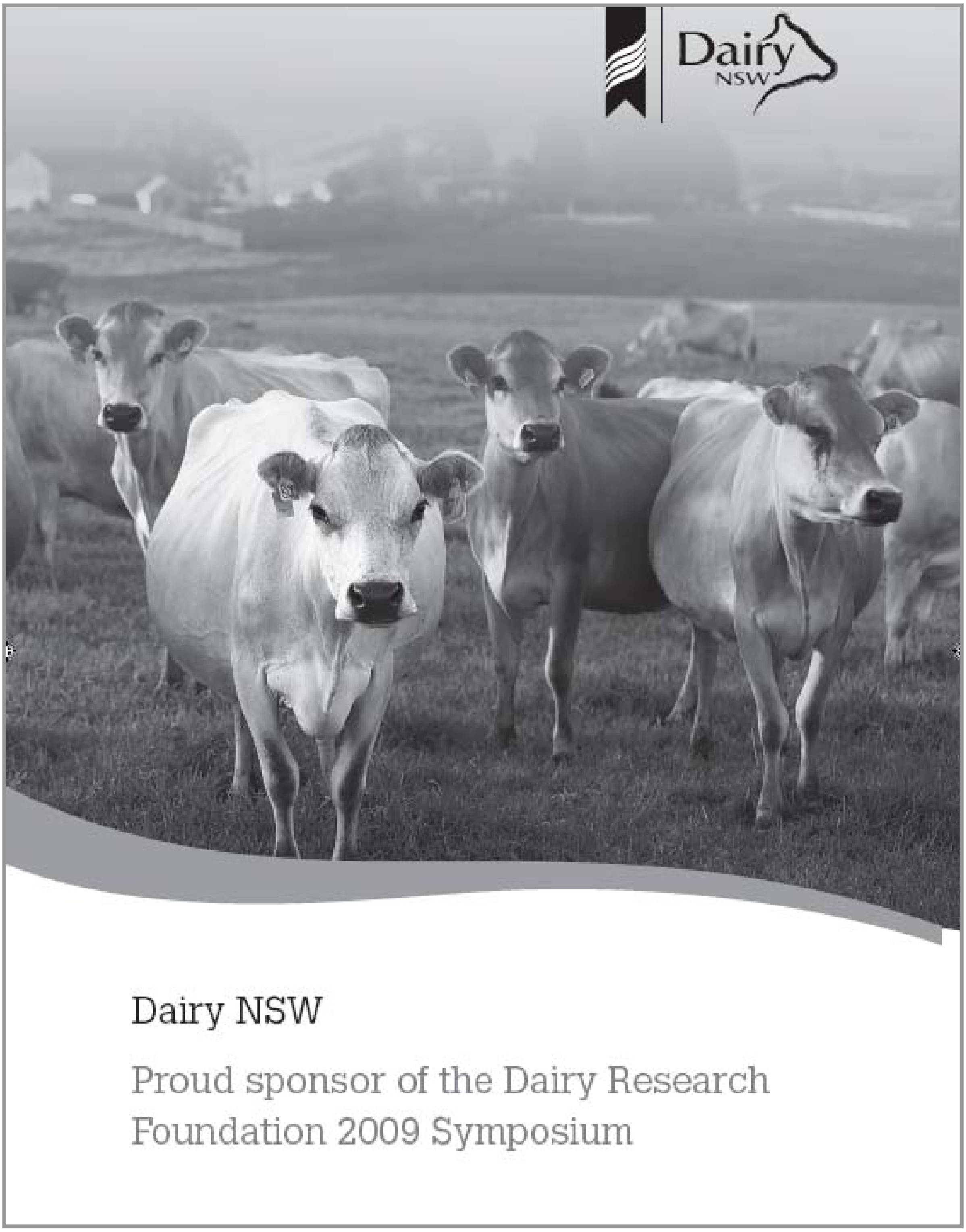
Celi, P. and Raadsma, H. W. 2009. The effects of Yerba Mate (*Ilex paraguarensis*) supplementation on the productive performance of lambs. Proc. XIth Int.l Symp. Ruminant Physiology, Clermont-Ferrand, France (In Press).

Makkar, H.P.S., Francis, G., and K. Becker, 2007. Bioactivity of phytochemicals in some lesser-known plants and their effects and potential applications in livestock and aquaculture production systems. Animal 1 : 1371-1391.

Martin, G.B. and H. Kadokawa, 2006. "Clean, Green and Ethical" Animal Production. Case Study: Reproductive Efficiency in Small Ruminants. J. Reprod. Develop. 52 : 145-152.

Lee, M. S. and Y. Kim 2009. Epi-gallocatechin-3-gallate Enhances Un-coupling Protein 2 Gene Expression in 3T3-L1 Adipocytes. Bioscience Bio-technology and Biochemistry 73: 434-436.

Lykkesfeldt, J. and O. Svendsen. 2007. Oxidants and antioxidants in disease: oxidative stress in farm animals. Veterinary Journal 173(3): 502-511.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SUBACUTE RUMINAL ACIDOSIS IN FIELD CONDITIONS IN THE NORTH OF ITALY: EPIDEMIOLOGY AND SYSTEMIC-METABOLIC EFFECTS INVESTIGATION

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Introduction

SubAcute Ruminal Acidosis (SARA) represents one of the most important metabolic disorders in intensive dairy farms (Owens *et al*., 1998; Enemark *et al*., 2002; Morgante *et al.,* 2007). SARA can develop following the administration of excessive amounts of rapidly fermentable carbohydrates, deficiency of fibre or errors in delivery of the ration. It has been suggested that acidic rumen environment, changes in osmotic pressure, and the endotoxin released from lysis of Gram-negative bacteria in the rumen may render the rumen epithelium susceptible to injury resulting in translocation of endotoxin into the bloodstream and onset of organic inflammatory response (Kleen *et al*., 2003). The aim of this study was to investigate the incidence of SARA in high producing dairy cows. Possible relationships with some haematological parameters were also investigated.

Material and Methods

In this study we used 132 high producing cows from 12 herds located in Veneto region in the North of Italy. Ruminal and blood samples were collected by rumenocentesis and jugular venipuncture, from 12 healthy cows randomly selected within each herd. Of the 132 cows sampled: 92 were between 5 and 60 Days in Milk (DIM), 40 between 61 and 270 DIM. Rumen pH was measured immediately and the cows were divided in the following groups (Bovine Class) according to the classification proposed by Nordlund and Garrett, (1994): group 1 = animals with rumen pH > 5.8 (normal); group 2 = 5.6 < pH < 5.8 (risk of SARA); group 3 = pH < 5.6 (SARA-affected). Furthermore we divided the farms into 3 groups (Herd Class): group A = farms classified as normal, group B = farms at risk of SARA, group C = SARA-affected farms. Blood samples were analysed for red blood cells (RBC), white blood cells (WBC), platelets, plasma proteins, glucose, beta-hydroxy-butyrate (BHBA) and haptoglobin. Analysis of variance was applied to evaluate the effect of ruminal pH on these systemic parameters within the Bovine Class, and within the Herd Class. Pairwise multiple comparison procedures (Tuckey Test) was applied to determine if differences were statistically significant (P<0.05). Pearson correlation coefficients were determined for the parameters measured in this study.

Results

Our result show that 95 cows presented physiological rumen pH values while 20 were at risk and 17 had SARA. The istribution of cows within Herd Class was very similar (51 cows in Group A, 36 in Group B, 45 in Group C). Statistically significant differences (P<0.05) were observed for various blood parameters (Table 1). Overall they showed a negative correlation with rumen pH in Groups A and C, but always within reference ranges.

Discussion

Our data confirmed that SARA must be considered as a herd problem because animals within a herd present similar pH values. SARA is not only typical of fresh cows but is quite common in mid/late lactation (Table 1) and thus should be monitored across the entire lactation.

Table 1: Mean and standard deviation of rumen pH, DIM and blood parameters in the Herd Class.

Parameter	Group A	Group B	Group C
Rumen pH	6.19 ± 0.39	6.06 ± 0.34	5.84 ± 0.35
DIM	43.69 ± 29.05	38.39 ± 22.24	82.73 ± 62.10
RBC (106/µl)	5.05 ± 2.01a	5.78 ± 0.62b	5.83 ± 0.60b
HGB (g/dl)	8.88 ± 3.49a	10.18 ± 0.92b	10.28 ± 0.88b
HCT (%)	26.12±10.30a	30.04 ± 2.91b	30.43 ± 2.81b
PLT (103/µl)	434.54 ± 209.88a	548.24 ± 146.89b	447.16 ± 106.29b
WBC (103/µl)	6.06 ± 2.71	6.89 ± 1.84	6.51 ± 1.91
Neutrophils (103/µl)	2.89 ± 1.69	3.57 ± 1.54	3.06 ± 1.36
Lymphocytes (103/µl)	2.46 ± 1.94	2.48 ± 0.59	2.66 ± 0.78
Tot proteins (g/l)	79.92 ± 8.22	78.58 ± 9.26	82.09 ± 8.69
Albumin (g/l)	34.29 ± 2.83a	33.94 ± 4.56a	35.98 ± 3.08b
Haptoglobin (g/l)	0.18 ± 0.42	0.06 ± 0.14	0.11 ± 0.06
Glucose (mmol/l)	2.90 ± 0.31a	3.03 ± 0.43a	3.24 ± 0.56b
BHBA (mmol/l)	0.73 ± 0.76a	1.88 ± 7.57b	0.61 ± .48a

Different letters within the same row indicate statistical difference at P<0.05.

We found alteration in blood parameters: slightly increased RBC and WBC and platelets numbers, lymphocytes, PCV, total plasma proteins and albumin suggesting a moderate dehydration and a subclinical general unhealthy status and welfare decrease. The elevated glucose in group C and BHBA in group B may be the result of increased propionate and butyrate absorption by the rumen wall. The absence of strong correlation between the level of rumen pH and haptoglobin (r2 = 0.115; P = 0.191) made us think that experimentally induced SARA, which is followed by a rise in acute phase proteins, is different from SARA observed in field conditions. We cannot say that there is a direct relationship between SARA and metabolism but the variations noticed in some blood parameters could reflect a link between intra and extra-ruminal events.

References

Enemark, J.M.D., Jorgenssen, R.S., Enemark, P.S. 2002. Rumen acidosis, with special emphasis on diagnostic aspects in subclinical rumen acidosis. A review. Veterinary Zootecnie 20: 16-29.

Kleen, J.L., Hooijer, G.A., Rehage, J., Noordhuizen, J.P. 2003. Subacute ruminal acidosis (SARA): a review. J. Vet. Med. A Physiol. Pathol. Clin. Med. 50: 406-414.

Morgante, M., Stelletta, C., Berzaghi, P., Gianesella, M., Andrighetto, I. 2007. Subacute rumen acidosis in lactating cows: an investigation in intensive Italian Dairy herds. J. Anim. Physiol. Anim. Nutr. 91: 226-234.

Nordlund K.V., Garrett, E.F. 1994. Rumenocentesis - a technique for collecting rumen fluid for the diagnosis of subacute rumen acidosis in dairy herds. The Bovine Prac. 28: 109-112.

Owens, F.N., Secrist, D.S., Hill, W.J., Gill, D.R. 1998. Acidosis in cattle - a review. J. Anim. Sci. 76: 275-286.

CONTINUOUS MONITORING OF RUMEN pH USING RUMEN PROBES

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Introduction

In an extensive survey of dairy farms in Australia, Bramley (2004) found that at least 30% of the dairy cows suffered from subacute rumen acidosis (SARA). This occurs when large amounts of concentrates are fed resulting in a sudden decrease in rumen fluid pH. This would be expected to lead to a reduction in feed utilisation and animal performance. Farmers could, however, better manage these adverse effects if they could monitor the current status of the rumen. Rumen probes that monitor rumen fluid pH, temperature and pressure have been developed and are commercially available (e.g. Kahne Ltd., New Zealand). However, their accuracy has not been determined. Therefore, a study was conducted to assess the accuracy of the probes when left into the rumen for a period of up to 10 days compared to the most common method of monitoring rumen pH (rumen fluid samples collected manually from fistulated animals and pH measured with a laboratory pH meter).

Material and Methods

The probes were calibrated and set to read rumen fluid pH every 20 minutes in rumen-fistulated sheep. The experimental design was a 4×4 latin square design to evaluate the behaviour of the probes under a range of rumen conditions. The sheep were fed one of the four diets varying in the forage to concentrate ratio: Diet G 0 (0% concentrate + 50% maize silage + 50% lucerne hay); Diet G 30 (30% concentrate + 35% maize silage + 35% lucerne hay); Diet G 60 (60% concentrate + 20% maize silage + 20% lucerne hay); or Diet G 60 fed as partial mixed ration (PMR). After the animals achieved the target level of intake (1.5 times maintenance requirements) for eight consecutive days, manual rumen fluid samples were taken for the next 2 days on day 9 (4, 8, 12, 16, 20 and 24 h) and day 10 (2, 6, 10, 14, 18 and 22 h) in order to have 12 samples at 2 h interval over a 24 h period. Rumen pH of these samples was recorded immediately.

Statistical analysis was performed to compare between the two methods using mixed models based on REML procedure. A range of other parameters were calculated which included-Mean square prediction error (MSPE) to measure the accuracy of the new method (Tedeschi, 2006); Pearson's correlation coefficient (r); and Lin's concordance correlation coefficient (CCC).

Results and Discussion

The probes started drifting when left inside the rumen of sheep for a period of 10 days. This drift was corrected mathematically by linear regression analysis. The probes were taken out of each animal, cleaned and re-calibrated before the other three sampling periods. There was no significant interaction ($P > 0.05$) between diet and time of sampling for either method (Figure 1). However, the disagreement between the two methods was indicated by: first, lower mean (± se) manual pH (6.10 ± 0.07) reading than the corrected probe pH (6.23 ± 0.08) reading; second, higher root mean prediction error (RMPE), which is square root of MSPE between manual pH and probe pH reading (0.46 pH units); and finally, by low Pearson correlation coefficient (r=0.38) and Lin's CCC (CCC=0.36) between the two methods of sampling (1.0 indicating perfect correlation).

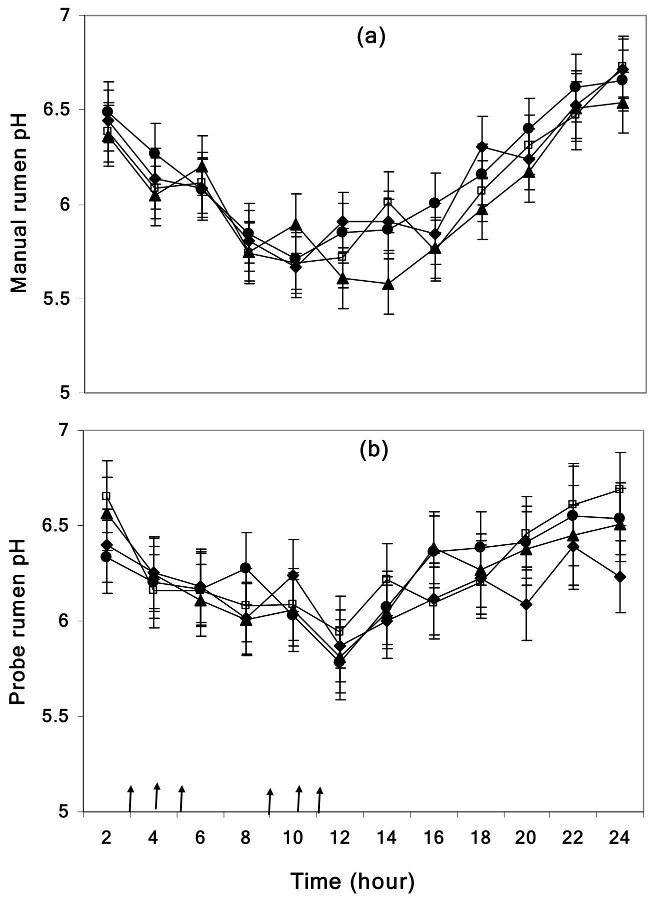

Figure 1. Diurnal variation in rumen pH depicted by (a) manual method and (b) probes after feeding diet G0 (◆), G30 (●), G60 (▲) and G60 (PMR) (□). Arrows indicate the time of feeding.

In conclusion, the results of the present study found a significant discrepancy between the two methods in relation to rumen pH. These probes need to be further refined to fix the time dependant upward drift in pH. This limits the use of these rumen probes for research and particularly for on-farm monitoring of rumen pH in intact animals.

References

Bramley, E. 2004. Ruminal acidosis in southern Australian dairy cattle. Ph.D Thesis, the University of Sydney, Australia.

Tedeschi, Lw.O. 2006. Assessment of the adequacy of mathematical models. Agricultural Systems 89, 225-247.

QUANTIFICATION OF THE EFFECTS OF INACCURATE PASTURE ALLOCATION IN A PASTURE BASED AUTOMATIC MILKING SYSTEM

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Introduction

As on-farm adoption of Automatic Milking is increasing in Australia, it is of increasing importance that a full understanding of the impact of pasture management and allocation within a pasture-based AMS is generated. This will to ensure that these and future installations are well equipped to achieve high levels of system performance. Regardless of the milking system, in Australia, pasture utilisation levels are closely linked with farm profitability due to the fact that pasture is the cheapest form of feed. Pasture allocation on conventional farms is often based on farmer instinct, desired grazing rotation length and historical practices. In reality the average farmer allocates the desired quantity of feed with an error rate of plus/minus 50% target (Fulkerson *et al*., 2005). On any farm inaccurate pasture allocation will likely impact on wastage levels, subsequent quality, regrowth and ultimately milk production (and the cost of this). The purpose of this study was to quantify the importance of accurate pasture allocation within an AMS.

Materials and Methods

The project was carried out at the AMS research farm (DPI NSW, Elizabeth Macarthur Agricultural Institute). The study involved the milking herd of around 160 pre-trained, mixed aged lactating cows milked through two DeLaval Voluntary Milking systems (VMS). The trial grazing area consisted of around 16ha of kikuyu and ryegrass based pasture. Cows were allocated two grazing strips of pasture a day and trafficked through a set of automatic drafting gates to get to fresh pasture after depleting the previous strip. At the drafting gates cows were drafted to the dairy if milking permission was granted or to the paddock if milking permission was denied. Accurate and inaccurate pasture allocations were alternated within each grazing run.

Accurate pasture allocation: Cows were allocated 50% of their daily pasture allocation in each of the day and night paddocks (normal practice for AMS pasture-based farm using 2-way grazing). Prior to each grazing run (in total, 8 grazing runs covering a period from 6/8/08 to 18/4/09; each run comprised 6-10 days) pasture was measured using a C-Dax Rapid Pasture Meter to determine pre-grazing pasture masses (kgDM/ha). From this information a grazing plan was generated for the following seven days based on pre-grazing covers and an anticipated daily pasture growth rate.

The FarmWorks P-Plus software was used to map the grazing strips for the ensuing week.

Inaccurate pasture allocation: A similar method was used to simulate inaccurate pasture allocation. It was important that this was simulated rather than allocated randomly to ensure that total pasture intakes were similar across the two treatments for each trial run. Over a 48 hours period the sum of the each inaccurate allocation (two allocations/day = four in total) equaled the total 48 hours requirement/cow.

Results and Discussion

The average number of cows that were fetched (Figure 1) in each trial run was generally slightly lower in the accurate treatment. The significantly lower number of cows fetched with inaccurate treatment in trial run 7 suggests the under-allocation outweighed the over-allocations in this trial run. The trial runs with higher numbers of cows being fetched (trial run 3, 4 7 and 8) generally coincided with times when little or no supplementation (<4 kg DM/c/d) was made available to cows on the feedpad.

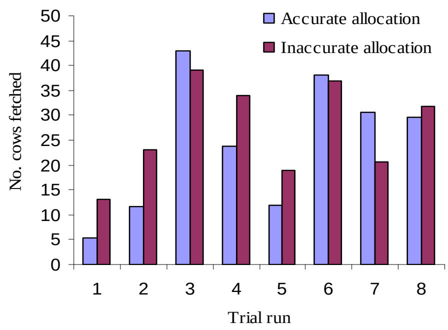

Figure 1. Average number of cows fetched/day for each trial run

Results presented in Figure 2 show that milking frequency was highest for accurate treatment in all but trial runs 5 and 7. Interestingly the higher milking frequency in grazing run 7 coincides with lower milk yields and fewer cows fetched which suggest inaccurate cows were underfed in this trial run. A similar trend was seen with milking frequency and milk production in trial run 5 (despite average fetchings being lower for inaccurate treatment in this trial run).

Milk yield results (fig. 3) showed that the accurate treatment resulted in 0.5-1.4 extra litres/cow/day in each trial run except for trial runs 5 and 6 (+/- 0.3 litres/cow/day).

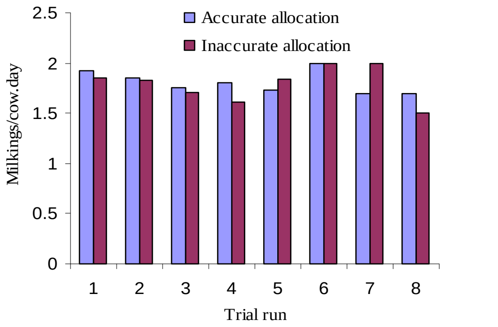

Figure 2. Average daily milking frequency for each trial run

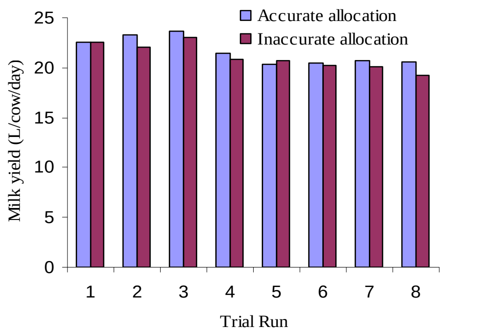

Figure 3. Average daily milk yields for each trial run

Conclusions

Whilst the results presented here are based on raw data, a full and detailed analysis will extend to comparisons between under allocation and over allocation (both contributed to the inaccurate treatment). Inaccurate pasture allocation on a commercial farm could result in cows generally being (a) under allocated, (b) over allocated or (c) averaging target *al*location levels with a higher level of variability (as in this study).

References

Fulkerson, W.J., McKean, K., Nandra, K.S. & Barchia, I.M. 2005. Benefits of accurately allocating feed on a daily basis to dairy cows grazing pasture. Australian Journal of Experimental Agriculture 45(4), 331-336.

FORAGE OPTIONS TO INCREASE FORAGE AND WATER PRODUCTIVITY IN AUTUMN-WINTER

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Introduction

In summer, 27 t dry matter (DM/ha) can be achieved by growing maize which is more than twice the yield of typical pasture over the same period (Garcia *et al*., 2008). However, about 8 ML/ha of total water are required to obtain such yield, from which about 5 ML must come typically from irrigation water. In low rainfall areas it is difficult for farmers to allocate such water to grow maize. One option to overcome this situation could be growing short rotation legumes in summer using about one third of the water required by the maize. These legumes can be followed in the forage rotation by either maize alone, or maize intercropped with forage rape or clover during autumn-winter. This system may offer several opportunities to the Australian dairy farmers as pasture availability is limited during this period. Growing forage maize for grazing or intercropping of maize with forage rape or clover may provide a way to increase forage yield in autumn which may in turn help farmers to reduce feed cost during this period. Water productivity (WP) of forage crops may be increased not only because of lower evaporative loss during this season, but also by using higher amount of rainfall that usually occurs during this season. Finally, the autumn sown maize and other crop can use the residual nitrogen (N) that was captured by the legumes grown in summer, which may lead to higher N productivity (NP) of the following autumn crops. Therefore, the FutureDairy 2 project is investigating a rotation of legume crops in summer, followed by maize grown alone or intercropped with forage rape or clover in autumn with the aim of providing forages during autumn-winter period when availability of home grown feed is limited.

Materials and methods

In summer, four legume forages (cowpea, fababean, lablab and soybean) were sown on 19 December with 240 kg diammonium phosphate/ha in 3 x 3 m plots at Camden. Total water received by all crops was 265 mm, of which 100 mm came from irrigation. All crops were harvested on 20 February and analysed for nutritive value. In early autumn, after harvesting the legumes, maize was sown either as a sole crop, or intercropped either with forage rape or Persian clover on 23 February. Sole maize received 100 kg N/ha, whereas forage rape received 70 kg N/ha but clover did not receive any N. All crops were harvested on 20 Apr. A total of 90 kg N/ha was applied to forage rape after 1st harvest. All crops received 101 mm irrigated water in addition to rainfall. Short rotation ryegrass was sown in plots of sole maize after harvesting. The 1st regrowth of the forage rape and other crops were harvested (2nd harvest) again on 30 June. A total of 44 mm irrigated water received by all crops during this period. The 3rd harvest of forage rape will be harvested in late August, but ryegrass and clover were harvested on 30 July. The final harvest (4th harvest) will be done in early-October.

Results

The total DM yield was similar for all legumes (6600 – 7600 kg/ha), although ~30% of yield of lablab and fababean was weed. Water productivity (27 – 31 kg DM/mm of total water) and ME (8.4 – 9.4 MJ/kg DM) content of all legumes were similar (Table 1). This led to higher WP (kg DM/mm) of maize-forage rape combination (77) than other treatments (48 - 50) (Figure 2) although N productivity was slightly lower in the former than the latter treatments.

Table 1: Foarge yield, water productivity and metabolisable energy of legumes.

Parameter	Cowpea	Fababean	Lablab	Soybean	s.e.d.	Significance
Total biomass yield (kg DM/ha)	7627	6795	7181	6624	244	ns
Water productivity (WP) (kg DM/mm)	31	28	29	27	1.0	ns
Irrigation WP (kg DM/mm)	69	62	65	51	2.22	ns
ME (MJ/kg DM)	7.8	6.6	7.4	7.2	0.02	P<0.001

ns =not significant;

Discussion

In summer, cowpea or soybean may be grown in situations where water is limited. In autumn-winter (up to 30 June), when the availability of forages for dairy cows is limited, a total of 11 t DM/ha is achievable from maize-forage rape intercrop combination by using only 1.5 ML of irrigation water. Garcia *et al*. (2008) obtained higher yield (17 t DM/ha) from a typical pasture using a total of 7.5 ML water, but over the whole year.

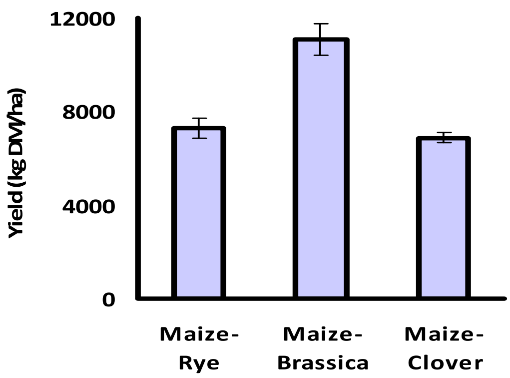


Fig 1: Yield (kg DM/ha) of forages grown in autumn-winter (up to 30 June).

This high yield and W productivity were possible simply by choosing the forage and by using the rainfall during this period. This result is significant because of at least two reasons. Firstly, it is giving a significant amount of forage when farmers need it, which ultimately reduce the cost of milk production. Finally, farmers able to better use the climate particularly rainfall, and consequently can save significant amounts of water. Another implication of this work could be the linking of the typical complementary forage rotation of maize-brassica-pea where maize-brassica intercropping instead of brassica in autumn-winter period which may lead to another 3 – 5 t DM/ha in addition to the yield of 40 t DM/ha that has already been achieved (Garcia *et al*., 2008).

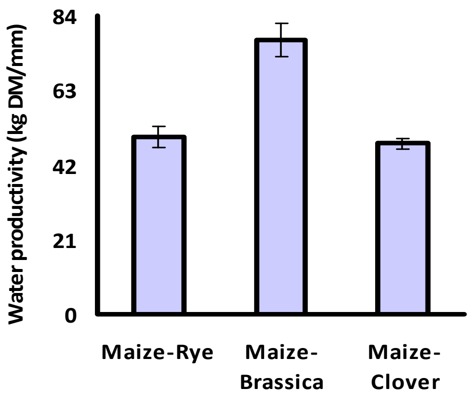
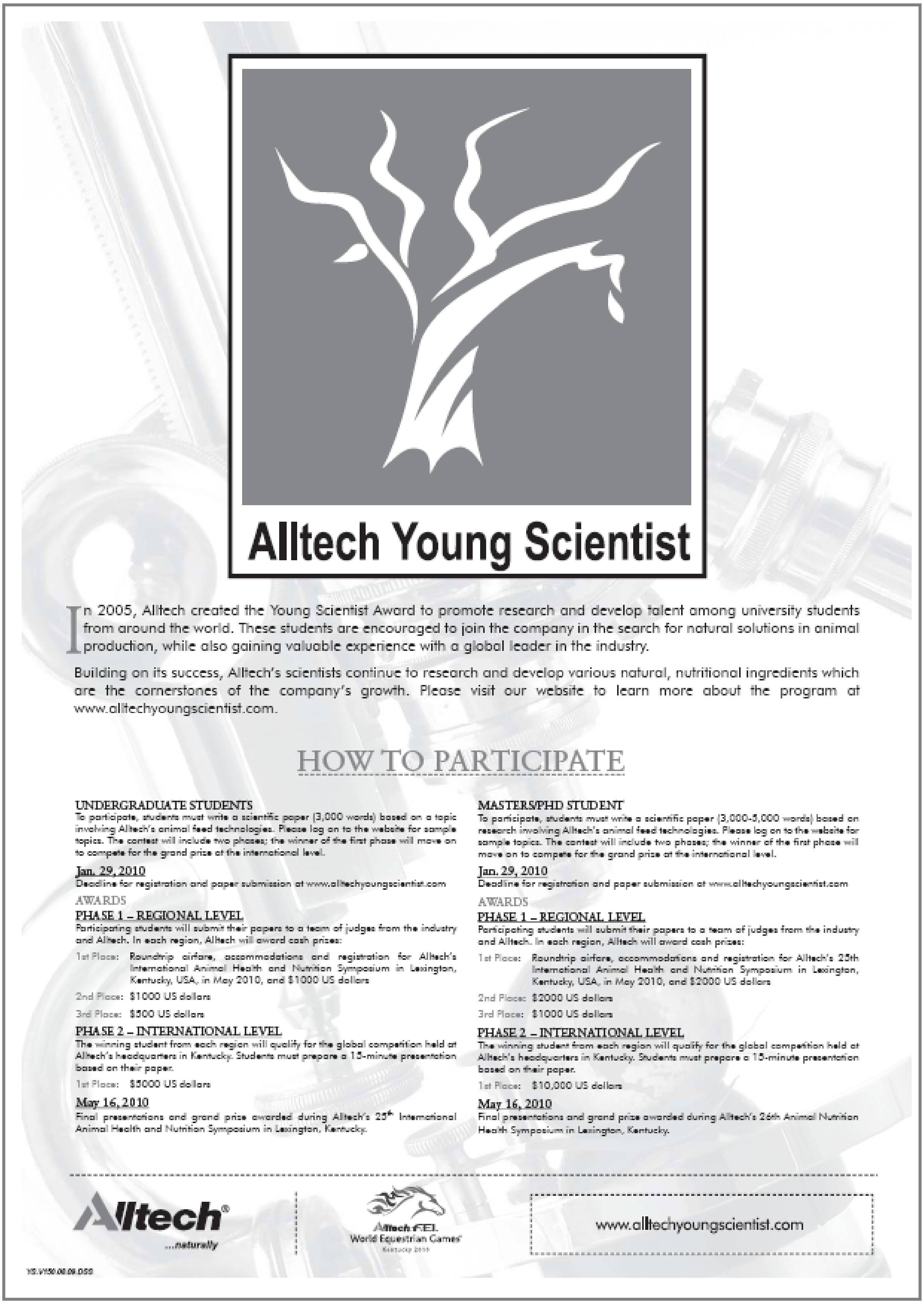


Fig 2: Irrigation water productivity (kg DM/mm) of forages.

References

Garcia, S.C., W.J. Fulkerson and S.U. Brookes. 2008. Dry matter production, nutritive value and efficiency of nutrient utilization of a complementary forage rotation compared to a grass pasture system. Grass Forage Sci. 63:284-300.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LATEST ADVANCES IN NUTRITION AND REPRODUCTION

Prof. John McNamara

Washington State University, USA

Abstract

Reproduction is a function of genetic makeup of the animal, nutritional state and other environmental conditions, including housing, season and temperature. These factors fully integrate in the animal, and there is no way that nutrition, reproduction and genetics can be separated in research or in practice. In practice, we select the best cows based on milk productive and reproductive efficiency, we keep them as comfortable as possible and we house and feed them in ways best to optimize cyclicity and fertility. Can't get simpler than that, right? In research, we set and test hypotheses that continue to define the most productively and reproductively successful animals. We need to integrate genetic elements, patterns of nutrient flux, and environmental conditions to describe their effects on the ovary, uterus and developing fetus. Using genetic and genomic approaches recognizes that nutrient use and reproductive traits are heritable and specific gene sequences associated with these traits can be identified. We now have technical tools to help define specific mechanisms that connect nutritional fluxes with reproductive success. The adipose tissue plays a central role in reproductive success, not just for energy use, but also as a source of hormones and control factors of reproduction. In order to move forward both in research and application, we must use dynamic, bio-mathematical modeling tools to help define reproductive processes that respond to nutrient status and genetic selection and those changes in nutrient flux that optimize reproductive efficiency.

Introduction

Reproduction is a function of nutritional state, and also a director of nutrient flux, and both have genetically inherited elements of control. These three systems (genetics, nutrition and reproduction) function integrally in the animal, and as such there is no way that nutrition, reproduction and genetics can be separated in research or practice. There are several systematic, dynamic controls of nutrient flux involved in ovulation, gestation, and lactation. Glucose alters the release of hormones from the hypothalamus to direct ovulation, and also directs the secretion of insulin or IGFI that affect metabolic activity in reproductive organs. Once an animal ovulates and fertilization occurs, additional interactive control systems are induced to help direct nutrients to the developing fetus and then to the mammary gland. Nutrigenetic and nutrigenomic approaches recognize that nutrient use traits and reproductive traits are heritable and specific gene sequences associated with these traits can be identified. Nutrient status affects gene transcription in many organs, which in turn alters metabolic activity in reproductive organs and thus fertility, and gestational and lactational success. We now have technical tools (transcription arrays, statistical approaches, mathematical models) to help define mechanisms that connect nutritional fluxes with reproductive success. The adipose tissue plays a central role in reproductive success, not just as an energy storage and release organ, but also as a source of hormones and control factors of reproduction. In order to move forward both in research and application, we must use dynamic, bio-mathematical modeling tools to help define those reproductive processes that respond to nutrient status and genetic selection and those changes in nutrient flux that respond to genetic selection and reproductive state. I am going to concentrate primarily on recent concepts and studies in research and then end with the practical application. I firmly believe that dairy managers are their own best decision makers when it comes to improving production and reproduction, so I'm not going to waste time telling you what you already know. Rather, I'm going to provide a glimpse of where we might go if we want to. End game: do you think it is possible that we can achieve productive efficiencies near the maximal biological potential, and at the same time have a pregnancy rate approaching 100 %? I do. But it will take a focused research and application effort.

PRACTICAL APPLICATION: RECOGNIZE THAT REPRODUCTIVE EFFICIENCY IS AFFECTED BY MANY FACTORS AND MANAGE THEM!

Body Fat and Reproduction

The role of nutritional status in reproductive fertility was recognized early in human history. Historical drawings and writings speak to traditions and perceptions of body fatness, shape and size in human fertility. Likewise, domesticated animals were fattened to become fertile and sleek fat cattle were desired for their fertility. Fertility and postpartum anestrous varies among species or even breeds, and can be attenuated or exacerbated by nutritional status. While a certain amount of body fat might correlate with improved fertility, too much may be detrimental. Today, we realize that there is more to fertility than just fatness: some animals alter fertility after increases or decreases in body fatness (Wade and Schneider, 1992).

Early observations showed there was some connection with being 'well-fed', if not fat, and fertility. Young females needed to mature to a certain range of body shape and fatness before obvious outward signs of fertility were observed. Even if those signs were observed, and acted upon by a male, actual fertilization and successful pregnancy, and lactation, also depended on some level of adequate nutrition. It was noted that gross or even moderate stunting of growth delayed sexual maturity in most females. A number of situations in which actual fertility was delayed or reduced were noted, including insufficient total food, or the lack of certain food components. Human families and animal farmers alike acted on these cues and attempted to ensure adequate nutrient status prior to serious attempts at reproduction. Eventually we came to understand that some amount of adipose tissue was necessary for a successful reproductive cycle of ovulation, fertilization, implantation, pregnancy to term, and not to be overlooked, a successful lactation.

However, there was a lot of variation in the amount of body fat, or body fat gain or loss and fertility; it was not a direct and complete connection. Although there is a connection between a positive energy balance (energy in > energy out) and reproductive success (Wade and Schneider, 1992); other questions arose: 'How can reproductive organs monitor and respond to the amount of body fat, or vice versa?' A corollary and related line of research asked the same question in relation to maintenance of body fat: 'How does the body monitor and maintain a fairly constant body fat percentage, and what are the situations in which this system can fail and obesity (or extreme thinness) or reproductive problems ensue?'

Research tested theories on the presence of signaling molecules or nervous activity to and from the adipose tissue as the link to reproduction. One major outcome of this research effort was that the amount of body fat alone did not account for even a majority of the variation in fertility. Large variations in the amount or change of body fat in reproductively successful females precluded body fat content as being the ultimate driving force (Butler and Smith, 1989; Wade and Schneider, 1992). Although the perception persists that body fat (body condition) directly relates to reproduction (Chagas *et al* 2007), the preponderance of evidence is that, although body fat is a key part of the system, it is the nutrient flux (energy balance or glucose supply) that is the mechanistic cause of changes in reproductive status and success (Wade and Jones, 2004).

The focus on body fat and potential signaling pathways lead to important discoveries, one is that adipose tissue is an endocrine organ, secreting, among many other substances, insulin-like growth factor and the intake controlling hormone leptin. These two molecules are critically important in tissue growth, ovarian metabolism, and food intake. In addition, glucose flux, even in ruminants directly affects and is affected by the amount and activity of adipose tissue. It is not the amount of body fat but flux of glucose or other nutrients such as vitamins and minerals that alter fertility or gestational and lactational success (Wade and Jones, 2004; Wade and Schneider, 1992; Chagas *et al*., 2007; Roche, 2006; Vinsky *et al*. 2006).

PRACTICAL APPLICATION: BODY CONDITION IS IMPORTANT TO REPRODUCTION, SO MONITOR AND CONTROL IT. BUT ADMIT IT IS NOT THE ONLY FACTOR.

Nutrient Flux and Reproduction

A major focus of research on reproduction then was on glucose. Many studies were done to ask the questions of ‘How does glucose status relate to reproductive success?’ We now know that a major driver of reproductive success is sufficient glucose flux in the body (Wade and Jones, 2004; Chagas *et al*. 2007). There are several functions of glucose in different organs that improve cyclicity and follicular development.

Eventually the research led to the endocrine aspects of nutrient flux and reproduction. Nutritional scientists started to realize that ‘reproductive hormones’ affected nutrient use, while reproductive scientists started to explore the effects of nutrients on reproductive processes. We cannot fully explain the connections between nutrient flux and reproduction without introducing the endocrine aspects. Reproductive hormones such as estrogen, testosterone, progesterone, luteinizing hormone, follicle stimulating hormone, prolactin, placental lactogen, human chorionic gonadotropin, all are affected by and in turn affect nutrient partitioning to somatic and reproductive organs. ‘Nutritional hormones’ such as insulin, somatotropin, insulin-like growth factor, thyroid hormone, and corticosteroids are involved in reproductive processes. These factors regulate cell division and tissue growth, they also control glucose entry and use in the ovary, follicular growth and fetal and mammary gland differentiation, growth and metabolism.

PRACTICAL APPLICATION: THE BEST WAY TO MANAGE GLUCOSE AND IMPROVE REPRODUCTIVE SUCCESS IS TO MANAGE DRY MATTER INTAKE! DO THOSE THINGS THAT OPTIMIZE DRY MATTER INTAKE OF A PROPERLY BALANCED RATION.

Genetics and Reproduction

To prove the point of the reality of the genetics of reproduction, recently, the Dairy Herd Improvement Association has added daughters' pregnancy rate, or days open, as a trait for bull selection, and other countries have done similar work (VanRaden *et al*. 2004; Weigel, 2006; Harris, B. L. 2005). The mass of empirical genetic data now show that in fact important traits of reproduction are heritable. We also know that the genome must be 'properly fed' to fully express its potential. Much has been written in the last decade of the declining fertility of Holstein dairy cattle, primarily in the US, with a myriad of suggested mechanisms, many of which actually have a little data to back them up (Roche, 2006; Chaga *et al*., 2007).

It is oft repeated that 'increasing milk production decreases fertility' and many statistics are cited to 'prove' fertility is lower in dairy cattle today. Yet on many herds and many hundreds of thousands of cows, simultaneously fast rates of milk secretion, feed intake and good fertility (any way you measure it) occur all the time. Also, the recognition that the end result of successful rebreeding during lactation can be a selectable trait in the bull proofs 'proves the point' that in fact, fertility is heritable, that it has many control factors involved, and that there is no overriding reason why all 'high producing dairy cattle' should be subfertile.

PRACTICAL APPLICATION: SELECT BULLS AND COWS BASED IN PART ON FERTILITY AND FEED AND CARE FOR THEM TO OPTIMIZE IT!

Nutrigenomics and Nutrigenetics

Nutrigenomics is generally defined as the effect of dietary nutrients on gene transcription: "Nutrigenomics aims to determine the influence of common dietary ingredients on the genome, and attempts to relate different phenotypes to differences in the cellular and/or genetic response of the biological system"(Mutch *et al*. 2005; Dawson, 2006). For example, studying the effect on changes in diet on gene transcription and metabolic flux in the adipose tissue during pregnancy and lactation and relating those changes to differences in reproductive processes. "Nutrigenetics, on the other hand, aims to understand how the genetic makeup of an individual coordinates their response to diet, and thus considers genetic polymorphisms" (Mutch *et al*., 2005). The practical application here is to identify the gene variants that relate to differential reproductive responses to nutrients or to genetic selection. There is tremendous overlap here and the two approaches can easily be related. I'm not going to go into any more detail on this now, but wanted to give you these 50-cent words you can throw around. These tools will supply the dairy research of the future (Loor *et al*, 2006).

PRACTICAL APPLICATION: SUPPORT RESEARCH THAT STUDIES THE WHOLE COW AND WHOLE SYSTEM, NOT JUST ONE LITTLE PART.

Mechanistic connections between nutrient flux, genetics and reproductive processes

The earlier observations and research findings introduced above have given us sufficient knowledge to seriously study the integrated functions of nutrient use, genetic expression and reproductive processes. Figure 1 presents a simple flux diagram of a model of nutrient use and reproduction. Another more conceptual one can be found in the excellent review of Chagas *et al* (2007). The flux diagram is aggregated at the nutrient flux level, in order to describe the basic processes in an animal that connect nutrient use and reproductive function. Although this might seem ridiculously complex to some, it is in fact what the cow manages every day, and I think any successful milk producer manages just as many variables too! There is an entire body of work dating back 50 years that demonstrates the utility of approaching research in a systematic way to order, study and define the complexity (Baldwin, 1995; McNamara and Baldwin, 2000; Baldwin *et al,* 1987; McNamara, 2000; McNamara and Boyd, 1998). More than we can go into here but suffice it to say that a large part of the research and improvement in dairy in Australia and New Zealand is a direct function of the approach taken by these scientists.

In order to understand the context and detail of such a model, we must revisit in brief research that allowed this flux diagram to be constructed. We can simplify the cycle of reproductive events to original sexual maturation, first ovulations and ability to conceive, to successful gestation, to the first lactation, and then, often, to renewed ovarian cyclicity and a second (and subsequent) gestation and lactation. In most species, females must reach a certain physiological maturity before the hypothalamus, pituitary and ovary can fully communicate and function to develop an oocyte capable of becoming fertilized (Senger, 2004). There is likely not any one nutrient that directs the first follicular waves, estrus behavior and ovulation, but the end result of nutrient flux allowing development of mature organs (such as adipose tissue), and adequate glucose availability. The growth rate of the animals, a function of both genetics and nutrient supply, dictates that animals will arrive at a body composition and glucose flux state that supports the actions of the hypothalamus, pituitary and ovary. Modern domestic breeds reach physiological maturity, and become pregnant, at much earlier ages then they did previously, based on our selection pressure on growth rate.

A key controller in the connection between the brain and the ovary for follicular development and ovulation is glucose. Glucose is known to have a direct effect on the hypothalamus that causes the release of GnRH, which in turn causes LH release from the pituitary (Senger, 2005; Wade and Jones, 2004). In addition, glucose elicits increases in circulating insulin and IGFI, which have positive effects on follicular growth. In most cases, fertility is not affected negatively until a serious deficit in glucose happens. Return to estrus after parturition is also closely connected with adequate glucose flux returning after the mammary gland starts to use large amounts of glucose and prior to sufficient increase in glucose. It is not only nutrient flux effects on ovulation that are important, but on development of a viable oocyte and, perhaps, support of a uterine environment conducive to blastocyst development and implantation. Glucose likely plays a role via stimulation of insulin and IGFI, which help to support anabolic metabolism and oocyte development.

Certain classes of fatty acids, primarily the omega-3 series and omega-6 series and their metabolites have also been identified as positive controllers of fertility (Ambrose *et al*, 2005; Bilby *et al*. 2006a, b). These compounds control basic cell development and membrane function, and reduce production of inflammatory molecules that hinder oocyte development (Ambrose *et al*. 2005; Armstrong *et al*. 2003; Trayhurn and Wood, 2004) There is ample evidence that specific fatty acids can alter gene expression in many tissues (Al-Hasani and Joost, 2005 and many references therein. Thus the ground for finding specific nutrigenomic mechanisms for fatty acids and reproduction is quite fertile, so to speak.

PRACTICAL APPLICATION: USE OF FATTY ACID SUPPLEMENTS MAY INCREASE FERTILITY ON HIGH GRAIN DIETS, BUT ARE LESS LIKELY TO BE EFFECTIVE WHEN FEEDING FRESH FORAGES.

It is also the case that the increased metabolic rate in top producing cows can affect the outward signs of fertility. Because estrogen and progesterone are key hormones in ovulation, signs of estrus and pregnancy establishment, their increased rate of breakdown in the liver can reduce the time outward signs of estrus are noticeable, and the increased clearance of progesterone can affect the early establishment of pregnancy (Chagas *et al*, 2007. This is the 'grain of truth' in the relationship between milk production and fertility, but it is not the case that high producing cows must be less fertile. This area of research will continue to identify those cows that produce lots of milk AND ovulate a good egg AND show estrus AND establish a pregnancy.

PRACTICAL APPLICATION: USE EXCELLENT HEAT DETECTION PRACTICES. FIND AND RECORD AND ACT ON HEATS, EVEN IF OUTWARD SIGNS ARE NOT STRONG.

In dairy cattle, a significant reduction in fertility is attributed to early embryonic losses, usually categorized as animals first diagnosed pregnant (28 to 42 days post breeding) then showing open. The flux diagram in the Figure shows the multitude of causes, including original oocyte integrity, uterine temperature, pH and ammonia concentrations. Early research connected, I think mistakenly, early embryonic losses directly with excess protein leading to changes in uterine ammonia and pH, but follow up research failed to show a strong connection. Now we know that even moderate heat stress, leading to an increase in body temperature as little as 0.5 or 1 degree C can alter the uterine environment (pH and ammonia concentration) that may hinder embryonic development. This is an exciting ongoing area of research, which promises to improve our understanding of nutrient use, environment and fertility. Because gene transcription events are functions of metabolic reaction rates, there is (an admittedly broad) potential involvement of nutrigenomic mechanisms.

There is in fact, potentially a role between environmental temperature, protein nutrition, amino acid metabolism, genetics and fertility. This is likely not a major function of dietary protein, but a subtle interaction between body temperature, amino acid balance, gene transcription and endocrine regulation. Genomic studies have suggested a connection between variants in the myostatin and calpastatin genes and fertility in the cow (Chagas *et al.,* 2007; Garcia *et al*., 2006; Mitchell*, et al*. 2006; Szyda and Komisarek, 2007). The protein myostatin may in fact regulate glucose uptake in reproductive and other organs (Mitchell *et al*. 2006). These intriguing studies may provide initial evidence for a mechanistic link between protein metabolism, gene expression and reproduction in a true nutrigenetics and nutrigenomics way.

PRACTICAL APPLICATION: FEED A PROPERLY BALANCED DIET WITH NO EXCESS PROTEIN, KEEP COWS COOL AND KEEP EXCELLENT RECORDS ON PREGNANCY LOSS/RETURN TO ESTRUS.

Integrating reproductive and nutritional functions in a formal way

In order to move forward in research and practical application, we need to take our knowledge and translate that to strict mathematical formalism, so that we can test (and eventually apply) the specific effects of genetics and environment on reproductive success. I am going to provide a few simple examples to show, hopefully, that this is very possible, and is not too complex. We are beginning to construct equations that describe the fluxes represented in Figure 1, and thus the mechanistic connections between nutrient use and reproductive processes. All variables are in mass, concentration or rate of flux.

Fertilized Egg to Calf

Calf = Developing Embryo – Embryonic Death

Embryonic_Death_28 ∫ ∑ [To, pH, NH3]

Embryonic_Death_45 ∫ ∑ [To, pH, NH3]

These equations capture the following processes: a live calf is a function of a conception, minus the rate of embryonic or fetal death (here represented at 28 and 45 days post fertilization). Embryonic death is a function of uterine temperature, pH and NH3 at d 28 through d 45 after conception.

Ovulated Egg to Fertilized Egg

Fertilized_Egg ∫ ∑ [ovulated_egg, viable_sperm]

Max_Fert_Egg = 0.75 ovulated_egg

The equation here is based on data presented by J. Santos at the Dairy Cattle Reproductive Council Meeting in Denver, October 2006, in which he described that in fact, the rate of fertilization of an egg by the sperm, in dairy cattle is approximately 75 %. (One wonders, if the dairy industry wants to improve reproduction by 25 %, why don't they work on this aspect more?)

Follicular Development & Dominant Follicle to Ovulated Egg

Ovulated_egg ∫ ∑ [Dominant_follicle, Luteinizing Hormone].

Dominant follicle, second wave follicle, first wave follicle ∫ ∑ [follicle stimulating hormone, progesterone, 1/estrogen, IGFI, insulin, glucose, 1/NEFA, growth hormone].

The equations here capture the knowledge that a dominant follicle, which will ovulate, is a function of three different waves in one cycle of 21d. The first wave (recruitment) is a function, either directly or indirectly, of FSH, progesterone, insulin, glucose, and the reciprocal function of NEFA, estrogen and perhaps growth hormone.

The role of the hormones of reproduction, in prose form as opposed to equations, include: progesterone is a function of the presence of corpus luteum, the placenta, 1/estrogen concentration, and of the rate of progesterone clearance in the liver. PGF2a concentration is a function of uterus PGF2a, and of luteal oxytoxin and perhaps of omega-6 fatty acid concentration. Luteinizing hormone is a function of the concentration of gonadotropin releasing hormone (GnRH), low progesterone and increased estrogen. Follicle stimulating hormone is a function of the concentration of GnRH; of low progesterone and of the concentration of estrogen and inhibin. Gonadotropin releasing hormone concentration is a function of the secretion of GnRH by the hypothalamus, which is a function of glucose concentration; the clearance of the GnRH by the liver, estrogen, low progesterone and perhaps leptin concentration.

From these equations and functions, we see the connection of nutrient flux, primarily glucose, perhaps some specific fatty acids, perhaps NH3 in the uterus (as function of amino acid concentrations and also increased temperature) to reproductive physiology. The challenge, of course, is then to find sufficient data from the literature to set parameters for these equations. If none exists, specific experiments have to be designed to determine the parameters of the equation. If this is unsuccessful, then the scientists involved need to judge whether parameters cannot be obtained because the research tools are not there to measure them; there is some other reason for not being able to measure parameters.

The will to the way forward

We have a long way to go. We need a re-invigorated, multi-investigator, multi-disciplinary, integrated approach to solve the present and future problems of reproduction, and specific to the role of nutrigenetics and nutrigenomics for improved reproduction, this research effort will require construction and testing of mechanistic bio-mathematical models. Finally, we need to train students, scientists and professionals in the importance of using integrative biology and bio-mathematical models to identify, solve and prevent reproductive problems.

PRACTICAL APPLICATION: MONITOR, RECORD AND MANAGE ALL THE VARIABLES THAT AFFECT REPRODUCTIVE SUCCESS: DMI, RATION COMPOSIITION, COW COMFORT, TEMPERATURE, ESTRUS, GOOD TRANSITION MANAGEMENT. SUPPORT RESEARCH INTO IDENTIFYING THE CHARACTERISTICS OF THE MOST PRODUCTIVELY AND REPRODUCTIVELY EFFICIENT COWS AND SELECT FOR THEM.

References

Al-Hasani, H. and H.-G. Joost. 2005. Nutrition/diet-induced changes in gene expression in white adipose tissue. Best Practice & Research Clin. Endocrinol. & Metab. 19:589-603.

Ambrose, D. J., J. P. Kastelic, R. Corbett, P. A. Pitney, H. V. Petit, J. A. Small and P. Zalkovic. 2006. Lower pregnancy losses in lactating dairy cows fed a diet enriched in alpha-linolenic acid. J. Dairy Sci. 89:3066-3074.

Armstrong, D. G., J. G. Gong, and R. Webb. 2003. Interactions between nutrition and ovarian activity in cattle: Physiological, cellular and molecular mechanisms. Reprod. Suppl. 61:403-414.

Baldwin, R. L. 1995. Modelling ruminant digestion and metabolism. Chapman & Hall, New York, USA, pp. 469-518.

Baldwin, R.L., France, J., Gill, M. 1987a. Metabolism of the lactating cow. I. Animal elements of a mechanistic model. Journal of Dairy Research 54:74-105.

Bilby, T.R., J. Block, B. C. do Amaral, O. Sa Filho, F. T. Silvestre, P. J. Hansen, C.R. Staples and W.W. Thatcher. 2006a. Effects of dietary unsaturated fatty acids on oocyte quality and follicular development in lactating dairy cows in summer. J. Dairy Sci. 89:3891-3903.

Bilby, T. R., T. Jenkins, C. R. Staples and W. W. Thatcher. 2006b. Pregnancy, bovine somatropin, and dietary n-3 fatty acids in lactating dairy cows: III. Fatty Acid Distribution. J. Dairy Sci. 89: 3386-3399.

Chagas, L. M., J. J. Bass, D. Blache, C. R. Burke, J. K. Kay, D. R. Lindsay, M. C. Lucy, G. B. Martin, S. Meier, F.M. Rhodes, J. R. Roche, W.W. Thatcher and R. Webb. 2007. Invited Review: New perspectives on the roles of nutrition and metabolic priorities in the subfertility of high-producing dairy cows. J. Dairy Sci. 90: 4022-4032.

Dawson, K. A. 2006 Nutrigenomics: feeding the genes for improved fertility. Animal Repro. Sci. 96:312-322.

Garcia, M. D., J. J. Michal, C. T. Gaskins, J. J. Reeves, T. L. Ott, Y. Liu and Z. Jiang. 2006. Significant association of the calpastatin gene with fertility and longevity in dairy cattle. Animal Genetics 37:293-307.

Harris, B. L. 2005. Multiple trait fertility model for the national genetic evaluation. Livestock Improvement Corporation. 1-24. www.aeu.org.nz/page.cfm?id=59&nid=35

Loor, J. J., Dann, H. M., Janovick Gruretzky, N. A., Everts, R. E., Oliveira, R. Green, C. A., Litherland, N. B., Rodriguez-Zas, S. L., Lewin, H. A., and Drackley, J. K. 2006. Plane of nutrition alters hepatic gene expression and function in dairy cows as assessed by longitudinal transcript and metabolic profiling. Physiol. Genomics 27: 29-41

McNamara, J.P. 2009. Nutrigenomics for improved reproduction, Chapter 18 in Reproductive Genomics in Domestic Animals by Jiang, Z. and T. Ott, eds.

McNamara, J. P. 2000. Integrating Genotype and Nutrition on Utilisation of Body Reserves During Lactation of Dairy Cattle. In. Symposium on Ruminant Physiology. Pp 353-370, Cronje, P. B. , ed. CAB International, London.

McNamara, J.P. 2005. Research, Improvement and application of mechanistic, biochemical, dynamic models: from Genetics to Kinetics. Chapter 6 In: Mathematical modelling in nutrition and Toxicology. Proceedings of the 8th International Conference on Mathematical Modeling in Nutrition and Health Science. Georgia Center for Continuing Education, pp 87-110.

McNamara, J. P., D. E. Boyd. 1998. Hormones as Quantitative Controllers. In: I. Kyriazakis, (Ed.) A Quantitative Biology of the Pig. CAB International, London, UK., pp 199-225.

National Research Council. 2001. Nutrient requirements of dairy cattle. 9th Ed. Natl. Acad. Press., Washington, DC.

Roche, J. F. 2006. The effect of nutritional management of the dairy cow on reproductive efficiency. Anim. Reprod. Sci. 96:282-296.

Staples, C. R., W. W. Thatcher, and J. H. Clark. 1990. Relationship between ovarian activity and energy status during the early postpartum period of high producing dairy cows. J. Dairy Sci. 73: 938-947.

VanRaden,P. M., A. H. Sanders, M. E. Tooker, R. H. Miller, H. D. Norman, M. T. Kuhn, and G. R. Wiggans. 2004. Development of a National Genetic Evaluation for Cow Fertility J Dairy Sci. 87: 2285-2292.

Wade, G. N. and J. E. Jones. 2004. Neuroendocrinology of nutritional infertility. Am. J. Physiol. Regul. Integr. Comp. Physiol. 287:R1277-R1296.

Wade, G. N., and Schneider, J. E. 1992. Metabolic fuels and reproduction in female mammals. Neurosci. Biobehav. Rev. 16:235-272.

Weigal, K.A. 2006. Impact of genetic selection on female fertility. Proceedings of the Dairy Cattle Reproductive Council, DCRC. November 2006

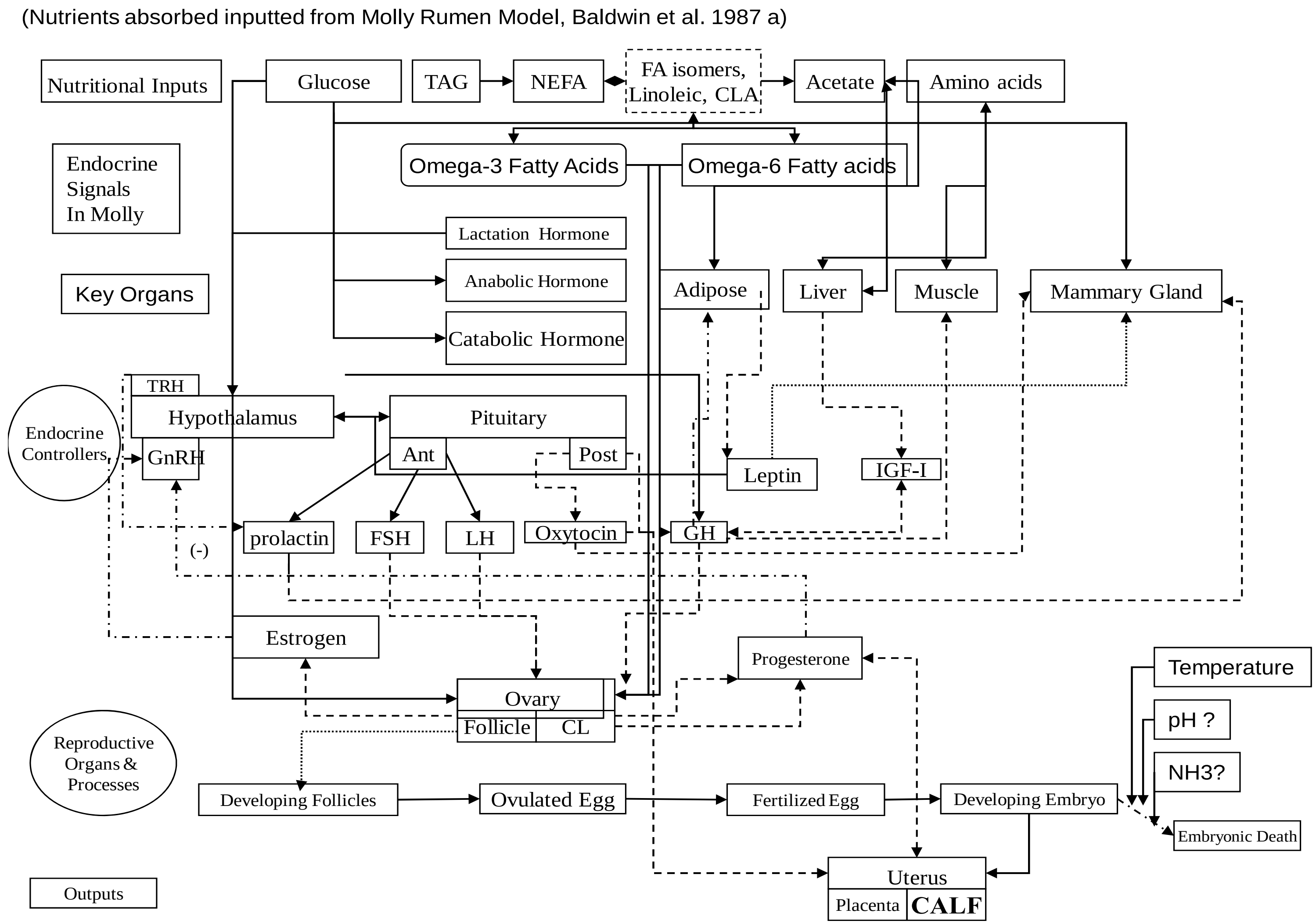

Figure 1. Schematic model of the multivariate control of reproductive functions in the dairy cow. Adapted from McNamara, 2009.


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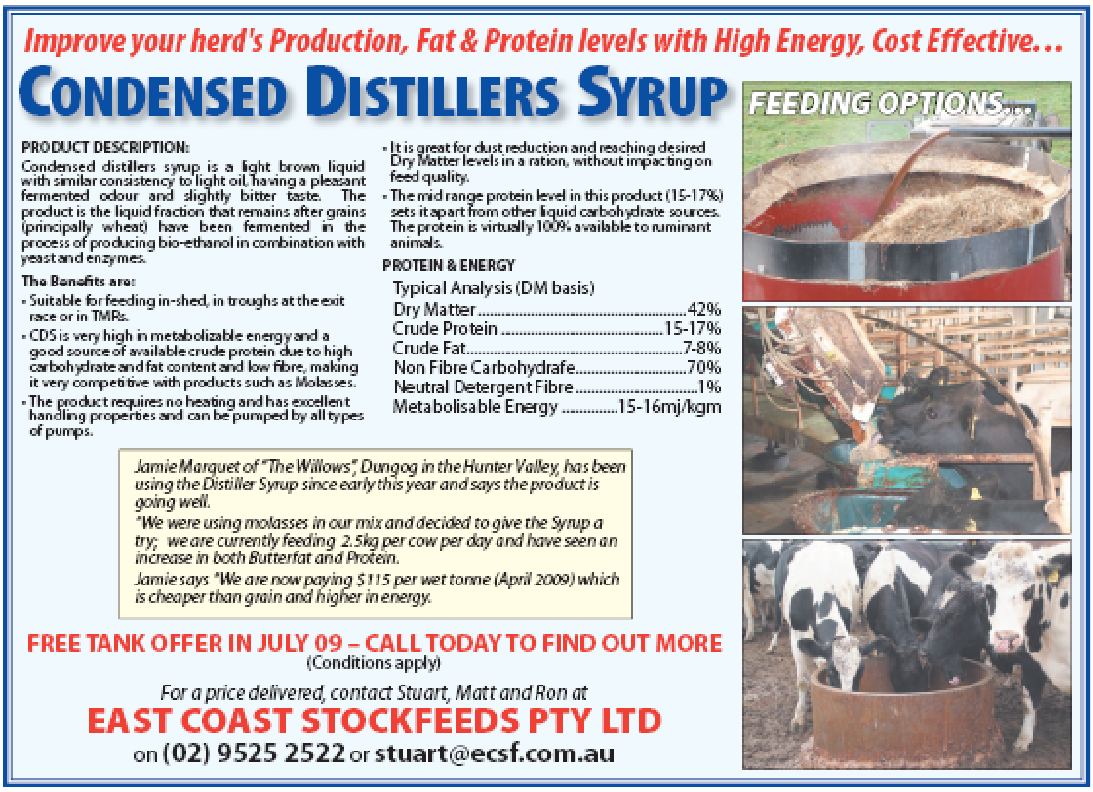
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FEEDING AND REPRODUCTION IN AUSTRALIA

Assoc. Professor John House

The University of Sydney, Livestock Veterinary Services

Introduction

Nutrition, reproduction and cow comfort are primary drivers of cow productivity with nutritional management either positively or negatively impacting reproductive performance and vice versa. Good reproductive management provides for a healthy herd structure which is responsive to nutritional inputs. Accurate pregnancy diagnosis and record keeping facilitates appropriate movement of cows so they are fed the correct ration at the correct time. Good transitional management reduces the risk of hypocalcemia, negative energy balance and acidosis all of which have a negative impact on reproductive performance. A proactive reproductive plan minimizes the proportion of cows that fail to get pregnant in a timely fashion and the number of stale cows in the herds that become over conditioned and subsequently more likely to experience metabolic disease when they calve. Good outcomes are usually associated with proactive plans that include performance monitors, targets and contingency plans for deviations from the plan.

Dairy Farming Systems

Australia and in particular New South Wales has a diversity of dairy production systems ranging from pasture based to intensive freestall dairies with many permutations in between. From the cows perspective the principles regarding nutrition and reproductive management are similar across the systems however the logistics of feed delivery and the degree of flexibility in regards to nutritional management are very different. The nutritional status of pasture based herds that have minimal brought in feed is more directly impacted by seasonal conditions. It is generally more common to see non-cycling cows in pasture based herds associated with negative energy balance than total mixed ration (TMR) fed herds. Conversely it is more common to see cystic ovarian disease and problems with over conditioning in TMR fed herds. In many ways managing the nutrition of pasture fed cows is more difficult than TMR fed cows as there are fewer options available to achieve rapid and sustainable changes in the nutritional status of the herd when pasture availability becomes limited.

Herd Structure

The productivity of a herd is largely influenced by its demographics. With year round calving herds 13 months is generally used as a target calving interval which equates to an average days in milk of around 170 days. There is a significant opportunity cost associated with a protracted calving interval. A reduction in average days in milk from 220 to 170days equates to around 2 to 3 liters of milk per cow per day. Inputting supplementary feed to a stale herd sees an increased proportion of energy partitioned to changes in body condition and less into milk. Poor reproductive performance also limits voluntary culling decisions to remove low producing, mastitis, and lame cows. The number of first lactation heifers in the herd provides an indication of the herds cull rate. A low cull rate in a stale herd suggests that the herd has a protracted history of poor reproductive performance as there is a shortage of replacements. Most herds in this area have cull rates between 20 – 30%.

As a rule of thumb in a year round calving herd that achieves the target average days in milk (170 days) you expect 50% of the lactating herd to be pregnant. If the average days in milk is protracted the percentage of the milking herd that is pregnant should be greater than 50%. If not it indicates that the reproductive performance of the herd is continuing to deteriorate. To achieve a 13 month calving interval, cows need to conceive by 120 days in milk. The proportion of lactating cows greater than 150 days in milk that are not pregnant provides a current measure of reproductive failure.

Targets

Average Days in Milk -	170 days
Average days to conception	120 days
Proportion of lactating herd that is pregnant	50%
Proportion of cows > 150 days that are not pregnant	<18%

Heifer Replacements

There is a direct correlation between the body weight of heifers at calving and milk production during the first lactation. We recently reviewed heifer milk production records on one farm and observed a 3 liter difference in daily milk production between heifers in the top and the bottom calving weight quartiles. Poorly grown heifers are also more difficult to get back in calf as they need to partition more energy into growing during lactation. When the energy status of the milking herd is compromised it is commonly reflected by non-cycling in first lactation cows particularly poorly grown heifers. Indicators of this scenario include poor body condition and the recurrent finding of small inactive ovaries during reproductive examinations. Hormonal interventions to induce oestrous in these animals are generally ineffective as the problem reflects a primary nutrient deficiency and not a drug deficiency. A horse trainer once said “Proper prior preparation prevents piss poor performance.” (Pat Pirelli) This saying is also true for the management of dairy cattle. In regards to the growing of heifers there are a number of options. The economy of the different options is largely influenced by the production system and the cost of feed. Growth rates of 800 gms per day are expected in farming systems that feed heifers supplementary feed to have heifers enter the herd at 23 - 24 months of age. Lower growth rates are anticipated in pasture fed heifers which have a tendency to enter the milking herd at lower body weights and often at an older age. As a rule of thumb heifers should calve at approximately 85% of the mature weight of the adult cows in the herd and milk production during the first lactation should be ≥ 85% of adult cows.

Target

Weight at calving	≥ 85% of mature weight
Milk production of heifers	≥ 85% of adult cows

Heat Detection

Heat detection is a fundamental driver of reproductive efficiency. The best measure of heat detection is to calculate heat detection efficiency. Heat detection efficiency is calculated by firstly determining which cows are eligible to be bred and then determining what proportion of these cows are bred over one cycle (21 days). The number of eligible cows is calculated according to the following formula.

Eligible cows = # milking cows – cows within voluntary waiting period – cows listed to be culled – pregnant cows.

For example in a herd milking 300 cows there may be 30 cows less than 40 days in milk which are not considered eligible to be bred, 150 pregnant cows and 15 cows that are to be culled for various reasons.

Eligible cows = 300-30-150-15 = 105

If 65 of the 105 cows were bred over a 21 day period the heat detection efficiency would be 65/105 = ~ 62%

The most common cause of low heat detection efficiency is related to observation failure. Alternatively poor heat detection efficiency could reflect the fact that cows are truly not cycling. The most common causes of true anoestrous (non-cycling) are negative energy balance and cystic ovarian disease with the former much more common than the latter. Rectal palpation or ultrasound is useful to determine if “anoestrous” is associated with detection failure or true anoestrous. The finding of corpra lutea on the ovary of “non-cyclers” is compatible with detection failure where as the finding of poor body condition associated with small inactive ovaries suggests nutritionally associated anoestrous. Cystic ovarian disease tends to be more sporadic, with a higher incidence in higher producing cows. Cystic ovaries do not normally indicate a nutritional cause unless the incidence is very high in which case it may reflect consumption of oestrogenic compounds within the feed.

Target

Heat detection efficiency 65%

Pregnancy Rate

Pregnancy rate and conception rate are different measures that are sometimes confused. The number of cows calving each month is important for the economics of the dairy business. Every dairy should have a monthly pregnancy target. As a rule of thumb for every 100 lactating cows approximately 11 cows should calve per month in a year round calving herd. These 11 cows will include first calf heifers in a ratio that is consistent with the herds cull rate.

Pregnancy rate is related to heat detection efficiency as it relates to the proportion of eligible cows that get pregnant during each 21 day period. In the example above we determined that there were 105 cows eligible to be bred. Sixty five of the 105 cows were bred during the 21 day period of observation giving a heat detection efficiency of ~ 62%. If 24 of the 65 breedings resulted in a pregnancy the conception rate would be 24/65, (~ 37%). The pregnancy rate would be 24/105 = 22.85%. The pregnancy rate therefore reflects the proportion of eligible cows that get pregnant each cycle. In a year round calving herd it is important to maintain a pregnancy rate ≥ 18% to minimize involuntary culling and to maintain a productive herd structure.

Target

Pregnancy rate ≥ 18%

Conception rate

A low pregnancy rate may reflect low heat detection efficiency and or a low conception rate. There are many variables that impact conception rate including environmental conditions, semen quality, AI technique, and cow health. Data regarding environmental conditions is available from local weather stations. Breeding record analysis is useful for identifying the specifics of conception failure. Common analyses include conception rate by technician, lactation, breeding number, days in milk category, and sire. The conception rate to synchrony programs may also be evaluated to monitor the effectiveness of interventions. Milk production is an important variable to consider when interpreting conception rate data. Higher conception rates are more common in cross bred and lower producing herds. We propose a target conception rate of 40%, higher is better but in our experience most herds do not maintain a conception rate greater than this all year round.

Negative energy balance during the transition period increases the risk of retained placenta, metritis, and subsequently endometritis. Problems with uterine involution may be reflected by low first service conception rates. Useful monitors of negative energy balance include first test milk fat, first test milk yield, changes in body condition score, post partum disease incidence, pre-calving levels of non esterified fatty acids, and post partum blood ketones.

Lower conception rates may also be observed in herds experiencing problems with subclinical acidosis. Plotting milk fat and protein verses days in milk is often informative when acidosis is suspected as it helps to highlight the differences associated with early and peak lactation.

Target

Conception rate	40%
Incidence of retained placenta	< 10 %
Left displaced abomasums	0-3 %
Hypocalcemia	0-5 %
Pre-calving cows NEFA concentration > 0.4 mmol/L	≤ 10%
Post partum cows BOHB concentration > 1.4 mmol/L	≤ 10%
Milk fat < 2.5%	≤ 10%
Early lactation milk protein nadir < 3.05	≤ 15 %

Summary

There are many interactions between the nutrition and reproduction. Maintaining good breeding and health records provides the basis for evaluating herd and reproductive performance and identifying problem areas. Monitoring milk components with regard to the stage of lactation also provides insight as to the nutritional status of the herd. If it is measured it can be managed.

MANAGING REPRODUCTION AND FEEDING FOR LONG TERM PROFITABILITY AND MOTIVATION

Tracey Russell

Boscawen Holsteins

Brundee via Nowra, NSW 2541

Farm Snapshot:

Our family has been on this farm since an original land grant in 1826. Our children are now the 7th generation to work the land. Brundee is about 5 kms East of Nowra and heading towards the coastal beaches we are on a flood plain with rich soil and have fairly reliable rain fall and access to the towns REMS (Regional effluent management system) water .

A pocket of very efficient farmers surround this area with long term sustainable milk volumes being available to the Sydney market.

Boscawen Holsteins was recently awarded our Master breeders award from HFAA and are already 10 years into the second award. Thanks must also go to the hard work and dedication of our parents Geoff and Elaine Herne. Though mum has now passed away, Dad still has a role to play on the farm managing our property at Boorowa and backup for everything else on the main farm.

My brother Bob, husband Tom and our two sons, along with a string of almost family members and other staff, help manage the everyday running of the operation

Milking numbers:	565 currently and growing
Total Stock numbers:	101 dry
	554 replacements on the way

Breed Profile

Holsteins	95%
Jersey/Crossbreeds	5%

Area Managed

Boscawen, Brundee

Milking Area:	160 ha
Springers	6 ha
Dries	28 ha
Calves	68 ha
Swamp land	145 ha

Ghannell, Boorowa

Heifer run	570 ha

Production

Annual Litres:	6.1 million L
Per cow:	10,000 L

Feeding

Pasture utilisation	11.2 t DM/ ha
Concentrates	2.7 t/cow
Milk from home grown feed	42%

Labour structure	5 *full time family members & one partly retired*
	6 *casual female milkers (if they are not off having babies themselves)*

Farm Goal

To improve infrastructure & farm quality both financial and environmental for the long term benefit of future generations, with our children seventh generation on the farm and we have no plans to go elsewhere.

What satisfies and motivates us most is milking a fresh herd of well looked after, well conditioned cows that will last a long time. I would rather milk top producing cows to their potential than struggle through being overstocked and underperforming. We have grown in numbers from our own stock by better managing our own replacements and avoided importing problems.

All farm decisions are based on measured performance from keeping detailed accurate records. We use the LIC computer herd management system to capture data and assist in keeping things happening when they should. We also work with a number of advisers in areas such as Herd health, reproduction, and nutrition to challenge our thinking to look outside the square to continuously improve our efficiency

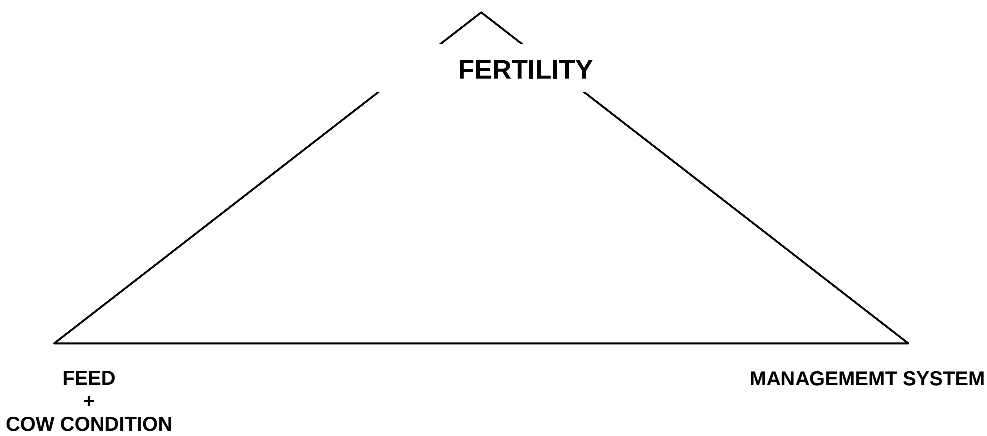
This approach allows us to keep our finger on the pulse of what is happening and make informed decisions and ensure we are achieving a Cash **($)** cow system- put cash in (as feed) get more cash out (in Milk).

This year so far we have produced our personal best average 41.5L per cow and we haven't reached spring yet.

There is always a lesson to be learnt and we are still learning

How are we doing it?

A key focus for our farm is getting the fundamentals right. For us it is cow fertility, it is like a pyramid. If the reproduction is at its peak the gains from these efficient cows helps stabilise the variables in costs and weather conditions - feeding a fresh herd is the driver of our herd efficiency.



Fertility

Improving reproductive performance is the major part of what we strive to achieve. We have great satisfaction milking a herd with a high proportion of fresh cows year round that have an appetite to milk.

***Key strategies*:**

- Heat detection – having a system that keeps you focused on the cows to watch
- Herd Health program – fortnightly pregnancy testing and cow checks by our vet
- Computer prompts – cow status alerts also makes milking interesting

Getting them healthy and back in calf early in their lactation, ideally before they hit peak production and start loosing too much weight to us has been the key to lifting herd performance.

This is a fairly contentious issue with the research being done into extended lactations, but I still like putting cups on a cow that's udder is plump with milk and not a shriveled up bag

Sure it's a problem to dry a cow off that's still doing 36 litres of milk but it is easier to pull the litres back by decreasing feed in the dairy to a cow that needs to go dry (sometimes up to a month before she is due to go for her two month holiday before calving) than milk a cow at 500 days for 14 litres, waiting for her due dry date so she's not in the back paddock for 6 months as she has little milk to pay for her place in the dairy.

In the past we didn't focus as much on the management of cows for fertility, more the cows would control when they got in calf. We did herd health checks – the vet would turn up, we would pregnancy test, a number would be empty and we would send them to the sale. As a result, herd fertility, and average days in milk (DIM) suffered and more often than not we were milking and feeding a stale herd, working hard and not seeing the returns.

Then I met my now great friend, Vicki Smart who had just moved to our area as the Dept Ag Livestock officer (Dairy). Vicki had brilliant ideas of painting cows and using other heat detection aids. Her passion on the subject didn't take long to rub off.

With her help we set up our own program and introduced weekly "patch n paint" where all cows 40 days calved received a Kamar and coloured tail paint. All cows that had already been mated had their paint touched up only. I was being a little stingy with the Kamars here though, it's best to have both.

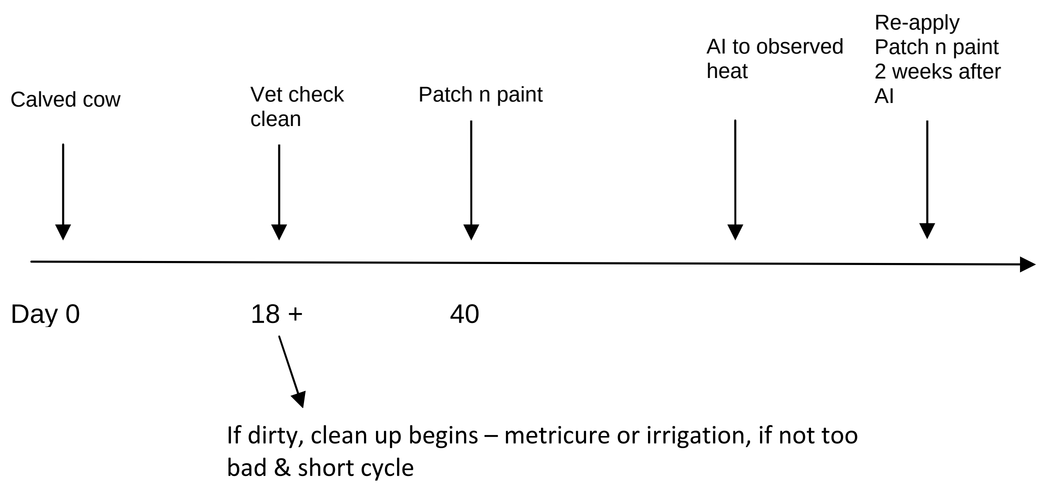
(If you want to save money buy the mis-tint acrylic paints from your paint shop and lather it on them @ $3 to $ 4 a litre it's a good price to pay if you buy in bulk. They love you as it

cleans up their store of mistakes and its easy to change paint colours, no two tins are the same . We even use it to paint houses!!!.)

By changing paint colours it's easier to focus on the selected group, we scratch off the old paint when the cow has been preg tested in calf but it's hard to get every trace off so just change colours. Having control over submission of cows for mating improves the rate cows get back in calf.

Fortnightly herd health vet visits have become more effective with less empty cows and early detection of "problem cows after calving" from 18 days post calving we check the cows uterine health. We were finding that cows looked ok were still dirty and of course not going in calf we were wasting a lot of good semen. Including this as part of our fertility management has helped with conception rates and getting cows in calf sooner.

We still like to keep things as natural as possible and only use PG to short cycle a dirty and a use a modified Gonnabreed on non cycling cows. We see the value of getting on top of complications e.g. cysts & non cyclers before they are too stale to give much milk and become a bigger problem where 'truck'-acylin is the only treatment.

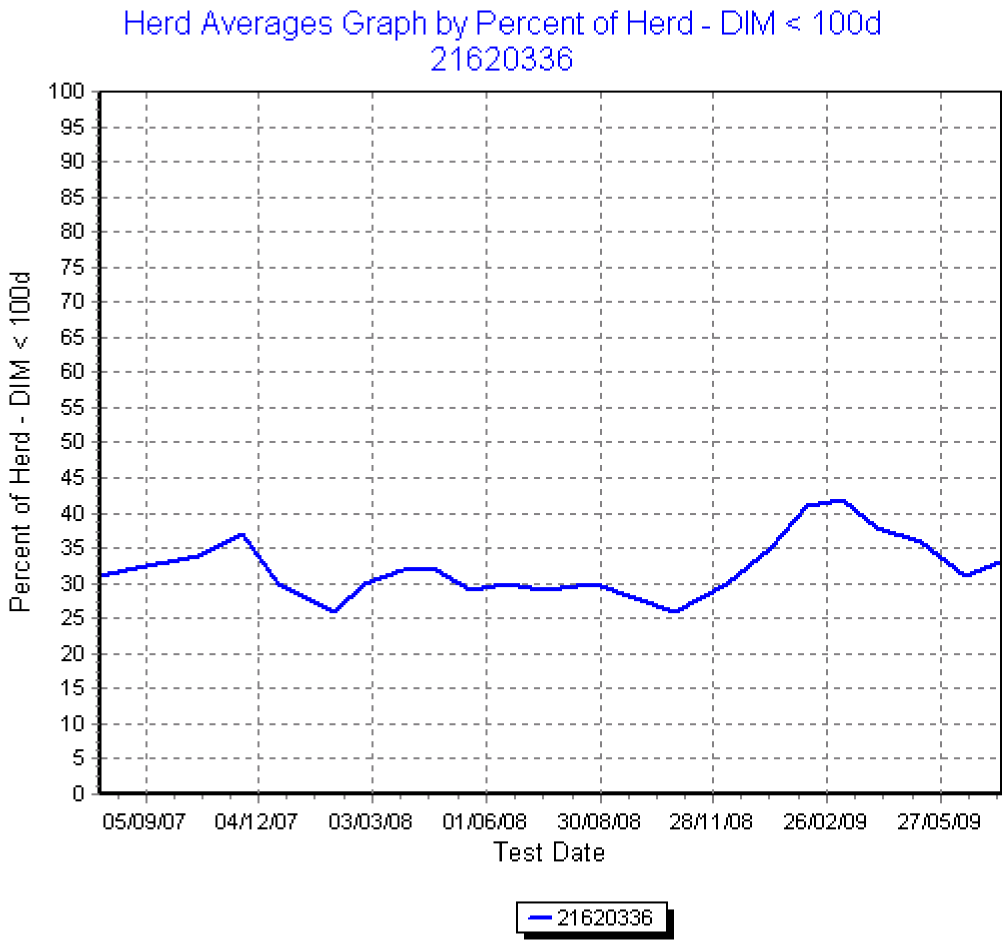


Different splashes of paint on the pins and up the back alert the inseminators of the cows' status if she is dirty or too early to mate but ended up in the draft yard by mistake

Utilising our Dairy ID computer prompts has been invaluable. Following each vet visit the computer records are updated and reproductive status reviewed. We Patch n paint that afternoon so the whole fortnightly management cycle starts again. At every milking you know what cows are up to and which ones to look at for heat signs. Having these details at your finger tips is a big advantage. We can set the voice prompt on our computer system to alert us of actions required. Like- check kamar. This technology is an integral part of the system and helps keep the sometimes mundane job of putting cups on cows interesting as it gives you something else to focus on while milking..

Is the effort worth it?

The herd performance has lifted in production through more cows calving more often, hence average days in milk is between 130 and 160, and there is less of a tail of cows open for a large number of days, or wasting time in the dry paddock but the big bonus is we have more calves as replacements to choose from. It is also rewarding to look at our monthly herd recording and see the proportion of cows in the herd under 100 days in milk lifting to above a third of the herd and maintaining this target year round (Graph 1). Also, the proportion of cows 300+ days calved group staying below 10% all year round (currently 6.4%). We think it is definitely worth it and with less wastage in our system that's more money in our pockets.



Graph 1 demonstrates the improvement in proportion of fresh cows (<100 DIM) in the herd over last few year as a direct result of improving our focus on fertility and doing a better job.

Rules: No short cuts and lately no splitting semen straws – not worth it. Yes you will get some cows pregnant but you will get a lot not. When you put the effort into finding and submitting these cows you want to see a good result.

Feeding + cow condition

Feeding the most efficient converters and getting the ration right drives cow appetite and condition

When it comes to feeding we have made some significant changes in quality and quantity of feed on offer.

Key strategies:

- *Pasture utilisation* – maximise the proportion of milk produced from home grown feed
- *Feed quality and quantity*
- *Drive dry matter intake* - feed for lactation stage, production level and cow condition

In the past we haven't used an outside consultant for nutritional advice. We worked things out for ourselves, but we have found the benefits of having an independent opinion on cow condition, someone who can keep the ration right for health issues, who is a sounding block for new ideas and is working outside the everyday area of the farm. For this task we use Phillip Pittolo from Pittolo Nutrition in Bega.

He helps us set production targets and reviews them regularly to check we are where we want to be.

A key has been Improving utilisation of pasture and reducing the paddock wastage, ensuring milking quality feed is on offer at all times and varying supplement feed levels to control grazing pressure.

It is important to the success of our system to keep focused on being a pasture based grazing system and managing our Kikuyu and ryegrass improved pastures efficiently as this is our cheaper feed base and why we own land. We crop 25ha maize silage annually and are continually growing the home grown feed base.

We strive to balance the cow ration and feed the cows what they need which has lead to feeding cows for production level and stage of lactation as well as managing body condition. In the first six months of changing to three times a day milking we didn't push production so the rise in production was slower but we managed not to drop body condition which to us is a key profit driver.

As production has climbed we refined the concentrate feed (hard feed) program, lifting the rate of feed allocation and the level of feeding of cows in their first 14- 21 days. Cows now receive an average of 10Kg and a maximum of 14 kg (DIM and production level triggered) of hard feed where in the past they were lucky to get 8 – 9 kg in the dairy. As a result we have increased the hard feed by 14% allocation resulting in a 30% increase in milk.

We utilise a range of feed types to balance quality variation of individual feeds and the associated risks

The challenge we see in the future is sustaining the balance of matching the supplementary feed to the pasture base to continually maximise profit margins.

Management System

Pulling the system together fertility, milking and feed allocation

Key Strategies:

- Computer data, feed and draft system- control of cow treatments
- Consistent feeding and milking three times a day provides consistent management of feeding, milk harvesting and fertility
- Automation – keeps everything in control

Going three times a day was a big step and took 18 months of thinking before we took the plunge. It was the next step for us as our cows were busting with milk. It enabled us to continue with our choice of not extending lactation of the cows. Our cows are in peak lactation more often and not stale. Pushing our boundaries makes milking cows more exciting.

All members have to be keen, in our system females do all the milking and the boys help if we are short staffed - they get the cows and feed them and do the inseminations and most of the other things that need to be done, it’s a good team effort. In the first three months we wondered about three times a day but as the cows started to settle and climb in production we stopped wondering.

It allows us to better feed our cows and having three feed periods a day provides more consistent feed delivery system. We have installed a feedpad and purchased a feed mixer wagon to facilitate a controlled feed delivery and mixing wagon to stop wasting feed. We use to drag the silage feed cart into the renovated pastures in wet times and bog it all up again. We have also invested in concrete bunkers for storing our silage especially maize.

Cows are healthier and happier, cell counts are lower and easier to manage. The big advantage of that is less cows on buckets and less manual handling for the girls.

Mating management is also easier we have more opportunity to pick cows in heat and get them mated .

Automation helps ensure that things happen when they should, by programmed drafting cows get caught and actioned on – Automatic cup removers are our next move to streamline our system and make cups off easier.

Where to from here?

There will be further increase in per cow production in the medium term (2-5 years) but in the short term there will be a drive to utilise the current infra structure purchases in the most efficient way. Production performance will be based around improving components more than volume. Feed purchase and management is also likely to become more refined and keeping the balance between home grown feed and purchased feed.

We continually recognise problem areas and room for improvement and are willing to make changes to our system. Now we are getting more heifer replacements we recognised we could do a better job with their growth after weaning and have invested in to a property to grow better heifers. Still more challenges to meet.

Underlying all this is the fact that running a good condition, high producing herd is what we like to do.

This is our life choice, if we didn't like doing it we wouldn't be doing it – so why not make the most of it.

TECHNOLOGICAL INNOVATIONS IN FUTURE FEEDING SYSTEMS

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Abstract

Dairy farmers are being pressured to increase production while reducing their environmental impact. Pressure is being applied not only by environmental agencies but through commercial contracts and market regulation. Therefore it is becoming increasingly difficult to separate these two aspects of production. This paper explores some possibilities where due to increased efficiency these two goals can be at least partially achieved.

Farming is a knowledge intense industry and it is also a hostile environment to introduce technology, much of the technology push in recent years has been directed towards better methods of data collection in order to assist with management decision making. Due to the knowledge intensity it is difficult to avoid adding complexity when it comes to management systems. But we know that adding complexity will adversely affect adoption of new technologies. The apparent promise of new technology has not been fulfilled and the speed of technological development and process improvement is not keeping pace with the desire to increase productivity as expressed through the aspirational goals and targets of the main dairy companies for example.

This paper examines some of the technological areas that could assist in increasing productivity and reduce environmental impact of our dairy systems. It does not attempt to discuss how the adoption process could be improved throughout the industry.

Introduction

How well are dairy farmers performing at the moment? Maybe re-phrase that to say; how well are dairy farmers performing at the moment with the level of technology available to them? It seems each new generation of technologist thinks they are the only ones that have ever been interested in increasing efficiency, or, are convinced that their technology is the answer to everyone's needs. We have been farming for thousands of years and continually looking for improvement. So, one might think that we should be fairly efficient by now given all the years of practice. However when one starts to seriously measure aspects of our performance we soon come to the realisation that we are not nearly as efficient as we believe we are.

A simple mono-culture crop such as maize can serve as an example. Grassini *et al* (2009) conducted a large study on maize production and related the yield achieved to the evapotranspiration of the locality over a large area of the US cornbelt. They found a relationship between yield potential and evapotranspiration from the data within the study. They then ascertained the level of on-farm performance, the best 10% of farmers achieved 80% of that yield potential, whereas the average farmer only achieved around 50% of the yield potential. This is a mono-culture much of which is under irrigation so why is efficiency so low? Cassman (2009) went on to describe how the results from this research showed that the average level of yield improvement was 2% per annum over a twenty year period. Numerous technological improvements had occurred during that period including, pesticides, soil testing, integrated pest management, plant breeding, irrigation, etc. But significant step wise yield improvement still proves difficult to achieve. Given this history there is no real indication yet that we can expect a significant change to the apparent ceiling on yield. Improvement is likely to come from a large number of integrated on-farm steps that will allow farmers to improve productivity. This then leaves us with a further problem, agriculture is an extremely knowledge intense industry and each time we bring in a new element to our management system we add complexity. This makes adoption of new technology more difficult as life needs to be simplified not made more complicated. It could also be argued that the adoption of genetically modified maize has more to do with lifestyle choices of the farmer rather than lifting the yield ceiling. However successful adoption will increase average yields on farms as pest and weed completion is reduced and more efficient use can be made of fertiliser and water inputs, but dramatic improvement eludes us.

If we do not anticipate a “silver bullet” then clearly the only way to achieve our goals of increased production and environmental safeguard is through a large number of integrated incremental steps. We are also increasingly being asked to document and reflect upon our environmental impact through carbon footprints, water use footprints, CHG emissions, energy audits and nutrient use efficiency. Ultimately this should help the industry focus on becoming more efficient. While these measures can be useful if used for the appropriate purposes, Jones (2009) demonstrated that there are very large differences between Life Cycle Analysis (LCA) criteria and rules depending on the system being employed. It is quite feasible that different ratings could be given to a product depending on the method of calculation. Systems appear to be used as marketing tools rather than a serious attempt to quantify performance in a standardized way and therefore their usefulness to us is destroyed as they would appear to have little credibility.

The need for simplicity has been emphasised as a requirement but it is the desire for simplicity that has led to our apparent poor performance, farming by averages or averages (temporal) of averages (spatial) is not the answer. It has been the experience of the group at the Centre for Precision Agriculture at Massey University that when we measure parts of our agricultural systems in greater detail they often fall well short of expectation. This has happened because new measurement tools have been developed, tools that can be repeatedly used to better understand the temporal variation in a system and tools that can be used with GPS to place the measurement within the landscape and reduce the need to consider geographical averages, but recognise the differences and in some cases use these differences to farm more efficiently. If we can avoid using temporal averages then it will allow us to make better use of our inputs such as fertiliser and water, as their response is dependent upon temporal factors such as rainfall, soil moisture, solar radiation etc. Recognising the geographic differences can help us establish the yield potential of any area of our farms and farm to it, again achieving better resource use efficiency.

Three examples are used to illustrate measurement techniques involved and the management techniques that can be used to improve resources use efficiency. These are the use of:

1. Accurate fertiliser placement.
2. Pasture measurement as a means of improving the utilisation of pasture.
3. Variable rate irrigation to improve the utilisation of water.

Method

Accurate Fertiliser Placement

In New Zealand around 85% of fertiliser is spread by contractors, both aerial and ground spreading. Tight margins over the last decade have meant that these operators are tending towards larger capacity, wider spread widths and faster throughputs in order to give farmers a very competitive price for spreading. Work was initiated by the spreading and fertiliser industries to investigate on-farm performance of fertiliser spreading. Many operators have their spreaders tested to examine the level of variation of spread through a system called “Spreadmark”. This has the same purpose as “Accu-Spread” in Australia. Spread patterns are tested and a bout width calculated on the basis that a 15% coefficient of variation (CV), in spread for nitrogen fertiliser, could be tolerated. There then seemed to be an assumption that when the spreader went out into the field that that same level of performance was achieved. Clearly there are other factors that would make it unlikely that this would be the case. It assumed perfect driving, perfectly regular field shapes, no turning, no starts and stops and uniform speed. Lawrence (2007) tested these notions over 104 paddocks and found that the average "field" CV was 37% rather than 15%.

Lawrence (2007) also examined the effect this had on the fertiliser utilisation on the farm. The main problem area was the application of urea, this had a significant economic impact. Table 1 illustrated the annual expenditure on fertiliser in order to maintain fertility on a typical Waikato dairy farm. Lawrence compared the effect of what was actually achieved in the field to perfect spreading. The cost was calculated on the basis of reduced production, which he calculated to be $66 ha-1 in 2006, this increased in 2008 because the value of pasture was greater, to $116 ha-1, Yule (2008). In both cases it amounts to a significant proportion of the total fertiliser cost. As well as negatively impacting on yield it clearly demonstrates that "we" have poor control over our fertiliser applications at a scale which makes variable rate fertiliser application, recognising spatial variation, less likely to be effective. It is possible to achieve significant benefit by improving the standard of spreading if we reduced the CV to 27% it would save $45 ha-1 in 2008 figures.

Table 1: Typical Waikato Dairy Farm annual expenditure on fertiliser

		2006		2008		2009	
Fertilisers	Kg ha-1	$ T-1	$ ha-1	$ T-1	$ ha-1	$ T-1	$ ha-1
Superphosphate	505	191	96	560	282	390	197
Potassium Chloride	128	425	54	859	110	1146	147
Nitrogen (Urea)	326	500	163	1,100	359	620	202
Ag. Lime	242	17	4	28	7	28	7
Total			318		758		553

On larger paddocks and with regular shaped paddocks “field” CV could be reduced. If we consider a calculated bout width based on a “test” CV of 15%, then it seems likely that a “field” CV of between 20 – 25% could be achieved. If we dropped the “test” CV to 10% then that would give a significant improvement in performance. Discussions are going on in New Zealand to introduce a form of “type” testing of machines where testing with greater stringency would be performed on new machines in cooperation with the manufacturer or importer. These would be designed to ensure machines brought into the market were of a high standard, were consistent in their performance and consistent between individual machines. It is intended that this initiative would help improve the overall quality of machines in the fleet and ultimately help in reducing “in-field” CV.

New innovations are occurring in the fertiliser spreading industry. Spreaders with variable rate control are available and assuming we can get these spreaders to perform adequately, the question is, what knowledge do we base the decision to vary fertiliser. In mono-cultures such as cereal or maize production reflectance sensors have been used, Yule and Pullanagari (2009) outlined a large number of indices that could be used for the purpose of adjusting the fertiliser application. What considerations should be used in dairying for deciding on the N application required? Another area of improvement is a camera system mounted on a spreader which will change the setting of the machine if the spread pattern changes due to changes in material being spread. For example a greater proportion of fine material would lead to a more spiked pattern, with more material around the centre of the spread pattern. While this is useful to have this facility it is not clear whether it is financially viable at this stage, it is likely that driver assistance guidance, which will improve the drivers performance will have a larger economic benefit.

It is clear that having wide machines, doing a fast but cheap job is not giving farmers the best opportunity to achieve maximum return. Fertiliser is being wasted. In Europe they now estimate they are using twice as much fertiliser as is actually necessary. Farmers need to re-think and perhaps the industry as whole needs to re-think the desire to drive down costs, it could be counter-productive.

One project that the Centre for Precision Agriculture is embarking on is to examine ways of making better utilisation of fertiliser N. We know that the amount of N a cow excretes in urine is related to N in the diet. Work by Castillo *et al* (2000) demonstrated that as the level of daily N intake increases beyond the 400g N intake per day, the major route of output is through urine, with the N output through urine increasing exponentially beyond that 400g N threshold. It is returned to the land as urine patches which have extremely high N application rates in concentrated spots. It is this that creates many of our leaching problems from grazed dairy systems. The work being undertaken at Massey is designed to identify if we can successfully reduce the amount of N in a cows diet without affecting productivity and pasture quality. Two factors used to control the N intake of the cow are actual N applied and time interval between nutrient application and grazing. Menneer *et al* (2003) looked at the effect of urine application and defoliation on the N content of subsequent forage growth. This gives a clear indication that the concentration of N is reduced as the time between nutrient application and grazing increases. One way that this could be actioned is to change the current practice of having a contractor come in to spread the whole farm with Urea, rather, programme the fertiliser application according to the grazing rotation. Clearly in pasture grazing systems any significant reduction in pasture quality will be counter-productive, but it is at least worth exploring the possibility of adopting methods that would increase our nutrient use efficiency.

Table2: Adapted from Dalley *et al* (2009) Evaluation rankings for current and developing pasture assessment techniques.

Category	Pedestrian				ATV Mounted, Proximal			Remote	
	Plate meter	**Visual(calibrated)**	**Laneway Drive by**	**Sward Stick**	**Rapid pasture meter**	**Crop Circle Reflectance (b)**	**Automatic Feed Reader**	**Spectral Satellite**	**Radar**
Speed	✓	✓	✓✓✓	✓	✓✓	✓✓	✓✓	?	?
Ease of use	✓✓	✓✓	✓✓✓	✓✓	✓✓✓	✓✓	✓✓✓	?	?
Accuracy	✓✓	✓✓	✗	✓✓	✓✓	✓✓	?	✓	✓
Ability to calibrate	✓✓	✓✓	✗	✓✓	✓✓	✓✓	?	✓	✓
Representative of paddock	✓	✓	✗	✓	✓✓✓*	✓✓✓*	✓✓✓*	✓✓✓	✓✓✓
Cost	✓	✓	NA	✓	✓✓	✓✓✓	✓✓	?	?
Insensitivity to weather	✓	✓✓	✓✓	✓	✓✓✓	?	?	✓	✓✓
Consistency between operator	✓	✓	✓	✓✓	✓✓✓	✓✓✓	?	NA	NA
Software connectivity	✓✓a	✓	✗	✓	✓✓✓	✓✓	?	?	?
Portability	✓✓✓	✓✓✓	✗	✓✓✓	✓✓	✓✓✓	✓✓	?	?
Pasture Friendly	✓✓	✓✓	✓✓	✓✓	✓	✓	✓	✓✓✓	✓✓✓
Hazard Rating	✓	✓	✓✓✓	✓	✓✓	✓✓	✓✓	NA	NA

✓ Low ✓✓ Medium ✓✓✓ High ✗ Not suitable ? currently unknown NA not applicable

* If used with GPS and mapping software (Additional column added to include Crop Circle sensors, additional row to include Software connectivity)

(a) Dependent upon download capabilities.

(b) Opinion of the author.

Pasture Measurement

Pasture measurement is an area where silver bullets have been promised but never really delivered in terms of a total answer for farmers. Measurement of pasture is a very complex problem. A sward is a complex thing, constantly changing, both in terms of growth stage and composition. Most of the methods currently being promoted can be termed “surrogate” measurements. These are measurements of some attribute which we then use as a surrogate for the characteristic we want to represent through calibration. Table 2 gives a description of methods that are either currently available to farmers or projected to come onto the market in New Zealand.

The first issue is the number of samples taken, their placement and in-field variability. How representative of the paddock are the samples taken. In all farming systems there is a relationship between the landscape and variability, these could be due to soil changes, topography or management practices. In the world of precision agriculture they can be represented by a semi-variogram, which can give the spatial structure to the data. The level of random variability changes throughout the year as the sward goes through its different stages of development, grazing and re-growth. An experiment that helps to demonstrate the problem of sampling was conducting using a 10m by 10m grid where 100 samples were recorded from the grid using a rising plate meter. The aim of the experiment was to examine how accurately we could represent that 10 by 10m grid using either, 1, 5, 10, 15, 20 or 25 samples. Using a random number generator to select sample location, sampling was simulated over 25 sampling events. The question asked was how repeatable are the measurements. While the average of the 25 sampling events appears reasonable it is the range that is important in terms of variability between one reading and the next. Table 3 illustrates that the possible range of value when only one sample is taken is 2,240kg Dm ha-1, whereas taking 25 samples could give you a range of 358kg DM ha-1.

Table 3: Results from 25 simulated measurement events using different number of samples from a possible 100 measurements. Yule and Atmore (2006).

Number of Samples	Average kg DM ha-1	Maximum kg DM ha-1	Minimum kgDm ha-1	St. Dev
1	2017	3440	1200	710
5	2199	2908	1704	429
10	2069	2600	1718	264
15	2132	2469	1891	176
20	2110	2355	2026	103
25	2142	2342	1984	103

One of the key requirements of a measurement system is the reliability of measurement. We must be clear about the real “system” level of accuracy rather than the level of accuracy of individual measurements. Clearly there is a significant advantage in taking larger numbers of samples. So what is more accurate, a single cut sample taken from a paddock (we are constantly begin told this is the standard we should measure against), or a large number of surrogate measurements which will take spatial variability into account? Farmers now have choices on how they conduct measurement with either pedestrian or ATV based systems. They can choose to map the whole paddock with ATV systems or rather take more limited measurement through transects. This will take slightly longer than using a simple transect, but what is the difference in accuracy? Again an experiment was conducted using the C-Dax Rapid Pasture Meter to examine this question. Table 4 illustrates the result which indicates that transects are capable of giving accurate representation of the whole paddock but very large errors can also occur. The maximum difference was 60%, while the average error was 18%. Clearly if farmers are using transects they must ensure that they are representative of the paddock. This can be achieved by the C-Dax Rapid Pasture Meter where an instantaneous reading setting is available, where the user can explore the range of values within a paddock and design a transect which is representative. The table also shows the importance of using the same transect so that relativity can be compared. If you have different users conducting the measurement, they must follow the same transect.

Table 4: The difference between transect and full paddock measurement using a C-Dax Rapid Pasture meter.

	Transect Measurement		Whole Paddock Map		
Paddock	*Number of Readings*	*Average Pasture kgDM ha-1*	*Number of Readings*	*Average Pasture kgDMha-1*	*Percentage difference*
6	640	2739	5040	3170	15.7
7	580	2836	4380	2837	0
8	500	3235	4100	2980	7.9
9a	460	1849	2720	2946	59.3
10	400	2142	2760	2191	2.3
11	480	2808	3360	2295	18.3
11a	460	2904	2220	2285	21.3
Average					17.8

Table 2, showing different methods of pasture measurement, is adapted from Dalley *et al* (2009), the use of reflectance sensors (Crop Circle) are included to reflect some work completed in New Zealand. The Feed Reader is still some way off release in New Zealand and therefore we have no data on its actual field performance. The options open to farmers can be split into three broad categories, pedestrian units, ATV mounted units and remote sensing units. Radar has been tried in New Zealand because of the problems in overcoming cloud cover for satellite based systems in the visible (VIS) and Near Infrared (NIR) spectral regions. Farmer's interest in pasture measurement has increased as they realise the financial benefits of better allocation of feed resources and the need to increase efficiency. The market is also developing in terms of the desire to have software that will integrate with other parts of the farming system, an example being the C-Dax Rapid Pasture Meter where their alliance with the Livestock Improvement Corporation (LIC) will allow animal productivity to be monitored within the same system as pasture production.

Irrigation

Irrigation is a major issue for many dairy farmers. One technical advance that is of interest is the development of variable rate irrigation systems, (VRI). This concept has been applied to centre pivot irrigators. Although they are increasingly popular amongst farmers, mainly due to their low labour inputs, centre pivots are very inflexible systems. This inflexibility leads to wastage of water in the case of dairy farming. At the simplest level the irrigator can be programmed to switch off over infrastructure, such as races and collection yards etc. This saves water. If the basis of managing the irrigator is changed to work from a geographical information system (GIS), then individual paddocks can be given different depths of irrigation and their paddock boundaries do not have to coincide with the sector of the irrigator. The GIS provides the basis for changing rate, so if the control system is aware of the irrigator's position and is instructed as to what application rate is expected under it, then it can be controlled to deliver the correct quantity of water at any point. That flexibility can be transferred to a number of things driving the requirement for water, slope can also be taken into account. At its most complex level, the soil can be mapped using Electro Magnetic Induction (EMI) to calculate the water holding capacity of the soil. When this is done these water holding capacity maps can be used to calculate a soil water balance prediction model for every area under the irrigator. This can be used with real time logging of soil moisture content where the EMI methodology has been used to zone the paddock so that the soil moisture measurement devices are placed in areas of the paddock that are representative of each of the different zones. In a number of case studies used, Hedley and Yule (2009) and Hedley *et al* (2009), the application of this methodology appears to provide a considerable saving in water use and power requirement. Hedley and Yule (2009) used two sites to demonstrate; Site 1, a 20% water saving under dairying, and Site 2, a 26% water saving under maize over a three year period (2004-2005 to 2006 – 2007 seasons).

Hedley *et al* (2009) demonstrated through simulation that a number of Key Performance Indicators (KPI's) benefitted from the application of the VRI system. The KPI's considered were, Irrigation water use, Drainage water loss, Nutrient leaching, Energy Use, Irrigation Water Use Efficiency (IWUE) and Virtual Water Content. Soils were surveyed and mapped in each of three sites and three zones considered at each. In all cases the introduction of VRI had a positive impact. Energy costs were reduced because water use was reduced. Drainage leaching losses and irrigation water use in terms of mm of water used per tonne of product was also reduced. The results are illustrated in Table 5. The system is being developed by a company called Precision Irrigation; their website is http://precisionirrigation.com.nz where further information is available.

Table 5: A comparison of VRI and URI of pasture, potatoes and maize grain for total irrigation requirement, drainage, N leaching, energy use and IWUE. From: Hedley *et al* (2009)

Site	Site 1	Site 2	Site 3
	Dairy pasture	*Potatoes*	*Maize grain*
Irrigation		mm season-1	
I uri	510	215	385
I vri	466	188	311
% saved	9	13	19
Drainage /Run-off (during period of irrigation)		mm season-1	
D uri	68	50	59
D vri	37	35	45
% saved	45	29	25
N leached		kg ha-1	
N uri	29	11.9	22.1
N vri	26	9.4	22.1
% saved	10	21	0
Energy used		kg CO2-eq ha-1	
E uri	386	163	291
E vri	352	142	235
% saved	9	13	19
Irrigation Water Use Efficiency		mm t-1	
IWUE uri	29	13	28
IWUE vri	26	11	22

Cattle Tracking

Cow movement around the farm and their interaction with their environment can also be measured. Their grazing behaviour is being examined as well as their impact on nutrient re-distribution around the farm. The cows are equipped with various sensors including urine sensors. These sensors have been developed by AgResearch, Betteridge (2007) and allow us to track when a urination event takes place. Further work by Lindsay *et al* (2009) on restricted grazing trials also demonstrates how the cows grazing behaviour can impact on nutrient distribution around the dairy farm. Although in its early stages the collars appear to give accurate location of the cows around the paddocks and race ways allowing the analysis of behaviour to take place, 30 collars are being used under present experiments. The work is being funded through the Fertiliser Manufacturers Research Association (FMRA) of New Zealand. Table 6 illustrates some of the early results and shows an analysis of activity during a cow's day.

Table 6. Behavioural parameters extracted by knowing cows location every 2 min over a 10 day period.

Activity	Hours per day	%
Grazing	6.4	26.5
Resting/Ruminating	12.3	51.2
Drinking Water	0.5	2.1
Walking to and from shed	1.1	4.7
In and around shed	1.5	6.3
Other	2.2	9.3
Total	**24**	**100**

Conclusions

Improvements are being made over time but there is no one technology that appears to offer a significant and immediate improvement in production. The area of pasture measurement can clearly offer advantage to farmers if the information from the systems are used to improve management, this should lead to an improvement in pasture quality as well as better utilisation of what pasture is offered to the cows. This is probably the most promising area for improvement at the moment. The point is if we can bring our pasture management up to new levels then we are in a much better position to exploit further technological improvements such as monitored or controlled grazing in systems such as fenceless farms. So that rather than achieve 50% of the yield potential we get it closer to 80% and beyond.

The areas discussed in this paper all have a contribution to make and development is on-going. There is a clear need for simple, robust systems that can help to collect high quality information from our dairy farms and act on it through supporting the decision making processes on the farm. Integration of management information systems is also seen as very important. The technology market is entering a new phase where more players are coming into the market, some will succeed and some will fail. Farmers must endeavour to keep themselves abreast of these developments and carefully examine their potential to improve their own on-farm performance.

References

Betteridge, K., Costall, D., Hoogendoorn, C., Carter, M., Griffiths, W., 2007. A New Dawn Required For Lake Taupo. 11th Australasian Symposium on Precision Agriculture, Massey University, 14th September 2007.

Cassman, K. 2009. Biofuels: Good or Bad? Keynote Address, American Society of Agricultural and Biological Engineers, Annual International Meeting, June 21st to June 24th, Grand Sierra resort, Reno Nevada, USA.

Castillo, A.R., Kebreab, E., Beever, D.E., Barbi, J.H., Sutton, J.D. 2001. The effect of protein supplementation on nitrogen utilisation in lactating dairy cows fed grass silage diets. J. Anim Sci. 79:247 – 253.

Dawn, D., Clark,D., Pairman, D., Dynes, R., Yule,I., King,W., Mata,G., 2009 Current and future pasture measurement technologies – what can you expect? SIDE 2009 – ResilientSIDE, June 22nd to 24th, Lincoln University, New Zealand.

Gitelson, A.A., Vina, A., Ciganda, V., Rundquist, D.c., and Arkebauer, T.J., 2005. Remote estimation of canopy chlorophyll content in crops. Geophys. Res. Lett, 32, L08403.

Grassini, P., Yang, H., Cassman, K.G., 2009. Limits to maize productivity in Western Corn-Belt: A simulation analysis for fully irrigated and rainfed conditions. Agricultural and Forest Meteorology 149: 1254 – 1265.

Hedley, C.B., Yule, I.J., 2009. Soil water status mapping and two variable- rate irrigation scenarios. Precison Agric. 10:342 – 355.

C. B. Hedley, I. J. Yule, M. P. Tuohy, I. Vogeler. 2009. Key Performance Indicators for Simulated Variable Rate Irrigation of variable soils in Humid Regions, Accepted for the Transactions of the American Society of Agricultural and Biological Engineers, July 2009.

Lawrence, H., 2007 Adoption of Precision Agriculture Technologies for Fertiliser Placement in New Zealand. PhD Unpublished, Massey University, Palmerston North, New Zealand.

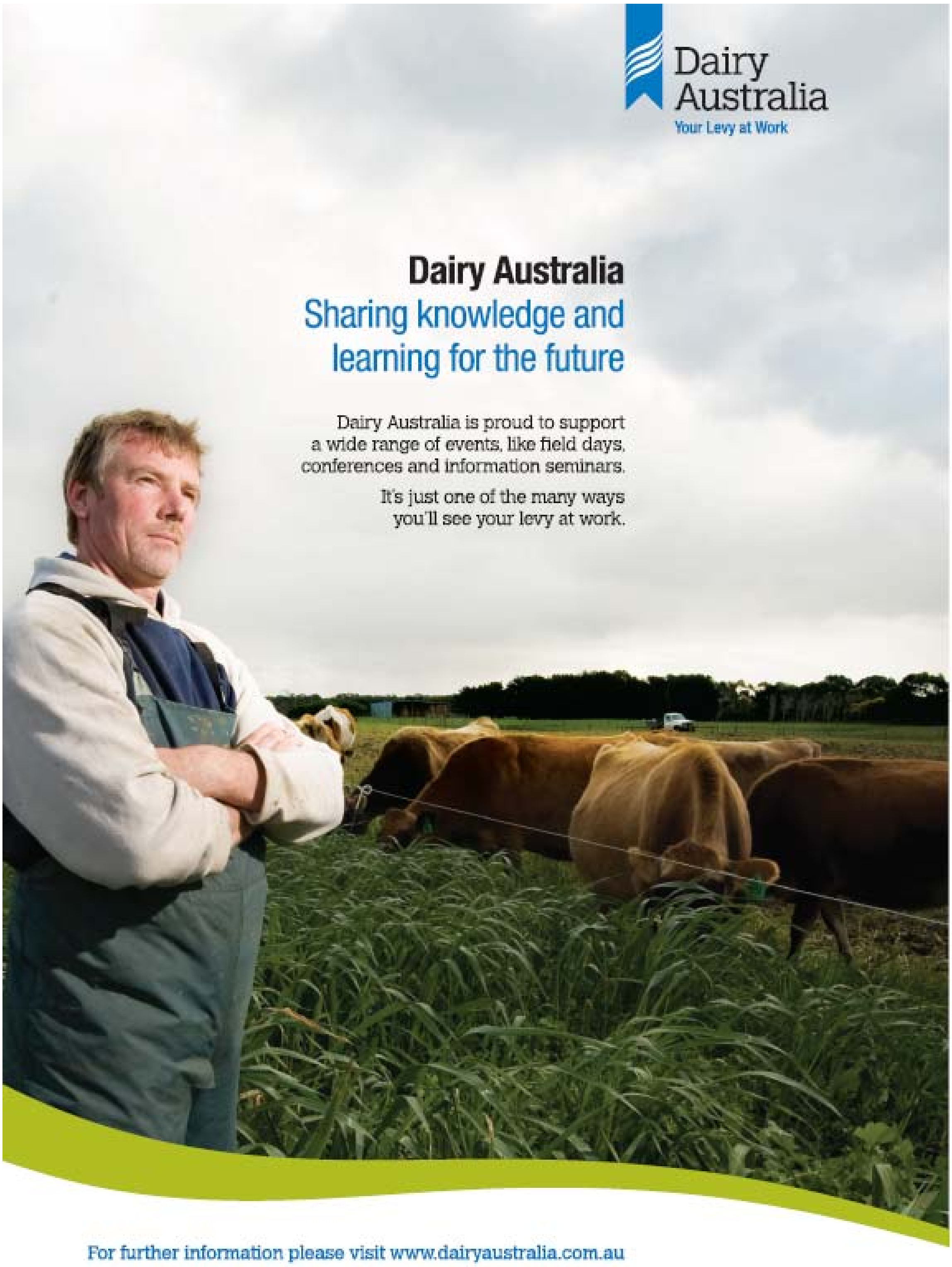
Lindsay, C., Hanly, J., Hedley, m., Horne, D., 2009. Controlling nitrogen and phosphorus loss from dairy farms using restricted grazing practices. In: Nutrient management in a rapidly changing world. (Eds L.D.Currie and C.L. Lindsay). Occasional Report no. 22. Fertiliser and Lime Research Centre, Massey University, Palmerston North, New Zealand. Pp 70 – 79.

Menneer, J.C., Ledgard, S., McLay, C., Silvester, W., 2003. The effect of a single application of cow urine on annual N2 fixation under varying simulated grazing intensity, as measured by four 15N isotope techniques. Plant and soil 254:469 – 480.

Yule. I.J. 2008. The economic importance of Accurate Fertiliser Spreading. Fert Research Conference, 70th Annual New Zealand Grassland Association Conference. Innovative and Adaptive Farming Systems. Oct 14 – 16th, Blenheim New Zealand.

Yule,I.J., Atmore, V., 2006 Rapid Pasture Assessment – Smart Technologies. Dairy 3 Conference “Smart & Sharp”. Hamilton New Zealand, April 3rd to 5th.

Yule, I.J., Pullanagari, R., 2009 Use of reflectance sensors to optimise nutrient management. In: Nutrient management in a rapidly changing world. (Eds L.D.Currie and C.L. Lindsay). Occasional Report no. 22. Fertiliser and Lime Research Centre, Massey University, Palmerston North, New Zealand. Pp 70 – 79.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FEEDING IN AN AUTOMATED MILKING SYSTEM

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Abstract

The principles of feeding cows and managing pastures are common regardless of the milking system incorporated. However, in an automated milking system cows are expected to move around the system in a voluntary fashion. To achieve voluntary and distributed milkings incentives are used to motivate cows to traffic around the system. The most reliable and useful incentive is feed and it is therefore important that feed allocation is measured and known in each paddock or area of the system. Without knowing the true allocation the system will become unreliable and the milking frequency can be erratic or cow intakes may not be maintained. Results presented here from the Camden AMS research farm indicate that high levels of pasture utilisation, milk production and daily DM intakes can be maintained.

Introduction

Automatic Milking Systems (AMS) do not just provide a new way of milking cows, they are a whole new way of farming where milking becomes a background operation and as such it is important to consider the impacts of the technology on all aspects of the dairy operation. In this paper the impacts of AMS on pasture management and feeding will be addressed.

Farmers who are successful at AMS keep the following principles in mind :

- Voluntary cow movement – infrastructure and management strategies that encourage consistent and reliable cow traffic around the farm are essential.
- A distributed milking pattern – reaping the benefit of the investment in each AMS unit by ensuring utilisation rates are optimal.

- Incentive based system – pasture/feed management is the key to reliable cow movement. Cows are mostly motivated to move by the hope of accessing more feed.

As an incentive based system AMS is reliant on having the right incentives in place at different times of the day to encourage cow traffic and generate the distributed milking pattern needed in a successful system.

In this paper some aspects of feed and pasture management will be discussed in relation to pasture-based AMS.

Pasture Utilisation, Management and Allocation

Pasture Utilisation

Historically there has been a misconception that high levels of pasture utilisation cannot be achieved in an AMS. In fact there is no known reason why a good pasture manager with a conventional milking system cannot achieve high levels of pasture utilisation when AMS is incorporated into the operation.

High pasture utilisation levels achieved at the Camden AMS research farm indicate that provided the conditions exist to grow pasture then there is no reason why utilisation levels should be reduced in an AMS.

	2007/08	2008/09
Tonne DM/ha utilised across whole milking area	13.0	13.3
Tonne DM/ha utilised on reliably irrigated paddocks	14.9	15.6
Proportion of farm receiving reliable irrigation	65%	81%
Highest yielding paddock (tonne DM/ha)	19.7	19

Pasture Management

The principles of pasture management remain unchanged regardless of the milking system (conventional or automated) and the hours spent on this task should remain unchanged if AMS is adopted. However, the fact that less hours will be spent on milk harvesting may allow more time to be spent focusing on pasture management and improve the quantity of home grown feed harvested. Ensuring that optimal pre-grazing plant stages and post-grazing residuals are achieved will ensure that optimal pasture utilisation, regrowth and pasture quality are maintained.

If pasture allocation was too high and post-grazing residual targets are not achieved then the opportunity to use the milkers to re-graze an area exists in an AMS just as it does in any other milking system. If for some reason this is not an option then excess residuals should be reduced by slashing or grazing with dry cows.

Pasture allocation

An AMS is an incentive based system. Despite what you might read in the media cow do not choose to traffic to the dairy simply because they desire a milking or to relieve the pressure on their udders. In fact with no incentives in place (i.e. if cows have a plentiful supply of feed, water, comfortable loafing areas, shade/shelter and herdmates) then only a small proportion of the herd will traffic to the dairy for milking. Monitoring the milking frequency and distribution of milkings will allow you to understand when the incentives are not working in a manner that will ensure farm system targets to be met.

Accurate pasture allocation is important in any system but the key impacts of not practicing this in an AMS will be the impact seen on milking frequency and voluntary cow traffic.

In a conventional milking system over or under allocation of pasture will have an effect on post-grazing residuals and as a result on pasture regrowth and quality (and ultimately milk production and the cost of production). In these systems cows are generally restricted to their paddock with the gate closed so they have no option but to keep harvesting from the paddock even when post-grazing residuals are low. On the other hand cows are manually driven from the paddock at milking time and will be forced to leave a higher than desirable residual if their allocation has been high.

In an AMS the paddock gate is never closed so cows can freely enter and leave the paddock when it suits them. In this situation cows will leave the paddock when the pasture source is depleted – regardless of the time of day or the interval since they entered the paddock. Smaller and more regularly available allocations of pasture will allow the achievement of higher milking frequencies and more opportunity to be selective about when cows will be drafted off for milking. It is generally recommended that pasture-based AMS farms should allocate three pasture breaks (three-way grazing) per 24-hours (where the farm layout allows this to be achieved). However, it should also be noted that provision of just two pasture breaks per day (two-way grazing) will allow reasonable milking frequencies to be achieved.

> The Camden AMS research farm practiced two-way grazing throughout the 2007/08 and 2008/09 seasons and achieved cow performance levels around 7,500 litres and 550 kg MS/cow/year with less than 1.3 t concentrate/cow.

The biggest factor affecting whether or not two or three pasture breaks can be allocated will be the farm layout and in particular the number of laneways that lead off from the dairy. If only one laneway exists from the dairy to the grazing paddocks then splitting this laneway with a fence will allow for two-way grazing (effectively splitting the farm in two). Having two laneways from the dairy will allow for one to be split creating an effect of three laneways and thereby allowing three-way grazing.

It is important to understand that high daily intakes can still be achieved in an AMS. Cows do not need to be underfed to achieve acceptable daily milking frequencies.

> During the 2008/09 season the average daily DM intake for the split-calving AMS research herd was 21.3 kg DM/milking cow/day.

Farm System Types

Farmers moving to automatic milking systems in Australia should continue to maximise their home grown feed to minimise the cost of production. However, the on-going impact of drought means that many will also consider a feed pad and associated loafing area to be essential too.

Research undertaken at Camden has been aimed at understanding how an AMS can be managed under Australian conditions.

The broad options for AMS system types in Australia are (see Figure 1):

- Pasture based system – no feed pad
- Pasture based with feed pad
- Feedlot style

Many farms could expect to change between systems at different times of the year or from year to year depending on climate, input prices and milk prices so infrastructure needs to allow the necessary level of flexibility for individual operations. The choice of dominant system type should not be dictated by whether or not AMS is being incorporated into the system but should be managed to ensure that effective cow traffic systems can be incorporated.

Assessing the varying levels of supplement to be fed at different times of the year (and potentially between years) will allow the appropriate feeding infrastructure and layout to be incorporated into the farm system.

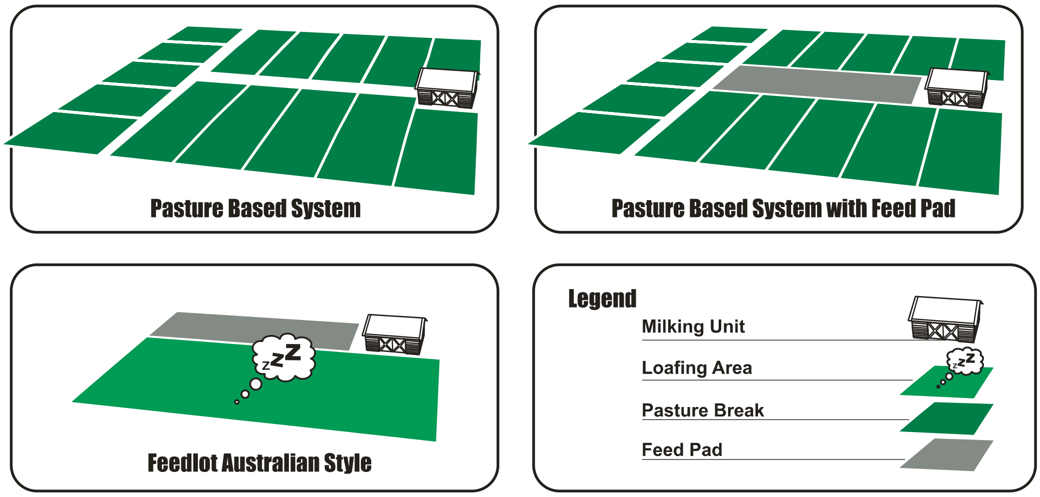

Figure 1: a diagrammatic representation of 3 possible system options for AMS in Australia.

Pasture based system – no feedpad

If no feedpad is incorporated into the AMS farm then any supplements (except those fed in the dairy) will be fed at pasture. As with any milk harvesting system this is a low cost option which may have the disadvantage of associated pasture damage and wastage of supplementary feed. If only small amounts of supplementary feed are put into the system this may be a perfectly viable option.

With this system type it is important to remember that the allocation of supplementary feed is similar to pasture in that the total amount of feed (pasture and supplement) provided in one area/paddock should be in the range of 30-50% of the total daily feed allocation. This will ensure that the feed is depleted in a timely fashion.

Pasture based system with feedpad

If a feedpad is to be or is already incorporated in the system then an understanding of how it will be used will ensure that the appropriate infrastructure is included to ensure adequate milking frequencies are maintained.

The feedpad can be used to simply supplement the two or three pasture breaks per day (if up to 50% of the daily allowance is supplementary feed). In this instance cows will not need a comfortable loafing area associated with the feedpad and a concrete floor will ensure that cows move off the feedpad after approximately 2.5 hours in search of somewhere more comfortable to ruminate – this will happen regardless of how much feed still remains available in this location.

However if it is your intention to use the supplementary feed supplied on the feedpad as a complete feed allocation (e.g. a pasture break during the night and a feedpad allocation during the day) then a loafing area will need to be made available to the cows. It would be acceptable for the loafing area to simply be a dry/sacrifice paddock but that the location of one-way gates between the feed and the loafing area would ensure cow traffic and therefore milkings are maintained during this period of the day. For example cows could come from milking to the feedpad, then freely move to the loafing area through one-way gates. To regain access to the feedpad they may have to traffic through a drafting gate and potentially move through the dairy (if they are selected for a milking) prior to regaining access to the feedpad.

Feedlot Australian Style

An Australian style feedlot could be designed similarly to a European barn style system but with the feeding and loading areas more remote from the milk harvesting units. In this situation it would definitely be desirable to have a controlled traffic system between the feeding and loafing areas of the feedlot. Again it would be expected that cows could freely access the loafing area from the feedpad and then would have to move through the drafting gates to regain access to the feed. It would be imagined that in a well designed system the cows would traffic through the drafting gates many times a day as they move from loafing to feeding and would therefore create a system in which a very controlled milking frequency could potentially be achieved with minimal variation in milking intervals.

Concentrate/grain supplementation at the dairy

An AMS allows the provision of concentrate in the milking station during milk harvesting. However, the amount that a cow can consume in this location will be largely dependent on how many minutes she spends in the station per day. This is obviously largely affected by the milking frequency and speed of milking. It would be difficult to hold average concentrate consumption levels above 6 kg. Higher consumptions levels maybe achievable with higher producing cows (>7,500 litres pa) and if higher milking frequencies (>2.3 average milkings/day) are being achieved. If the milking stations are well utilised then using these as feeding units to boost daily concentrate consumption levels would be inefficient and installation of a number of out of parlour feeders might be a better option. Out of parlour feeders are simply feeding stations (generally located after the milking stations) whereby cows can access any carry-over feed allocation that might be available to them.

An AMS allows individual feeding of cows within the herd and should allow different "groups" of cows to be fed to different levels or for cows to be fed individually based on production levels. Some care must be taken (particularly during the AMS establishment period) to ensure that feeding rates are appropriate to allow cows to consume the level of targeted allowance whilst minimising any wastage and residual feed in the station at the completion of each cows' milking session.

Conclusions

The feeding principles within an Automated Milking System (AMS) are generally the same as within a conventional milking system. Particularly with regard to a balanced diet and grazing pasture at the right time to optimise re-growth and minimise pasture wastage. However, the added complexity in an AMS is that the feed allocated to cows on a daily basis is generally the most reliable incentive used to motivate cows and generate voluntary cow traffic. Allocating too much or too little feed in any one area or at any one time will likely have some impact on cow traffic and as a result milking frequency. Ultimately there will also be an impact on daily intakes and direct and indirect effects on production.

Whilst feed is the key incentive to generate cow traffic it should not be misunderstood that cows need to be hungrier or underfed to achieve desirable milking frequencies. Generous average daily DM intakes can be maintained whilst high pasture utilisation levels are still achieved.


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FEEDING COWS IN DRYLAND DAIRY FARMS: HOW TO PLAN FOR THE UNCERTAINTY

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Abstract

The amount of dry matter (DM) required by the milking herd outstrips the available DM delivered by the pastures for a number of months of the year. During periods of peak fodder growth, on farm conservation methods are imperative to ensure the ongoing productivity of the animals. However, the effect of reduced rainfall in the south west region of Victoria is having a significant impact on the persistence of perennial ryegrasses, and hence the amount of fodder available for both grazing and fodder reserves. As a result, on farm profitability and productivity is placed under stress. Whilst it is impossible to alter the amount of rainfall received, a number of strategies are being put in place in an attempt to minimise the impact of this climatic issue. Utilisation of different pasture species, implantation of crop rotations and management of grazing strategies are all tools which are being used to maximise any and all available rainfall.

Introduction

With the changing climate, new pressures are being placed on farmers to produce home grown fodders. In South West Victoria, the Colac area rainfall has been reduced across the full growing season. During winter this has been a benefit with reduced pugging of pastures but has resulted in no recharge of dams and sub surface moisture. The reduced rainfall in the spring of the 2006 and 2008 seasons has had a significant effect on conserved home grown fodder and the longer summers have had an impact on the survivability of perennial pastures. In addition longer feed out times have had an impact on reducing profitability. On our farm we are attempting to maximise every drop of rainfall by having a range of home grown feed ranging from lucerne to annual rye grass and some trial work with other fodders.

Farm overview

“Craiglands” is predominately a dryland farm, comprising a 240 hectare milking area and a 150 hectare runoff area with approximately 10 hectares available for effluent spray irrigation which is double cropped. We run a closed herd of 450 registered Holsteins rearing 120 replacements each year, giving us a stocking rate of 1.9 cows/hectares on the milking area. The main supplement used is home grown silage with bought in hay and grain. The yearly consumption of grain per year (averaged over 3 years) is 1.8t/cow and hay is 0.6t/cow. Our calving pattern has recently changed from a sole autumn calving to a split calving, with 80% of the herd calving in the autumn and 20% in the spring (all AI produced). This was implemented due to incentives from our milk supply company and a move to extended lactation for higher producing cows.

Planning

"Let our advance worrying become advance thinking and planning"

(Winston Churchill)

The change in the amount and timing of rainfall has forced us to improve our understanding of the effect that this has on our traditional feedbase, in order to implement appropriate strategies. The predominant use of perennial rye grass has served us well over a number of years but the lower survivability and the lower total production in the face of decreased rainfall has meant that we need to limit our exposure by utilising a number of other rye grasses (perennial, Italian, annual, diploid tetraploid etc). Figure 1 illustrates that the rainfall in 2008 is below the 105 year average for the Colac area.

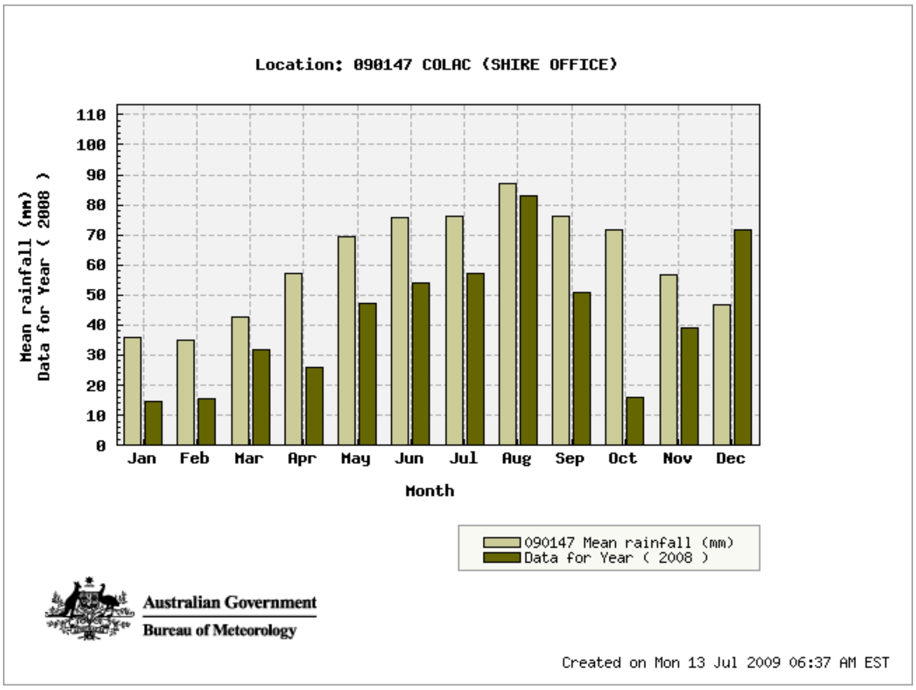

Figure 1: Colac 105 year average against 2008 rainfall.

The significant issue for our business in graph 1 is the rainfall deficit in the September/October period of 2008. The 50mm of rain in September fell in the first week of that month so the last 3 weeks of September and the whole of October produced only 17mm of rain. This is our normal harvest period and as such the deficit had a large impact on our silage and hay harvest due to reduced grass growth. In addition, the rain that fell in December was "wasted" as most of our rye grass pastures had finished and half of our summer crops had failed.

The outlook is no better as can be seen by the 2009 rainfall figures against the 105 year average (see Figure 2), with no rain in February and low April, May and June figures.

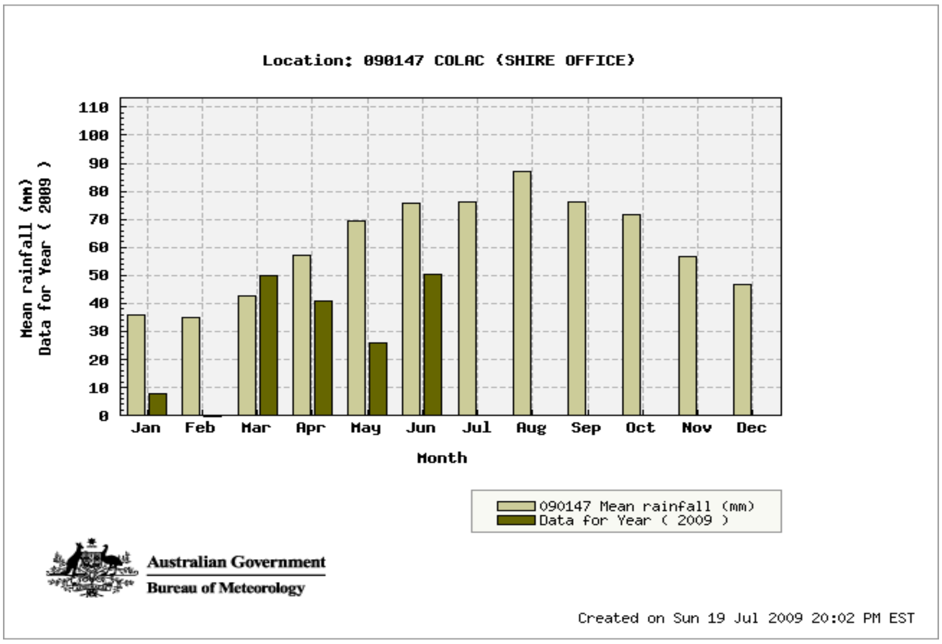

Figure 2: Colac 105 year average against 2009 rainfall.

With these rainfall figures in mind we can start to build a picture of what is needed in the way of supplementary feeding and feed grown on farm. With the knowledge of how our farm has performed over the last 5 years we can make some educated guesses based on graph 3.

Figure 3 highlights the need of nitrogen (N) in our system to boost the availably of feed both for grazing and harvest. In general, the average response of nitrogen is 435t DM which is very expensive to replace with bought in grain and hay.

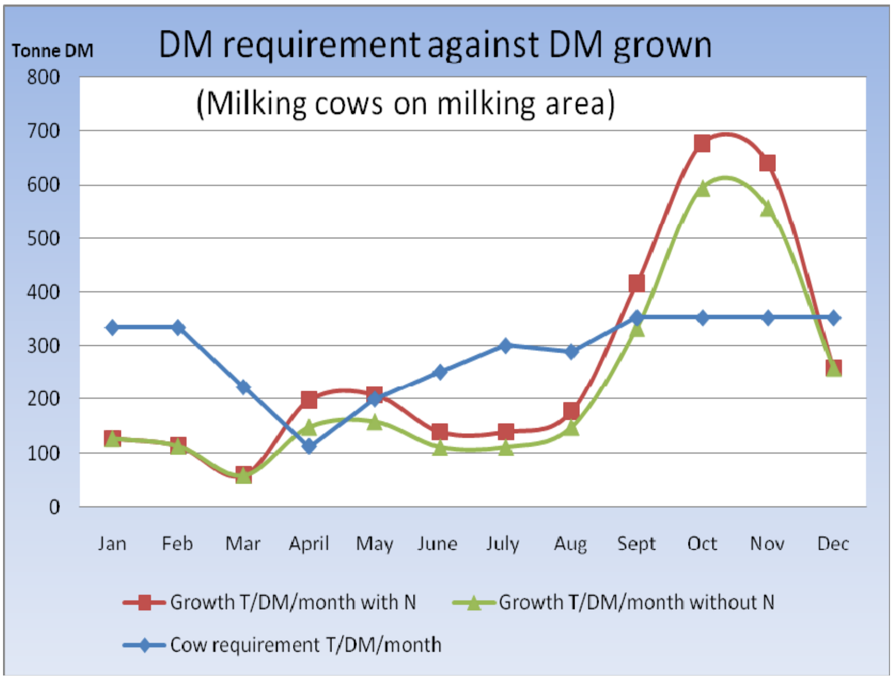

Figure 3: Average pasture growth rates against herd requirements in tonnes of DM (Ward, 1996; McKenzie, 1997)

So what do we do to maximise home-grown feed? Table 1 outlines the basic planning undertaken for each year, although minor changes may be made depending on the seasonal conditions and milk price.

Table 1: The "Craiglands seasonal plan"

Autumn	Winter	Spring	Summer
Calving Over sowing	Mating	Calving Harvest	Feeding Mating
Maximise high quality home grown forage Over sowing program including Annual rye/brassica , Italian rye, Perennial rye and other forages e.g. Forage rye corn. Fill feed gaps with bought in feed, Urea and silage to extend rotation and build feed wedge	Maximise cow condition for mating Maintain or increase farm pasture cover Tight grazing control (no overgrazing) Set up summer crop paddocks.	Tight grazing control (no under grazing) Ensure ALL surplus forage is conserved Prepare summer crop paddocks Assess conserved feed quantity and quality	Graze summer crops Use conserved feed, bought in hay and grain to supplement Spell perennial pastures use sacrifice paddocks Use lucerne and other fodders to capture "out of season rain"

Elements in our feed base

Autumn is the start of our pasture management and to ensure a good quantity of high quality feed, leafy turnip (Appin from Wrightson seeds) is added to our annual rye grass. The annual rye grass is sown at 30kg/ha and the turnip is added to the mix at a rate of 1kg/ha. This is sown mid March (dry) with a direct drill with 50kg/ha of DAP. In a normal year this gives us about 4t/ha at first grazing (see image 1). Feed testing (2008) showed the total fodder to be 13.4ME, 25.2% CP and a NDF of 34.6. First grazing is around 6 weeks from the "autumn break" The Appin on its own was 14.1ME, 23.6% CP and 22.5 NDF. After the first grazing, the paddock is treated as an annual ryegrass paddock in the rotation with the turnip diminishing to none after the 3rd grazing.

Image 1: Annual ryegrass sown at 30Kg/ha with leafy turnip sown at 1kg/ha 1st grazing

Image 2: Same paddock 42 days later (2nd grazing)

A forage ryecorn for early autumn feed was trialed in 2008, and was grazed about 4 weeks after the autumn break. Forage ryecorn has the potential to produce double the dry matter compared to oats at first grazing. This was direct drilled into a paddock which was sprayed with glyphosate after the first rain and sown at a rate of 100kg/ha with 50kg/ha of DAP. The paddock chosen is to be double cropped with a rape variety sown in early October 2009 and then resown to perennial pasture in autumn 2010.

Italian ryegrass is used as a long term annual in our system giving us reasonable autumn/winter feed and excellent silage. The advantage of using Italian with late flowering characteristics is that we can get good re-growth after silage if rainfall occurs.

Perennial pasture is still the mainstay of our system however as discussed earlier, the longer summers are having an effect on the longevity of these pastures. After the first autumn rain these paddocks enter the rotation first while the oversown paddock are establishing. We are finding that the newer tetraploid perennials are producing well in the first and second year but need topping up with an oversow or complete resow in year three or four. As a result, we are now looking at mid flowering perennials (Extreme AR37 and others) to increase seed set as the later flowering varieties are not finishing well due to the unreliability of the late spring rains.

Lucerne (6ha) was introduced into our system for the first time in spring 2008, after the hardest summer seen at our farm in 20+ years. The lucerne was impressive because of its drought tolerance and ability to respond to out of season rain. The lucerne added

Image 3: Yearlings grazing forage ryecorn

Image 5: First cut lucerne December 2008

approximately 42t DM at a time when there was no ryegrass growth and provided two grazings and one cut of silage in its first year. Due to this success we will be adding a further 6ha to the system in spring 2009.

Summer crops (normally brassicas) are sown after silage is taken off. The main issue we are faced with is that the silage crop uses a great deal of moisture and as such, we have to get the silage crop off at the end of September in order to retain as much of this moisture as possible for the subsequent crops. After two crop failures in spring 2008, millet will be sown with the brassicas as a risk management strategy.

The feedbase must be flexible to respond to seasonal variations. Whilst not perfect, we believe that our current programme and structure provides that flexibility.

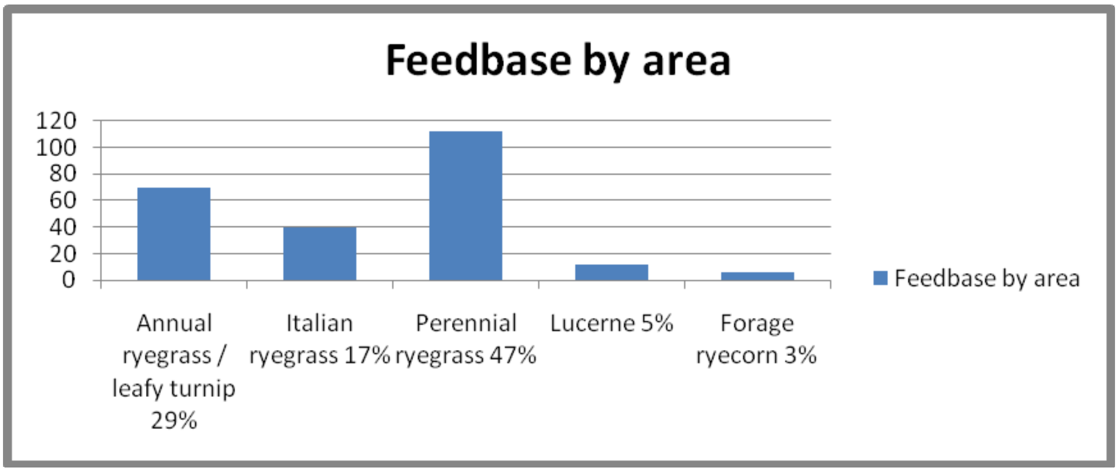

Figure 5: The Craiglands feedbase by area

Risk

It is vitally important for us to recognise a fodder shortfall well in advance of it happening. By recognising the early signs, we are able to source off farm feed and other high quality fodder for competitive prices. In addition, establishing and maintaining good relationships with fodder providers is essential in order to ensure good quality and continued supply. Silage is an easy feedsource to store long term on farm, and another strategy is to build a silage reserve each year for the next significant fodder shortfall. Based on this in an average year we attempt to put into reserve 400 – 500t of DM a year.

Conclusions

By knowing our farms strengths and weaknesses we can manage the risks associated with dryland farming in an ever changing climate. It is important that we keep looking past the front gate to see what our neighbours and others in the industry are doing, in order to implement improvements on our own farm. We need to have the confidence in our own abilities to utilise new information and have systems in place that are flexible enough to respond quickly to the good years and cope with the bad, depending on whether that be in the form of milk price or seasonal conditions.

References

McKenzie, F., 1997 May, WestVic Dairy News, pg 11, In, Target 10, 1998, Fertilising Dairy Pastures (pp 220), Department of Primary Industries

Ward, G., Personal communication, 7 May1996