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Establishing relationships between observed pasture conditions, NIRS predicted diet quality and grazing breeder cattle body condition in the Pilbara and Kimberley

Abstract

Changes in the body condition of breeders during the year are critical to their subsequent reproductive performance. To wean one calf/cow/year, managers require tools which allow them to monitor and predict the body condition of breeder cows throughout the season.

This project documented changes in body condition of breeder cattle grazing representative pasture communities in the Pilbara (7) and the Kimberley (3) over a 3 year period. Faecal samples were collected from groups of breeders at 4-6 week intervals from 25 sites across the ten pasture communities. Pasture and cattle management practices were recorded at each sampling. Near Infra-red Reflectance Spectroscopy (NIRS) was used to predict diet quality attributes from the faecal samples. Relationship between the NIRS results and wet and dry breeder body condition (up to 9 weeks prior to sampling) and observed pasture conditions were established.

Pasture digestibility nine weeks before sampling had the highest correlation with dry and wet cow body condition score (0.60, 0.57; and 0.43, 0.40) for the Pilbara and Kimberley respectively. The results also highlighted the speed of changing pasture quality conditions within the two regions. The project has provided a valuable information resource for decision making and more productive grazing management systems for the north Western Australian cattle industry.

Executive summary

By comparison with many other areas of northern Australia, little information has been documented on the production parameters of grazing cattle in the Pilbara and Kimberley regions of WA. Cattle properties in both regions are characterised by their extensive areas, large herds and, variable land systems and pasture communities. In addition, there is a highly variable climate which impacts on pasture quality and quantity throughout the year and this is generally accompanied by a lack of infrastructure and animal control. These factors all contribute to significant opportunities to improve and stabilise individual animal and overall herd performance. In order to facilitate the management changes required to make the improvements, simple, practical methods of herd, pasture and diet quality assessment need to be developed.

Breeder body condition was used as an indicator of animal performance in this project due to the extensive nature of the co-operating properties; the limited value of liveweights as a measure of breeder performance; the accepted usage of changes in breeder body condition by pastoralists as an indicator of how breeders are 'doing' and the documented value of breeder body condition as an indicator of future breeder reproductive performance (DAQ.098).

The development of Near Infra-red Reflectance Spectroscopy (NIRS) technology within the grazing industry allows for a rapid assessment of an animals' diet quality. The technology had not been previously used in the Pilbara and Kimberley. It offers graziers a robust tool to make better informed management decisions in areas such as timing of sales, weaning and supplementation.

This project had a number of objectives aimed at developing practical, strategic management tools for beef producers in the Pilbara and Kimberley regions of Western Australia.

1. Monitor changes in body condition of breeders in a range of pasture communities.
2. Evaluate the useability of current faecal Near Infra-red Reflectance Spectroscopy (NIRS) predictions of diet quality selected by grazing cattle in the Pilbara and Kimberley of WA.
3. Develop relationships between NIRS predictions and breeder body condition which will allow beef producers to make better informed decisions on supplementation programs, mustering and animal handling, weaning and sale programs.
4. Document changes in pasture quality and quantity over a number of seasons for the major pasture communities in the Pilbara and Kimberley

This project consisted of three main data collection categories: (1) breeder body condition and lactation status, (2) faecal samples and (3) pasture condition.

Information and data were collected at approximately 4-6 week intervals during a three year period from 25 sites representing ten pasture communities and 16 co-operator properties in the Pilbara and Kimberley.
Data collection sites were established at stock watering points and chosen in consultation with the co-operating pastoralists, to represent the productive pasture communities of each area where breeder cattle would normally be grazing for 12 months of the year. Body condition score of around 50 head of breeders was assessed using a nine-point scale. The

lactation status was also recorded. Fresh faecal samples were collected at each site for prediction of diet quality using NIRS.

The project found both lactating and non lactating (dry) breeders in the Pilbara maintained body condition longer following summer rains compared to similar groups in the Kimberley. Faecal NIRS predictions of diet quality were shown to be reliable indicators of diet quality and will provide useful information for breeder herd management and supplementation strategies in the future. NIRS estimates of digestibility were shown to be of some use as a predictor of changes of cattle condition in Pilbara pasture communities. However no relationship between NIRS diet quality and liveweight change was able to be established from this project. Liveweights of the cattle observed during this project were not recorded.

The project demonstrated that while faecal NIRS provided useful predictions of diet quality at the time of sampling, other parameters such as pasture quantity and quality need to be included in cattle and grazing management decisions. This information together with the improved understanding of how breeder body condition is likely to change during the year will assist managers and industry advisers to develop more productive management systems.

The limited capacity of faecal NIRS to predict future breeder body condition changes as documented in this project might be expected due to the large number of variables associated with the conduct of the project. Different individual animals were observed at the same site on different occasions; mating was not controlled; NIRS predictions were determined using calibration equations that do not include diet faecal pair information from pastures in these areas; to identify some of the variables.

All of the Pilbara observations were made and recorded by one operator as were the Kimberley observations. This improved the repeatability of observations and activities including; breeder body condition, pasture yields and quality, sample collection and handling and data recording.

It is recommended to:

1. Investigate and develop methods to collect representative diets from variable land systems and conduct diet faecal pair work to improve the reliability of current NIRS calibration equations for arid areas – especially the Pilbara.

2. Develop a series of photo standards of pasture yield for several Pilbara and Kimberley pasture types to enhance pasture assessments and grazing management decisions.

3. Emphasise caution when advocating supplementation of breeders in the eco fragile Pilbara region so that pasture communities remain in strong condition for extended periods following effective summer rains.

Contents

1 Background

In order to develop and successfully promote management strategies to improve the productivity of cattle businesses in the Pilbara and Kimberley it is essential to have an understanding of current production parameters. Developing some understanding of the diet quality that grazing cattle were able to select was seen as an important early step in this process.

There is a wealth of information published on land systems and pasture types of the Pilbara and some information on the nutritive value of different pasture species but little information available on diet quality that grazing cattle actually select and how this might vary on different pasture types.

Little information on cattle performance has been documented in the Pilbara. It is limited to the Cunyu Demographic Study (a well conducted and documented study from 1990-1998), the Mt Clere Producer Demonstration Site (1993-1997) and some unpublished interim reports of Producer Demonstration Sites (PDS) conducted at Muccan and Boodarie in the early 1990s.

Information from these studies indicates that while breeder reproductive performance can vary widely between years, pregnancy rates of up to 80% are achievable. Fletcher et al, reported steer growth rates over two seasons and three locations in the Pilbara of around 150kg a year. (Pilbara Steer Growth Evaluation 1994-96).

These studies indicate that there is potential to improve the productivity of Pilbara herds if the effects of seasonal variations in animal performance can be better managed. Developing a better understanding of how breeders perform in terms of body condition changes and the diet quality they are able to select was seen as an important first step in this process. By better understanding diet quality fluctuations and the ability of NIRS estimates to predict future animal performance, the timing of management practices to preserve breeder body condition, optimise sale weights and instigate supplementation could be more effectively managed.

2 Project objectives

The project was initially conceived to provide some information on the diet quality of cattle grazing the different pasture systems of the Pilbara. Unlike many areas of northern Australia there was little (if any) documented information on diet quality for this region. A secondary objective was to determine how useful faecal NIRS might be to predict diet quality and animal performance.

The specific objectives of the project were:

1. Establish initial animal performance ‘benchmarks’ of grazing cattle in the Pilbara region of WA.
2. Establish the reliability of faecal NIRS to predict animal performance and as a management tool in the Pilbara.
3. Produce a technical report, based on producer experience and best bet information, on the use of supplements in the Pilbara.

Objectives 1 and 2 were subsequently expanded to include project sites in the Kimberley.

3 Methodology

3.1 Sites

3.1.1 Pilbara site details

Cattle data collection sites were established at stock watering points on 7 of the more productive land systems/pasture types on properties in the Pilbara. Details of the collection sites and the land systems and pasture types included in a 3 km grazing radius from the stock watering point are presented in Table 1.

A 3 km grazing radius from water was selected for the purpose of establishing the main land systems/pasture types available for grazing at each site. It was assumed that cattle spend the majority of their grazing time within that area. These land systems and pasture types are described by Van Vreeswyk et al (2004).

Each site was selected in co-operation with pastoralists as being representative of that land system/pasture type on their property and likely to carry cattle throughout the year. An eighth site, Nimmingarra, was included only towards the end of the project period. A map of the Pilbara showing co-operating properties and collection sites is included in Appendix 1.

Table 1 Pilbara sites with land systems and pasture types within a 3 km grazing radius

Sites	Land systems	Pasture types
Cliffs Mill, Horseshoe, No6	Hooley, Brockman, Paraburdoo, Pindering.	Roebourne plains grass, buffel
Christmas Tank, Midway No3, Ram Quarry	Uaroo	Soft Spinifex, Aristida spp.
Crossroads, Tragedy	Cane, Horseflat, River	Tussock grasses inc. Ribbon, Roebourne plains and Buffel grasses.
Fredericks, Yorks Mill, Manawar	Brockman, Hooley	Mitchell and Roebourne plains
Minsons, River, Parsons	River, Mallina,	Soft Spinifex, Buffel
Stirrup Iron, Shaws, Stewarts	Sylvania, River, Divide, Fortesque.	Buffel, Roebourne plains, soft Spinifex, ,Aristida spp.
Victory Mill	Yamerina.	Buffel and marine couch
Nimmingarra	Uaroo, River, Boolaloo.	Soft and hard Spinifex (limited collections only)

The pasture communities included in the Pilbara component of the project were selected as the most common and productive pasture communities in the Pilbara (Sandra Van Vreeswyk pers. com.).

Pasture monitoring photo sites were established 1.5 and 3 km from water adjacent to roadways in areas representative of the target pasture type. These sites provided a photographic record of season and grazing effects on pasture quality and quantity during the project. Each pasture photo site consisted of two steel pickets 10 metres apart in a north-south orientation. Each site was located by GPS co-ordinates. Examples of photo records from one of these sites are attached as Appendix 3.

The pasture species listed in Table 2 represent the major species commonly identified by pastoralists and it is presumed that they provide a significant part of the diet on offer to cattle at different times of the year at each of the sites. Some infusion of buffel was evident at most sites and was apparently readily grazed where present.

Table 2: Pasture species common and scientific names

Common name	Scientific name
Roebourne plains grass	*Eragrostis xerophila*
Soft spinifex	*Triodia pungens*
Buffel	*Cenchus* spp.
Ribbon grass	*Chrysopogon fallax*
Marine couch	*Sporobolus* spp.

3.1.2 Kimberley site details

Cattle data collection sites were established at stock watering points central to one of 3 target land types/pasture communities on properties in the Kimberley (Table 3). Pasture photos sites were established 1 km from collection sites.

Table 3: Kimberley sites with land systems and pasture types within a 3 km grazing radius

Sites	Land systems	Pasture types
Bulka	Pindan	Soft Spinifex, buffel grass
Jubilee No1	Pindan	Soft Spinifex, ribbon grass, wattles
Myroodah	Pindan	Soft Spinifex, ribbon grass, wattles
Nerrima	Pindan	Soft Spinifex, ribbon grass, wattles
Jubilee Greenhide	River floodplains	Mitchell grass, blue grass, mimosa
Liveringa	River floodplains	Mitchell grass, bluegrass, native sorghums
Moola Bulla	Loamy creeklines/ rocky outcrops	Soft Spinifex, black speargrass, bluegrass

3.2 Cattle observations

All cattle and pasture observations were conducted and recorded by the same experienced operator in the Pilbara and Kimberley respectively.

Together with the use of cattle condition photo standards, this minimised the potential for between operator variability and increased the repeatability of observations and recordings. Cattle observations were made every 4-6 weeks (weather permitting) and included:

- Body condition (1 – 9 scale) as described by Nicholson and Butterworth (1986), of representative lactating, dry and growing animals present at each site. A minimum of 15 head of each status to a maximum of 30% of the cattle present was recorded. Photo standards of body condition were developed and used to ensure consistency of body condition assessment.

- An estimation of females lactating as a percentage of mature-age females present.
- Photographs of representative lactating and dry breeders to develop a record of body condition changes for each site for the benefit of co-operating pastoralists.
- An assessment of the current liveweight (condition) change status of dry animals. This assessment was usually a combination of the perceptions of the pastoralist and project officer and were recorded as gaining, holding or losing condition at the time of assessment.
- Cattle management activities/events (e.g. mustering, weaning, sales) that might affect grazing behaviour, stocking rate and body condition of the representative groups.
- Rainfall, fires etc that may have effected pasture quality or quantity.
- An assessment of quality of pasture on offer using pasture growth phases (as used in the EDGE*network* Nutrition workshop), leaf:stem ratio, % green leaf and an estimate of yield.
- A bulked faecal sample consisting of a 100 ml scoop of fresh (warm) faeces collected from 10 -15 dung pats. This bulk sample was thoroughly mixed and a 300 ml sub sample selected and immediately refrigerated. Samples were refrigerated for up to four days before freezing where not convenient to dry the samples immediately.

  Pilbara samples were dried in a drying oven at 60°C for 24 – 48 hours depending on initial moisture content. Kimberley samples were air dried in baking trays for 2-4 days depending on the prevailing weather conditions and initial moisture content of the samples.

3.3 Data management

Following each collection, condition score means were calculated and all information collected during the 'round' was entered on a field data collection form, developed by the QDPI&F NBP.303 project team. A copy of this information accompanied the samples for analyses.

Information collected and NIRS determinations were collated and recorded in a spreadsheet format to allow simple comparisons of changes in cattle condition and diet quality predictions. Towards the end of the project all data collected was entered into a data base developed by the QDPI&F NBP.303 project team to facilitate final analysis.

3.4 Analysis of samples

Each dried sample was thoroughly mixed and a sub sample selected and forwarded by mail to CSIRO, Townsville, for NIRS determinations by David Coates.

3.5 Data analysis

Statistical analyses were conducted by Jane Speijers, DAFWA, Perth. Complete reports of the analyses are included as appendices 4 and 5.

The Pilbara and Kimberley data sets were analysed separately on the basis of smaller numbers of records from the Kimberley. Kimberley sites were only initiated following a mid term project review.

The relationship between animal production and diet quality was examined using regression analysis.

Dependent variables: Average condition score of dry cows (Dry BCS)
Average condition score of wet cows (Wet BCS)

Independent variables: Crude protein (CP) at sampling and 3, 6 and 9 weeks prior to sampling.
Faecal nitrogen (FN) at sampling and 3, 6 and 9 weeks prior to sampling.
Digestibility at sampling and 3, 6 and 9 weeks prior to sampling.
Non grass (NG) at sampling and 3, 6 and 9 weeks prior to sampling.
Pasture yield category and interactions with diet variables
Pasture type category and interactions with diet variables
Percent lactating cows and interactions with diet variables
Paddock and interactions with diet variables

(* Values 3,6 and 9 weeks prior to sampling are interpolated values based on prior sampling records. There are no values/predictions available for these variables prior to the initial sampling.)

One of the major causes of variability in average CS for wet and dry cows was animals moving between the two groups. Wet cows, particularly towards the end of their lactation, can have much lower CS than dry cows. If a large number of calves were weaned between sampling dates then this could lead to a drop in the average CS of dry cows and perhaps an increase in the average condition score of wet cows at the subsequent sampling date. The percentage of cows lactating reflects change in the size of the wet and dry groups and may account for some of this variability.

Stepwise regression using GenStat for Windows was used to select the best multiple regression model. The process was constrained so that the principle of marginality was adhered to, i.e. if a particular interaction was significant then the main effects for factors or variables making up the interaction were also included. In addition ten variables of uniform random numbers were included in the process to identify the significance level to control terms entering and leaving the model. Plots of residuals were used to identify outlying points and affirm the assumptions underlying regression.

4 Results and discussion

4.1 Observations of breeder body condition changes

The body condition of individual lactating and non lactating (dry) breeders was assessed using a 1 - 9 scale at each data collection site on a regular basis during the project. A minimum of 15 head of each of lactating and dry mature breeders, to a maximum of ~ 30% of each class present was recorded at each observation. Mean condition scores for each group were calculated from the individual animal condition scores at each observation at each site. A summary of the number of data collections from each pasture type is shown in Tables 4 and 5.

Table 4: Number of Pilbara data collection observations from each pasture system

Land systems	Pasture types	Total observations
Hooley, Brockman, Paraburdoo, Pindering.	Roebourne plains grass, buffel	53
Uaroo	Soft Spinifex, Aristida spp.	60
Cane, Horseflat, River	Tussock grasses inc. Ribbon, Roebourne plains and Buffel grasses.	41
Brockman, Hooley	Mitchell and Roebourne plains	27
River, Mallina,	Soft Spinifex, Buffel	60
Sylvania, River, Divide, Fortesque.	Buffel, Roebourne plains, soft Spinifex, ,Aristida spp.	59
Yamerina.	Buffel and marine couch	27
Uaroo, River, Boolaloo.	Soft and hard Spinifex (limited collections only)	7
Total observations		334

Table 5: Number of Kimberley data collection observations from each pasture system

Land systems	Pasture types	Total observations
Pindan	Soft Spinifex, ribbon grass, wattles	39
River floodplains	Mitchell grass, bluegrass, native sorghums	15
Loamy creeklines/ rocky outcrops	Soft Spinifex, black speargrass, bluegrass	11
Total observations		65

The relationship between breeder body condition changes, rainfall and NIRS predictions of digestibility for a period of up to 3 years for each pasture type are reported in figures 1 to 9. Pasture types with few collections, Nimmingarra in the Pilbara and Moola Bulla in the Kimberley are not included.

Lactating cow body condition generally mirrored dry cow condition on all pasture types. Changes of individual cows between groups i.e. cows calving or being weaned between observations complicated these relationships at times.

It is generally accepted in northern Australia that breeders with older calves are in poorer body condition than breeders with younger calves. At a body condition observation immediately before a weaning muster the cows with the older calves would have been correctly recorded in the lactating cow group. At the same observation the dry cows would have only included 'legitimate' dry cows, which from these observations would be in at least one body condition score better.

At an observation of the same group of cows following a weaning muster, the weaner mothers, now dry cows in poor condition, would be recorded with the dry cows thus reducing the average condition score of that group. In addition the average condition of the lactating breeder group might be expected to improve as only the breeders with the younger calves and in better condition remain. Diet quality at the time of sampling, in these figures represented by faecal NIRS predictions of digestibility, generally foreshadowed future changes in body condition.

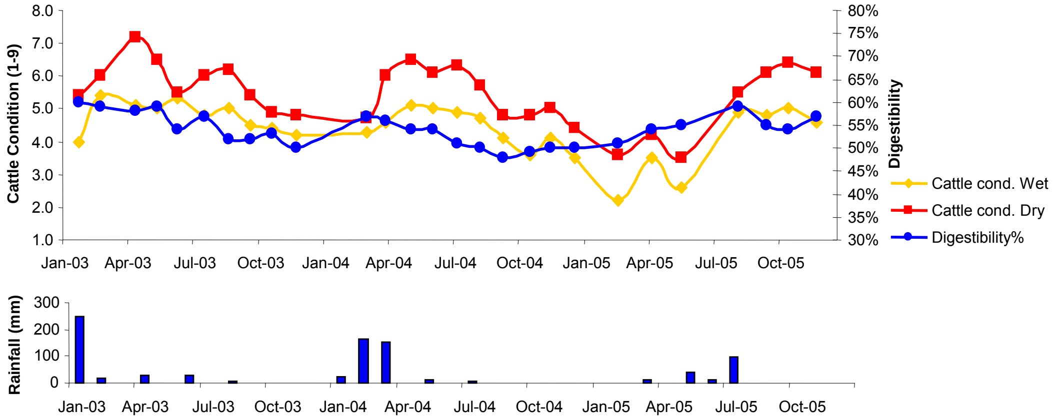


Figure 1: Cow condition (1-9 scale), digestibility and rainfall on a buffel grass and marine couch pasture January 2003 to December 2005 (Victory Mill)

The results for this buffel/ marine couch site, Fig 1, demonstrate the effect of a weaning muster in April 2003 on changes in cow condition recorded at subsequent observations. Average lactating cow condition was maintained or actually improved while dry cow condition declined dramatically over the same period, presumably due to the inclusion of weaner mothers in that group. A similar effect is demonstrated following a second round muster in October 2003.

The effect on cow body condition of a failed summer growing season in 2004-05 is also clearly demonstrated. Although digestibility improved following initial small falls of rain in April 2005 and more significantly following good rains in May and July body condition changes were delayed due to a low pasture yield at this site at that time <500kg/ha at the April and June 2005 observations.

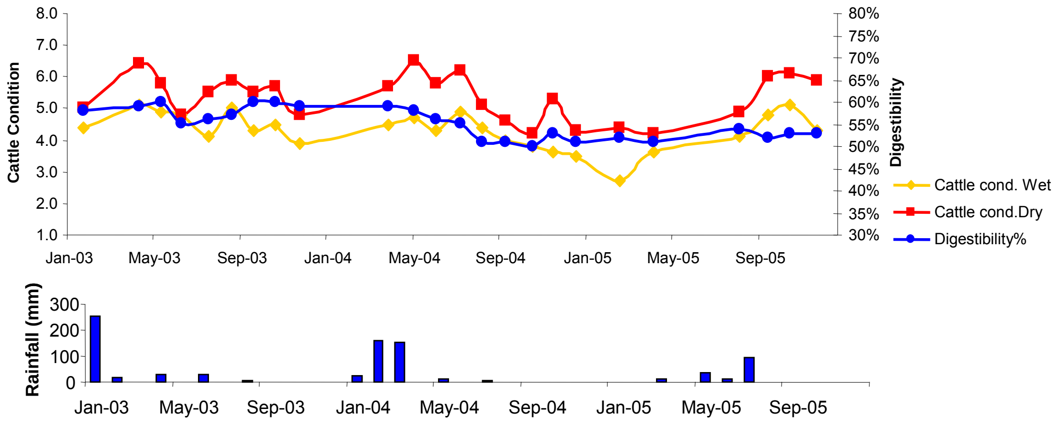


Figure 2: Cow condition (1-9 scale), digestibility and rainfall on a soft spinifex pasture from January 2003 to December 2005 (Ram Quarry)

Dry cows on this soft Spinifex pasture system, Fig 2, demonstrated the effect on body condition of a management system incorporating two weaning musters a year. Average dry cow condition only fell to score 4.2 following the failure of the summer growing season in 2004-05. The effect of lactation during the same period is clearly demonstrated with average lactating cow body condition declining to score 2.7 in March 2005. The effect of a weaning muster in March on the body condition of lactating cows recorded in April is also clearly demonstrated. The condition of the lactating cow group improved significantly while the condition of the dry breeder group continued to decline marginally due to the inclusion of 'weaner mothers' in that group.

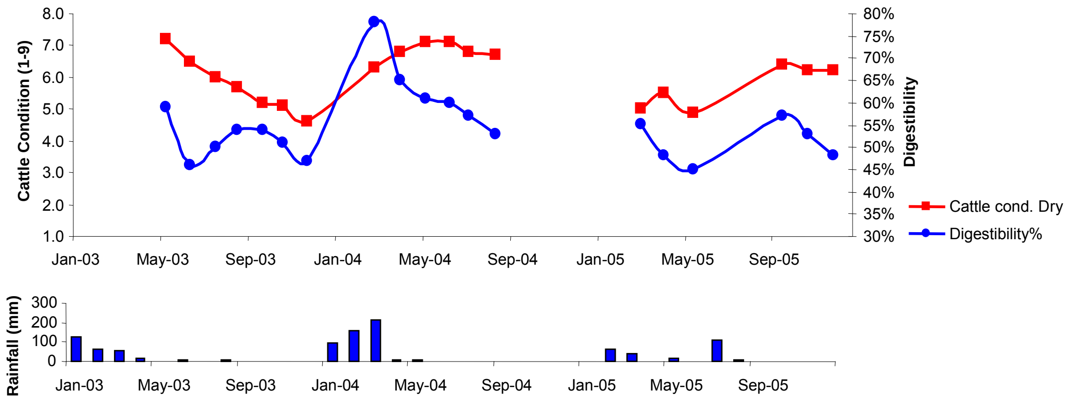


Figure 3: Cow condition (1-9 scale), digestibility and rainfall for dry cattle on a Mitchell, Roebourne Plains grass pasture January 2003 to December 2005 (Yorks)

This site, Fig 3, at Yorks Mill was the only site in the project that was stocked with dry cattle, 2 drafts of weaner and yearling heifers. Body condition score changes are likely to be confused with growth as no estimates of skeletal growth were recorded. The changes in digestibility and heifer body condition would be similar to what might be expected in other Mitchell grass areas of northern Australia with digestibility predictions ranging from 78% (diet CP 17.5%) in March 2004 during a good summer growing season and falling to below 50% by about July in years with useful summer rain (2003 and 2004).
Digestibility improved, presumably due to some herbage response to small falls of out of season rain in June and August 2003 but heifer condition continued to decline slowly even in the presence of an estimated pasture yield of 500 – 1000 kg/ha.

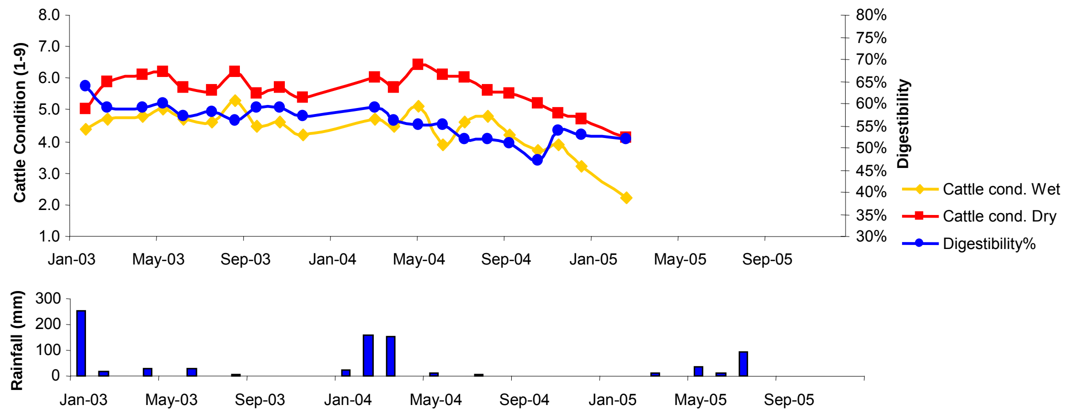


Figure 4: Cow condition (1-9 scale) digestibility and rainfall on a buffel grass pasture January 2003 to March 2005 (River)

Breeders maintained body condition on this predominantly buffel grass pasture, Fig 4, and predicted digestibility remained in the 55 – 60% range for an extended period during 2003 following big falls of rain in January. Small falls in April and June 2003 resulted in improved digestibility reflecting the ability of buffel to respond to small falls of rain.

Digestibility and breeder condition steadily declined following a single large rainfall event in February/March 2004 until the area was destocked in April 2005 following the failed summer growing season.

Body condition declined dramatically as a consequence of the failure of summer rains in 2004-2005 with average condition of lactating cows falling to score 2.2 in March 2005. Low pasture yield, < 500 kg/ha was a major contributing factor to this serious decline in condition as digestibility remained in the 50 – 55% range. This highlights the need to include pasture observations in the interpretation of NIRS diet quality predictions.

The improvement in average lactating cow condition scores compared to a decline in average dry cow condition scores associated with weaning is clearly demonstrated during 2004 when weaning musters were conducted in May and October.

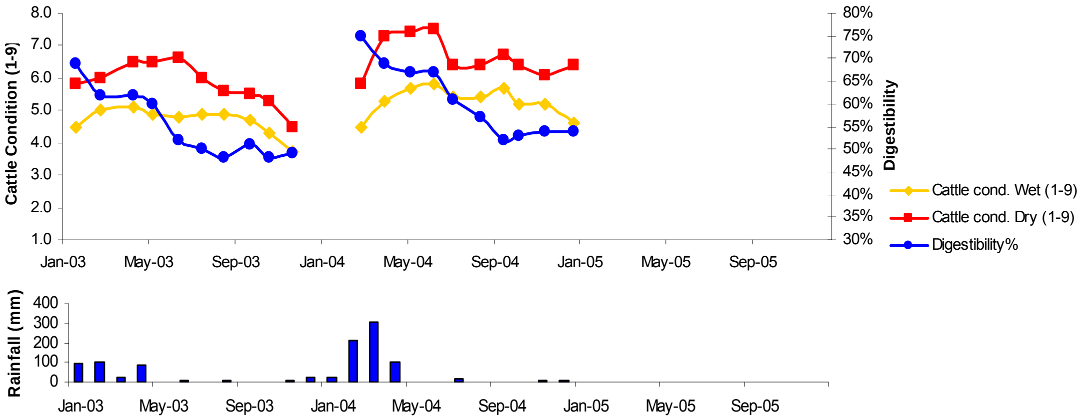


Figure 5: Cow condition (1-9 scale), digestibility and rainfall on a Buffel/Roebourne Plains grass pasture January 2003 to January 2005 (Horseshoe)

On this buffel/Roebourne Plains pasture community, Fig 5, Bos taurus breeders demonstrated an accelerated loss of condition from around October in each of the 2 years. This coincided with significant rises in daytime temperatures. The disparity between body condition changes of the lactating and dry cows around July each year coincides with weaning musters.

Digestibility fell to 48% in September 2003 reflecting a minimal response by this pasture type to a single small fall of rain in August. In contrast to a digestibility of 75% (diet CP 14.2%) predicted in March 2004 following good summer rains. Small falls of rain during the 2004 winter resulted in digestibility remaining above 50% and allowed dry breeders to generally maintain condition late in the year.

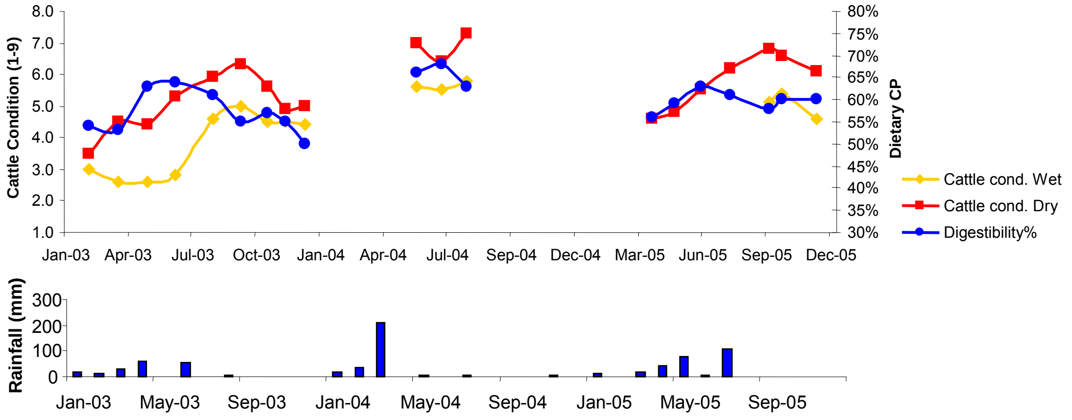


Figure 6: Cow condition (1-9 scale), digestibility and rainfall on a Ribbon grass, Buffel and Roebourne Plains grass pasture January 2003 to December 2005 (Tragedy Bore)

Cow body condition at this site Fig. 6, reflects the failure of the 2002-03 summer growing season and low pasture yield early in 2003. Useful falls of around 50 mm in April and June resulted in improved diet quality, quantity and body condition changes. Sampling was not possible at this site from December 2003 until May 2004 due to serious flooding from a single major rainfall event associated with cyclone Monty in March 2004.

Digestibility predictions remained above 50% for all observation on this pasture type and only declined to this level in December 2003 at the end of the dry season.

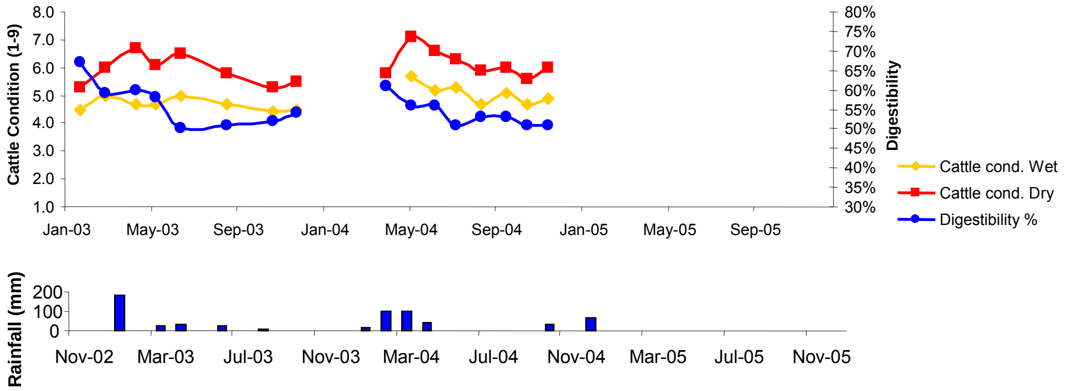


Figure 7: Cow condition (1-9 scale), digestibility and rainfall on a Buffel/Aristida grass and soft spinifex pasture January 2003 to December 2004 (Shaws Bore)

On this buffel/Aristida pasture type, Fig 7, cattle were generally able to select a diet that allowed dry cows remain in better than score condition 5 throughout the dry season. Digestibility predictions only fell to 50% in July 2003 and remained above this level at all other observations.

Lactating breeders remained in better than score 4 (1 – 9 scale) condition throughout the observation with dry and presumably pregnant breeders in condition 5 or better at the end of each dry season indicating a high probability of them conceiving again during their subsequent lactation.

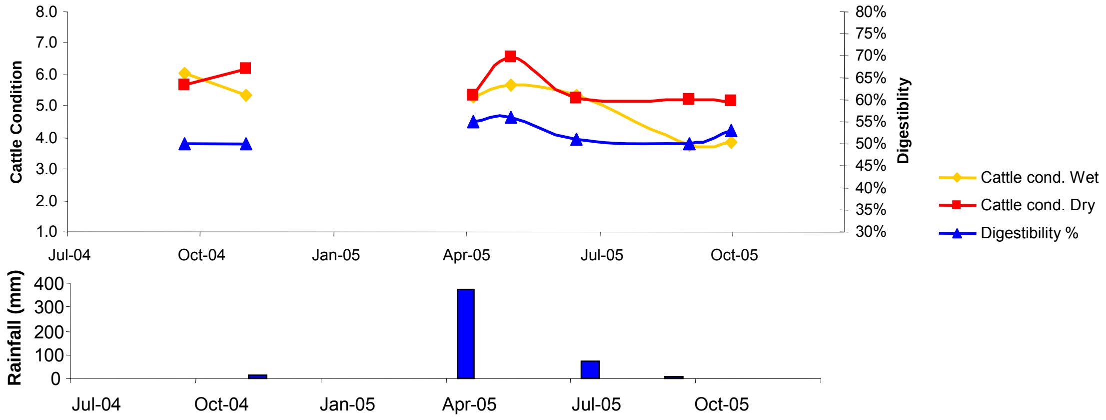


Figure 8: Cow condition (1-9 scale), digestibility and rainfall on a Kimberley Pindan land system pasture recorded from October 2004 to October 2005 (Pindan)

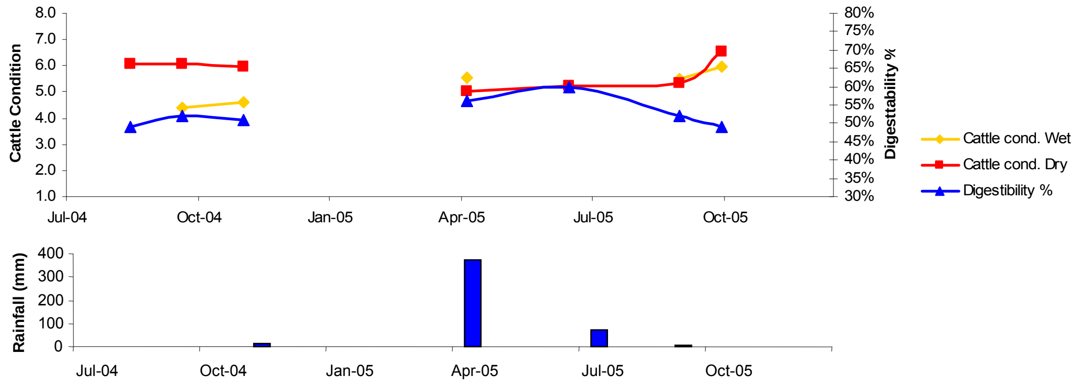


Figure 9: Cow condition (1-9 scale), digestibility and rainfall on a Kimberley river floodplain land system pasture recorded from September 2004 to October 2005 (Greenhide River)

The interesting information from these Kimberley pasture types, Figs 8 and 9, in comparison to the Pilbara sites, Figs 1 to 7, is the digestibility of diet predicted for both pasture types. Where predictions for most Pilbara sites seldom fell below 50% predicted digestibility, predicted levels for the flood plains system in the Kimberley was below this level at the commencement of observations and the pindan fell to this level again by July 2005 with the floodplain falling to below 50% again later in 2005. Diet CP predictions also fell to lower levels on both Kimberley pasture types in both years. Appendix 6.

This apparent difference between the two geographic and climatic areas in terms of diet quality selected during the 'dry' season indicates there may be opportunities for different cattle and nutritional management strategies for the two regions. While the general principles of cattle and supplementation management are well documented and accepted for the savannah regions of northern Australia they are less well developed for regions where cattle can select a better quality diet for a longer period after summer rains.

4.2 Pilbara statistical analysis summary

Digestibility 9 weeks before sampling was the independent variable most highly correlated with the CS of wet and dry cows (Table 4). Many of the independent variables were highly correlated with one another. Values of the same measurement 3 weeks apart had correlations ranging from 0.81 to 0.95. Values of the same measurement 6 weeks apart had correlations ranging from 0.57 to 0.79. Correlations between different measurements at the same time were generally lower. Under these circumstances it is difficult to identify which variables are having most effect on condition score and particularly difficult to distinguish accurately between measurements of the same variable that are three weeks apart.

Table 4: Correlations between condition scores and dietary parameters at sampling and 3, 6 and 9 weeks prior to sampling. Correlations in blue are between same parameter at different times. Correlations in cream are between different parameters at same time

	Dry BCS	Wet BCS	CP at sampling	CP 3 weeks before	CP 6 weeks before	CP 9 weeks before	D at sampling	D 3 weeks before	D 6 weeks before	D 9 weeks before	FN at sampling	FN 3 weeks before	FN 6 weeks before	FN 9 weeks before	NG at sampling	NG 3 weeks before	NG 6 weeks before	NG 9 weeks before
Dry BCS	1																	
Wet BCS	0.88	1																
CP at sampling	-0.01	-0.04	1															
CP 3 weeks before	0.11	0.08	0.81	1														
CP 6 weeks before	0.28	0.25	0.57	0.92	1													
CP 9 weeks before	0.43	0.38	0.38	0.68	0.84	1												
D at sampling	0.41	0.35	0.55	0.56	0.49	0.43	1											
D 3 weeks before	0.49	0.45	0.45	0.61	0.62	0.56	0.88	1										
D 6 weeks before	0.55	0.52	0.34	0.57	0.65	0.64	0.73	0.95	1									
D 9 weeks before	0.60	0.57	0.22	0.40	0.52	0.65	0.60	0.79	0.90	1								
FN at sampling	0.21	0.20	0.66	0.59	0.46	0.32	0.28	0.29	0.27	0.20	1							
FN 3 weeks before	0.34	0.31	0.54	0.70	0.70	0.54	0.36	0.40	0.42	0.34	0.83	1						
FN 6 weeks before	0.47	0.41	0.38	0.66	0.76	0.66	0.37	0.45	0.49	0.44	0.63	0.93	1					
FN 9 weeks before	0.59	0.49	0.25	0.48	0.63	0.76	0.34	0.45	0.51	0.52	0.48	0.72	0.86	1				
NG at sampling	0.30	0.31	0.27	0.28	0.25	0.19	-0.01	0.05	0.12	0.15	0.44	0.44	0.38	0.35	1			
NG 3 weeks before	0.28	0.29	0.23	0.31	0.30	0.26	-0.02	0.04	0.09	0.14	0.38	0.45	0.43	0.40	0.85	1		
NG 6 weeks before	0.26	0.26	0.14	0.24	0.27	0.28	0.00	0.02	0.06	0.12	0.28	0.38	0.40	0.41	0.62	0.91	1	
NG 9 weeks before	0.28	0.26	0.12	0.20	0.25	0.29	0.05	0.04	0.06	0.09	0.23	0.32	0.37	0.41	0.49	0.70	0.87	1

4.2.1 Average condition score of dry cows (Dry BCS)

Average CS increased with increasing pasture yield. Relative to cows on paddocks with pasture yields <500kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores 0.991 (±0.156; P<0.001) higher, cows on pastures yielding 1,001 – 2,000 kg/ha had condition scores 1.328 (±0.166; P<0.001) higher, and cows on pastures yielding 2,001 – 3,000 kg/ha had condition scores 1.302 (±0.263; P<0.001) higher. There was no difference in the CS of cows on the top three yield categories.

Relative to cows on buffel paddocks, cows on buffel soft spinifex had significantly higher condition scores (0.288±0.101; P=0.005); cows on buffel Roebourne Plains, buffel marine couch, hard spinifex, mitchell and tussock had similar condition scores (0.176±0.099; P=0.077; -0.024±0.123; P=0.846; -0.441±0.230; P=0.056; 0.042±0.145; P=0.770; 0.037±0.122; P=0.764); and cows on soft spinifex had significantly lower condition scores (-0.254±0.100; P=0.012).

4.2.2 Average condition score of wet cows (Wet BCS)

Relative to cows on paddocks with pasture yields <500kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores 0.859±0.144 (P<0.001) higher, cows on pastures yielding 1,001 – 2,000 kg/ha had condition scores 1.066±0.156 (P<0.001) higher, and cows on pastures yielding 2,001 – 3,000 kg/ha had condition scores 1.430±0.273 (P<0.001) higher. There was no difference in the CS of cows on the top three yield categories.

Average CS of wet cows decreased as the percentage lactating increased. Relative to herds with <25% lactating, herds with 25-50% lactating had a CS which was 0.270±0.160 (P=0.092) lower, herds with 51-75% lactating had a CS which was 0.350±0.156 (P=0.025) lower and herds with >75% lactating had a CS which was 0.906±0.267 (P<0.001) lower.

4.3 Kimberley statistical analysis summary

Digestibility 9 weeks before sampling was the independent variable most highly correlated with the CS of wet and dry cows (Table 7). Many of the independent variable were highly correlated with one another. Values of the same measurement 3 weeks apart had correlations ranging from 0.73 to 0.91. Values of the same measurement 6 weeks apart had correlations ranging from 0.14 to 0.77. Correlations between different measurements at the same time were generally lower. Under these circumstances it will be difficult to identify which variables are having most effect on condition score and in particular we cannot expect to distinguish accurately between measurements of the same variable that are three weeks apart.

Table 5: Correlations between condition scores and dietary parameters at sampling and 3, 6 and 9 weeks prior to sampling based on 23 samples with complete data (critical value for significance P<0.05 is 0.41). Correlations in blue are between same parameter at different times. Correlations in cream are between different parameters at same time.

	Dry BCS	Wet BCS	CP at sampling	CP 3 weeks before	CP 6 weeks before	CP 9 weeks before	D at sampling	D 3 weeks before	D 6 weeks before	D 9 weeks before	FN at sampling	FN 3 weeks before	FN 6 weeks before	FN 9 weeks before	NG at sampling	NG 3 weeks before	NG 6 weeks before	NG 9 weeks before
Dry BCS	1																	
Wet BCS	0.72	1																
CP at sampling	0.13	0.13	1															
CP 3 weeks before	0.26	0.25	0.84	1														
CP 6 weeks before	0.36	0.38	0.58	0.91	1													
CP 9 weeks before	0.37	0.39	0.49	0.77	0.90	1												
D at sampling	0.11	0.14	0.64	0.67	0.52	0.46	1											
D 3 weeks before	0.22	0.36	0.50	0.68	0.68	0.60	0.79	1										
D 6 weeks before	0.20	0.41	0.16	0.43	0.59	0.51	0.45	0.89	1									
D 9 weeks before	0.43	0.40	-0.01	0.26	0.47	0.57	0.37	0.66	0.73	1								
FN at sampling	0.30	0.23	0.21	0.11	0.02	0.00	-0.15	-0.09	-0.08	-0.07	1							
FN 3 weeks before	0.25	0.18	0.54	0.62	0.50	0.39	0.27	0.26	0.13	-0.01	0.73	1						
FN 6 weeks before	0.14	0.11	0.62	0.80	0.74	0.63	0.45	0.48	0.32	0.12	0.34	0.87	1					
FN 9 weeks before	0.12	0.17	0.57	0.76	0.76	0.77	0.48	0.50	0.33	0.25	0.22	0.71	0.89	1				
NG at sampling	0.33	0.04	0.09	0.00	-0.13	-0.27	-0.04	0.05	0.04	0.05	0.50	0.27	-0.01	-0.28	1			
NG 3 weeks before	0.27	-0.13	0.09	0.20	0.08	-0.03	0.13	0.08	-0.01	0.10	0.35	0.43	0.26	0.08	0.73	1		
NG 6 weeks before	0.17	-0.14	0.06	0.27	0.24	0.29	0.18	0.08	-0.04	0.17	0.13	0.38	0.38	0.39	0.14	0.75	1	
NG 9 weeks before	0.05	-0.04	0.20	0.32	0.30	0.46	0.27	0.20	0.05	0.12	0.04	0.32	0.40	0.55	-0.23	0.32	0.81	1

4.3.1 Average condition score of dry cows (Dry BCS)

As expected average CS increased with increasing pasture yield. Relative to cows on paddocks with pasture yields < 500 kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores which were 0.959 (±0.617; P=0.142) higher, cows on pastures yielding 1001 – 2,000 kg/ha had condition scores which were 1.143 (±0.721; P=0.135) higher, cows on pastures yielding >2001 kg/ha had condition scores which were 2.440 (±0.817; P=0.010) higher.

4.3.2 Average condition score of wet cows (Wet BCS)

As expected average CS increased with increasing pasture yield. Relative to cows on paddocks with pasture yields < 500 kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores which were 2.625 (±0.746; P=0.003) higher, cows on pastures yielding 1001 – 2,000 kg/ha had condition scores which were 2.447 (±0.856; P=0.013) higher, cows on pastures yielding >2001 kg/ha had condition scores which were 3.735 (±0.896; P<0.001) higher. It should be noted that there were only three records of Wet_BCS in the <500kg/ha pasture yield category.

4.4 Results – comparison across regions

The interesting information from the Kimberley sites in comparison to the Pilbara sites is the levels of diet CP predicted for both pasture types. Where predictions for most Pilbara sites seldom fell below 5% predicted diet CP, predicted levels for both Kimberley pasture types fell to this level by July in 2005.

This apparent difference between the two geographic and climatic areas in terms of diet quality selected during the ‘dry’ season indicates there may be opportunities for different cattle and nutritional management strategies for the two regions. While the general principles of cattle and supplementation management are well documented and accepted for the savannah regions of northern Australia they are less well developed for regions where cattle can select a better quality diet for a longer period after summer rains.

The project activities in the Kimberley have highlighted the difficulty in assessing NIRS predictions of diet quality in terms of understanding what is happening in the paddock at the time of collection. Potential influences on the sample results included:

- Dust and ash contamination following wind and burning when cattle were eating “contaminated” pasture;
- High levels of undigested seed noted in some samples may result in errors in the diet quality during grinding in the laboratory;
- NIRS only provides an estimate of diet quality, not quantity. As with some of the Pilbara sites it is probable, especially when cattle are chasing green pick generated after fires or recent rain that results indicate high diet quality, yet cattle are rapidly losing weight as there is insufficient dry matter to satisfy intake requirements.

5 Success in achieving objectives

The project has successfully documented changes in wet and dry breeder body conditions during a series of seasons over a number of years. Known relationships between body condition and subsequent reproductive performance can be used to improve current breeder herd management recommendations for Pilbara and Kimberley herds.

Analysis of the relationships between changes in body condition and NIRS diet quality predictions indicate they are useful predictors of animal performance for some pasture types, but care in the interpretation of paddock conditions needs to be taken before management decisions are made.

The collection and analysis of dung samples for evaluation of the reliability of faecal NIRS to predict changes in breeder body condition in the Pilbara and Kimberley has generally indicated that faecal NIRS, using the current calibration equations, is generally unreliable as a predictive tool. NIRS prediction of digestibility for several of the Pilbara pasture types may be an exception.

A publication outlining issues to be considered specifically by Pilbara pastoralists planning supplementation programs has been developed as part of this project. This report, “The role of supplements in the Pilbara” is included Appendix 5.

The findings of this project have allowed some better informed recommendation to be included in this document. With little documented information of animal performance in the Pilbara area prior to this project it was not possible to provide useful and potentially effective supplementation recommendations with any degree of confidence.

6 Impact on meat and livestock industry

6.1 Impact on meat and livestock industry – now

Prior to the conduct of this project there was very little information available on which to base simple recommendations on cattle management decisions including the time of mustering, preferred time of first calving, weaning and time to commence supplementation programs in the 250 – 300 mm rainfall region of the Pilbara. A common question asked by pastoralists is about the role of supplements in Pilbara cattle businesses. Before this work was conducted it was difficult to offer any reliable comment - there was no documented information available on how breeder condition changed during the year and no idea of what quality diet they were able to select from different pasture types.

This work suggests that, unlike breeders in the Kimberley and many other areas of northern Australia, breeders maintain strong condition well into the year following summer rains. The failure of summer rains can have serious affects on breeder condition on some pasture types.

With the information and experience provided by this project, much better informed advice can now be offered to pastoralists. The effectiveness and efficiency of supplementation programs, for example can be improved dramatically resulting in improved returns for pastoralists currently using supplements.

The findings of the project have indicated that faecal NIRS predictions of diet quality can be a useful tool to predict changes in breeder condition 6 to 9 weeks following sampling particularly in the Pilbara. The application of these findings has the potential for immediate use by industry to plan management strategies including the timing of sales, mustering and the initiation of supplementation systems.

6.2 Impact on meat and livestock industry – in five years time

Information developed by this project will be incorporated in production systems developed and adopted by Pilbara pastoralists into the future. One example is the Industry initiatives to improve young breeder performance in the Pilbara and Kimberley of WA - NBP.345 (Young Breeder Project) presently underway. In co-operation with experienced pastoralists, this project is developing and evaluating management systems to improve the productivity of young breeders.

Findings from this project allow some confidence (and caution) in developing recommendation for the time of first calving for young breeders with particular reference to problems associated with the failure of summer rains. This has shown to have potentially devastating effects on one monitoring group of heifers in the young breeder project.

Cattle production in the Pilbara and Kimberley has a great potential to expand into the future. Having a better knowledge of basic production parameters as provided by this project are an early step in realising this potential.

7 Conclusions and recommendations

7.1 Conclusions

This project has documented changes in body condition of breeder cattle grazing different pasture types in the Pilbara and Kimberley for a period of up to 3 years. Information on the diet quality selected by grazing cattle and pasture condition assessments has also been recorded. The reliability of faecal NIRS to predict changes in cattle condition was also assessed. Specific conclusions include:

1. While the NIRS prediction of digestibility may be useful in predicting future body condition changes of breeders, particularly in the Pilbara, other NIRS predictions of diet quality have proved to be unreliable in predicting future changes in body condition of breeders in the extensive grazing systems of the Pilbara and Kimberley.
2. NIRS diet quality predictions of grazing cattle may be useful in assessing the diet quality currently being selected by grazing cattle but should not be used in isolation of other observations including cattle condition and pasture availability, as the predictions only relate to diet quality not quantity.
3. Liveweight gain predictions seldom appeared to be useful when interpreted in terms of body condition changes and pastoralists estimates of how cattle were performing at each observation.

4. Cattle grazing in the Pilbara appear to be able to select a higher quality diet and maintain better body condition for a longer period following summer rains than cattle in the Kimberley and many other areas of northern Australia.

5. The combination of regular observation of cattle body condition, observation of edible pasture yield and apparent grazing behaviour and faecal NIRS diet quality predictions will provide useful information to assist managers to make better informed cattle and grazing management decisions in the Pilbara and Kimberley.

6. Based on the indication that NIRS predictions of digestibility in the Pilbara is potentially useful in predicting cattle condition, the rule of thumb "observations of cattle condition are about 6 weeks behind" may well be a reasonable assessment of the ability to forecast current animal performance by observation. This infers that, in the Pilbara at least, management decisions made on the basis of changes in body condition could be made a lot earlier and more efficiently by utilising faecal NIRS.

7.2 Recommendations

1. The investigation and possible development of methods to collect representative diets from variable land systems with a view to conducting diet faecal pair work to improve the reliability of current NIRS calibration equations for arid areas. Current methods of harvesting homogeneous pasture communities have limited practical application in the variable land systems and pasture types in the Pilbara particularly.

While this project demonstrated that current NIRS predictions were generally unreliable in predicting changes in body condition this might be expected as NIRS predictions were based on calibration equations developed from diets from other areas of northern Australia. The inclusion of information developed from 'local' diets in calibration equations may well improve the reliability and usefulness of faecal NIRS in these areas.

2. The development of a series of photo standards of pasture yield for several of the Pilbara and Kimberley pasture types is recommended.

The project demonstrated that pasture yield was an important factor related to breeder body condition. While it might be argued that at least some useful photo standards of yield might exist for some pasture types, particularly in the Kimberley, little if any information is available for the Pilbara.

Estimates based on the area required to feed a cow to calculate grazing days and stocking rates are promoted in some areas but appear to be cumbersome if apparently effective with experience.

The estimates of available edible feed, yield estimates, used by the project officers during this project were based on a combination of past experience with photo standards, pastoralists experience of edible plants and plant parts and observation of where and what cattle appeared to be grazing at any one observation. It is difficult to promote such a combination to pastoralists interested in improving grazing management.

The development of these standards would assist pastoralists to make better informed grazing management decisions and also assist in the development and delivery of Grazing EDGE in the Pilbara and Kimberley.

8 Bibliography

Agriculture Western Australia (1999) Cattle production in the Gascoyne and interior regions of Western Australia. A report on the Cunyu Demographic Study (1990-1998) and the Mt Clere Producer Demonstration Site (1993-1997). Department of Agriculture Western Australia Miscellaneous Publication 61/99.

Coates, D.B. (2002) Using faecal NIR to predict growth rate in grazing cattle. Final Report NAP.116.

Coates, D.B. (2004) Faecal NIRS – Technology for improving nutritional management of grazing cattle. Final Report NAP.121.

Dixon, Rob (2005) Utilizing faecal NIRS to improve grower and breeder cattle performance and supplement management. Final Report NBP.302 (submitted)

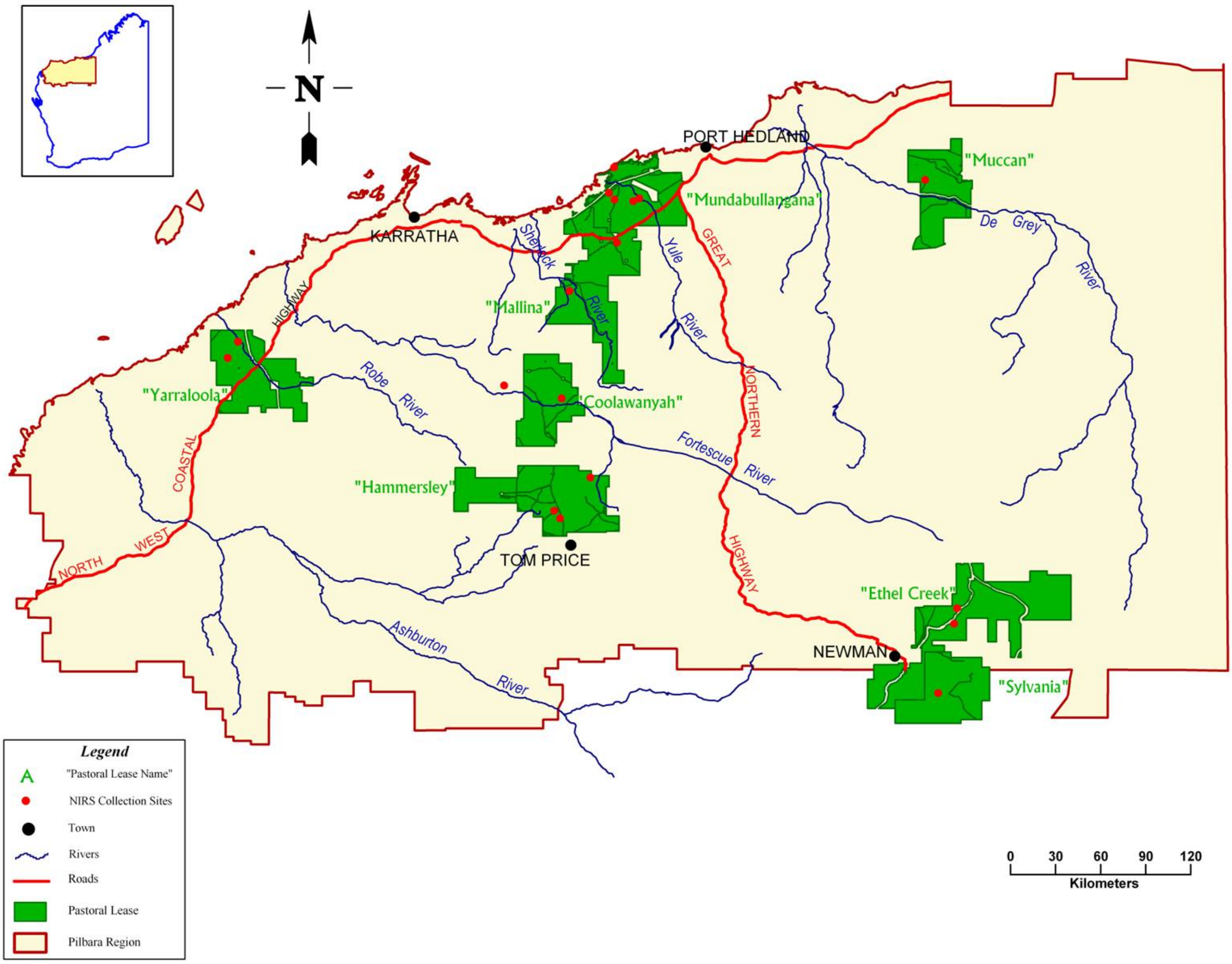
Fletcher, W., McIntyre, B., Nickels, R., Cridland, S. and James, J. (1996) Pilbara Steer Growth Evaluation 1994 – 1996. Department of Agriculture Western Australia Miscellaneous Publication 19/96.

Nicholson, M.H, and Butterworth, M.H. (1986) A guide to condition scoring of Zebu cattle. International Livestock Centre for Africa

Van Vreeswyk, A.M.E., Payne, A.L., Leighton, K.A. (2004). Pastoral resources and their management in the Pilbara region of Western Australia. Department of Agriculture Western Australia Miscellaneous Publication 21/2004.

9 Appendices

9.1 Appendix 1 – Map showing location of Pilbara project sites



9.2 Appendix 2 – Pilbara statistical report

Prepared by Jane Speijers, DAFWA, Perth
Diet Quality and the Performance of Grazing Cattle in the Pilbara

Method

Cattle data collection sites were established at stock watering points in 22 paddocks on properties in the Pilbara. Almost no data was collected on the three 9-mile paddocks on Yarraloola so these have been excluded from the analysis. Paddocks were classified into pasture types on the basis of their plant communities (Table 1).

Table 1. Sites with land systems and pasture types within a 3 km grazing radius

Paddock	Pasture types
Minsons River Parsons	Buffel
Cliffs Mill Horseshoe No6	Buffel, Roebourne plains grass
Victory Mill	Buffel and Marine couch
Stirrup Iron Shaws Stewarts	Buffel, Roebourne plains, soft Spinifex, ,Aristida spp
Nimmingarra	Hard and soft Spinifex (limited collections only)
Fredericks Yorks Mill Manawar	Mitchell and Roebourne plains
Christmas Tank Midway No2 Ram Quarry	Soft Spinifex, Aristida spp.
Crossroads Tragedy	Tussock grasses inc. Ribbon, Roebourne plains and Buffel grasses.

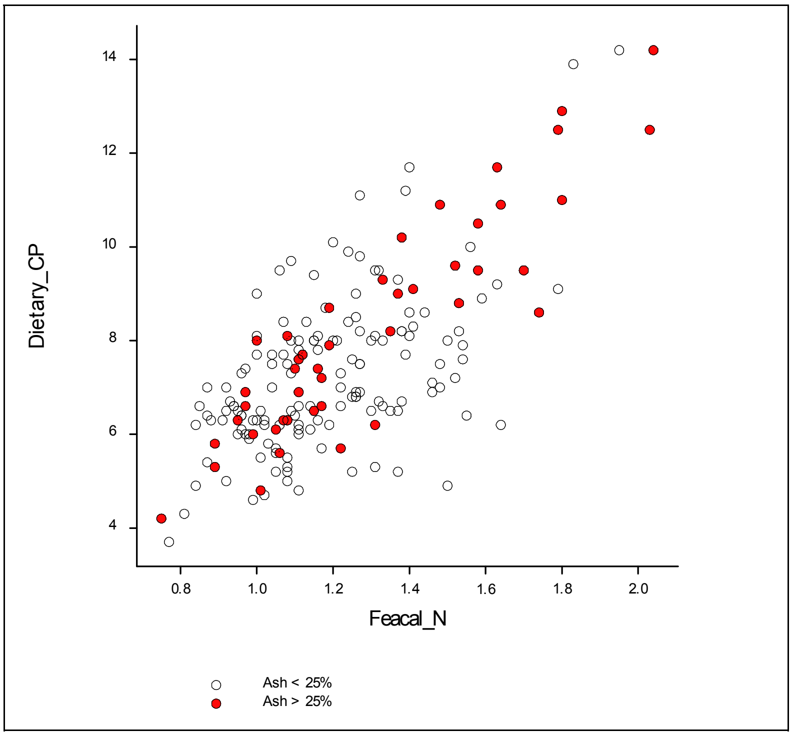
The following information was collected at 4-6 week intervals access permitting:

- Body condition (1 – 9 scale) of representative lactating, dry and growing animals present at each site. A minimum of 15 head of each status to a maximum of 30% of the cattle present was recorded.
- An estimation of females lactating as a percentage of mature age females present.
- An assessment of the current liveweight (condition) change of dry animals. This assessment was usually a combination of the perceptions of the pastoralist and project officer and recorded as Gaining, Holding or Losing.
- Rainfall that may have affected pasture quality or quantity.
- An assessment of quality of pasture on offer using pasture growth phases, leaf:stem ratio, % green leaf and an estimate of yield was recorded.
- A bulked faecal sample was submitted for NIR analysis which produced estimates of dietary crude protein (CP), faecal nitrogen (FN), % digestibility (D), % non-grass in diet (NG) and %ash (A).

Statistical analysis

The validity of high ash samples was examined by looking at the relationship between dietary CP and faecal nitrogen. Samples with high ash (>25%) were excluded if they had lower than expected faecal nitrogen relative to their dietary crude protein (Pers. comm.. David Coates CSIRO), i.e. outlying point above the dietary CP vs faecal N line with ash > 25%. No samples have been excluded on this basis (Figure 1).

Figure 1. Dietary CP vs faecal N for samples with low and high % ash

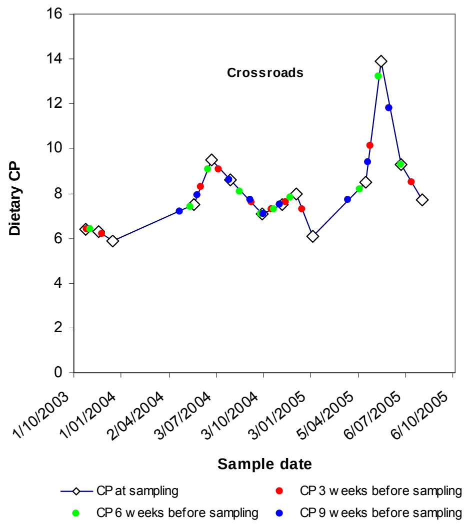


The relationship between animal production and diet quality was examined using regression analysis.

Dependent variables:	Average condition score of dry cows (Dry BCS) Average condition score of wet cows (Wet BCS)
Independent variables:	CP at sampling and 3, 6 and 9 weeks prior to sampling FN at sampling and 3, 6 and 9 weeks prior to sampling Digestibility at sampling and 3, 6 and 9 weeks prior to sampling NG at sampling and 3, 6 and 9 weeks prior to sampling pasture yield category and interactions with diet variables pasture type category and interactions with diet variables % lactating cows and interactions with diet variables paddock and interactions with diet variables

Dietary measurement 3, 6 and 9 weeks prior to sampling were estimated from linear interpolation between previous measurements and measurements at sampling for each paddock provided that the gap between samplings was 84 days or less (Figure 1 shows estimated values for a selected paddock, *Crossroads*).

Figure 2. Prediction of crude protein at Crossroads



Sample date	CP at sampling	CP 3 weeks before sampling	CP 6 weeks before sampling	CP 9 weeks before sampling
23/10/2003	6.4			
17/11/2003	6.3	6.4		
15/12/2003	5.9	6.2	6.4	
21/05/2004	7.5			
25/06/2004	9.5	8.3	7.4	7.2
30/07/2004	8.6	9.1	9.1	7.9
30/09/2004	7.1	7.6	8.1	8.6
9/11/2004	7.5	7.3	7.1	7.7
5/12/2004	8.0	7.6	7.3	7.1
6/01/2005	6.1	7.3	7.8	7.5
19/04/2005	8.5			
19/05/2005	13.9	10.1	8.2	7.7
26/06/2005	9.3	11.8	13.2	9.4
7/08/2005	7.7	8.5	9.3	11.8

One of the major causes of variability in average CS for wet and dry cows is animals moving between the two groups. Wet cows, particularly towards the end of their lactation, can have much lower CS than dry cows. If a large number of calves are weaned between sampling dates then this can lead to a drop in the average CS of dry cows and perhaps an increase in the average condition score of wet cows at the subsequent sampling date. Percentage of cows lactating reflects changes in the size of the wet and dry groups and may account for some of this variability.

Stepwise regression using GenStat for Windows was used to select the best multiple regression model. The process was constrained so that the principle of marginality was adhered to, i.e. if a particular interaction was significant then the main effects for factors or variables making up the interaction were also included. In addition ten variables of uniform random numbers were included in the process to identify the significance level to control terms entering and leaving the model (Alan Miller,2002). Plots of residuals were used to identify outlying points and affirm the assumptions underlying regression.

Results

Digestibility 9 weeks before sampling was the independent variable most highly correlated with the CS of wet and dry cows (Table 2). Many of the independent variable were highly correlated with one another. Values of the same measurement 3 weeks apart had correlations ranging from 0.81 to 0.95. Values of the same measurement 6 weeks apart had correlations ranging from 0.57 to 0.79. Correlations between different measurements at the same time were generally lower. Under these circumstances it will be difficult to identify which variables are having most effect on condition score and in particular we cannot expect to distinguish accurately between measurements of the same variable that are three weeks apart.

Average condition score of dry cows (Dry BCS)

Average condition score for dry cows on paddock Stirrup Iron on 5/8/2005 (Sample 499; CS 3.75) was removed from the data as an outlying value. All other average CS's for dry cows on the same paddock were ≥5.3. However the % lactating cows decreased from 51-75% at the previous date, two months earlier, to 25-50% on 5/8/2005 and the average CS of wet cows at the previous sampling was only 3.46 so it is probable that a number of wet cows with low condition had weaned calves in the intervening period.

Model (1) including pasture type, pasture yield category, lactation %, faecal nitrogen and digestibility 9 weeks before the measurement of CS and interactions between pasture type and the two dietary measurements (Table 3) accounted for 62.6% of the variance in average condition score of dry cows. Model (2) which excludes Lactation % and the interactions (the random variables indicate these effects are probably not significant), accounted for 57.7% of the variance in average condition score (Figure 3) and is useful in understanding the effect of pasture type and pasture yield categories.

Table 3. Significance of terms selected using stepwise regression

+ Faecal nitrogen $_{9\ weeks\ before\ CS}$	*Variance due to adding*	*d.f.*	*F pr.*
Dry BCS	+ Pasture type	7	<0.001
	+ Pasture yield category	3	<0.001
	+ Faecal nitrogen $_{9\ weeks\ before\ CS}$	1	<0.001
	+ *Faecal nitrogen$_{9\ weeks\ before\ CS}$ x Past.Typ	7	0.004
	+ Digestibility $_{9\ weeks\ before\ CS}$	1	<0.001
	+ *Digestibility $_{9\ weeks\ before\ CS}$ x Past.Typ	7	0.009
	+ *Lactation %	1	0.023
Wet BCS	+ Pasture type	7	<.001
	+ Pasture yield category	3	<.001
	+ Digestibility $_{9\ weeks\ before\ CS}$	1	<.001
	+ Digestibility $_{9\ weeks\ before\ CS}$ x Past.Typ	7	0.001
	+ Faecal nitrogen $_{9\ weeks\ before\ CS}$	1	<.001
	+ Dietary crude protein $_{6\ weeks\ before\ CS}$	1	0.367
	+ Dietary crude protein $_{6\ weeks\ before\ CS}$ x Past.Typ	7	<.001
	+ Lactation_%	3	0.004

** Excluded from model (2)*

Table 2. Correlations between condition scores and dietary parameters at sampling and 3, 6 and 9 weeks prior to sampling. Correlations in blue are between same parameter at different times. Correlations in cream are between different parameters at same time.

	Dry BCS	Wet BCS	CP at sampling	CP 3 weeks before	CP 6 weeks before	CP 9 weeks before	D at sampling	D 3 weeks before	D 6 weeks before	D 9 weeks before	FN at sampling	FN 3 weeks before	FN 6 weeks before	FN 9 weeks before	NG at sampling	NG 3 weeks before	NG 6 weeks before	NG 9 weeks before
Dry BCS	1																	
Wet BCS	0.88	1																
CP at sampling	-0.01	-0.04	1															
CP 3 weeks before	0.11	0.08	0.81	1														
CP 6 weeks before	0.28	0.25	0.57	0.92	1													
CP 9 weeks before	0.43	0.38	0.38	0.68	0.84	1												
D at sampling	0.41	0.35	0.55	0.56	0.49	0.43	1											
D 3 weeks before	0.49	0.45	0.45	0.61	0.62	0.56	0.88	1										
D 6 weeks before	0.55	0.52	0.34	0.57	0.65	0.64	0.73	0.95	1									
D 9 weeks before	0.60	0.57	0.22	0.40	0.52	0.65	0.60	0.79	0.90	1								
FN at sampling	0.21	0.20	0.66	0.59	0.46	0.32	0.28	0.29	0.27	0.20	1							
FN 3 weeks before	0.34	0.31	0.54	0.70	0.70	0.54	0.36	0.40	0.42	0.34	0.83	1						
FN 6 weeks before	0.47	0.41	0.38	0.66	0.76	0.66	0.37	0.45	0.49	0.44	0.63	0.93	1					
FN 9 weeks before	0.59	0.49	0.25	0.48	0.63	0.76	0.34	0.45	0.51	0.52	0.48	0.72	0.86	1				
NG at sampling	0.30	0.31	0.27	0.28	0.25	0.19	-0.01	0.05	0.12	0.15	0.44	0.44	0.38	0.35	1			
NG 3 weeks before	0.28	0.29	0.23	0.31	0.30	0.26	-0.02	0.04	0.09	0.14	0.38	0.45	0.43	0.40	0.85	1		
NG 6 weeks before	0.26	0.26	0.14	0.24	0.27	0.28	0.00	0.02	0.06	0.12	0.28	0.38	0.40	0.41	0.62	0.91	1	
NG 9 weeks before	0.28	0.26	0.12	0.20	0.25	0.29	0.05	0.04	0.06	0.09	0.23	0.32	0.37	0.41	0.49	0.70	0.87	1

As expected average CS increased with increasing pasture yield. Relative to cows on paddocks with pasture yields <500kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores 0.991 (±0.156; P<0.001) higher, cows on pastures yielding 1,001 – 2,000 kg/ha had condition scores 1.328 (±0.166; P<0.001) higher, and cows on pastures yielding 2,001 – 3,000 kg/ha had condition scores 1.302 (±0.263; P<0.001) higher. There was no difference in the CS of cows on the top three yield categories.

Relative to cows on Buffel paddocks, cows on Buffel soft spinifex had significantly higher condition scores (0.288±0.101; P=0.005); cows on Buffel RPlains, Buffel marine couch, Hard spinifex, Mitchell and Tussock had similar condition scores (0.176±0.099; P=0.077; -0.024±0.123; P=0.846; -0.441±0.230; P=0.056; 0.042±0.145; P=0.770; 0.037±0.122; P=0.764); and cows on soft spinifex had significantly lower condition scores (-0.254±0.100; P=0.012).

For every increase of one unit in faecal nitrogen 9 weeks before, average CS increased by 0.621±0.155 (assuming all other independent variables are unchanged) and for every increase of one unit in digestibility 9 weeks before, average CS increased by 0.0449±0.0076.

The variance of deviations from Model (2) indicate which pasture types and paddocks fit the model best (Table 4). Hard spinifex and Buffel soft spinifex have the lowest residual variances and therefore fit the model best, followed by Buffel and Mitchell pasture types. Other pasture types are worse fits. Within the tussock pasture type one paddock has a relatively better fit than the other (Crossroads and Tragedy, respectively) whereas within the soft spinifex pasture type all three paddock are relatively poor fits (Christmas Tank, Midway and Ram Quarry).

Average condition score of wet cows (Wet BCS)

Lactation % for paddock Shaws on 26/5/2004 (Sample 256; Lactation % is 0%) is clearly incorrect because there are condition scores for wet cows. The lactation % has been deleted thus removing this record from analyses.

Model (1) including pasture type, pasture yield category, faecal nitrogen and digestibility 9 weeks before the measurement of CS, dietary crude protein 6 weeks before the measurement of CS, lactation % and interactions between pasture type and two of the dietary measurements (Table 3) accounted for 62.9% of the variance in average condition score of wet cows (Figure 3). A model including the same independent variables but excluding the interactions accounted for only 53.5% of the variance in average condition score and is not considered further.

Relative to cows on paddocks with pasture yields <500kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores 0.859±0.144 (P<0.001) higher, cows on pastures yielding 1,001 – 2,000 kg/ha had condition scores 1.066±0.156 (P<0.001) higher, and cows on pastures yielding 2,001 – 3,000 kg/ha had condition scores 1.430±0.273 (P<0.001) higher. There was no difference in the CS of cows on the top three yield categories.

Average CS of wet cows decreased as the percentage lactating increased. Relative to herds with <25% lactating, herds with 25-50% lactating had a CS which was 0.270±0.160 (P=0.092) lower, herds with 51-75% lactating had a CS which was

0.350±0.156 (P=0.025) lower and herds with >75% lactating had a CS which was 0.906±0.267 (P<0.001) lower. These effects might be interpreted in the following way. As cows complete their lactation the percentage of wet cows decreases and the average CS of wet cows increases as the cows in poorest condition leave the group. The corresponding reciprocal effect on the average CS of dry cows is close to significance. As the percentage of cows lactating increases the average condition score of dry cows increases. Relative to herds with 0% lactating, herds with <25% cows lactating had a CS which was 0.483±0.258 (P=0.062) (Model (1)) higher, herds with 25-50% lactating had a CS which was 0.534±0.208 (P=0.011) higher, herds with 51-75% lactating had a CS which was 0.614±0.201 (P=0.002) higher and herds with >75% lactating had a CS which was 0.357±0.313 (P=0.256) higher.

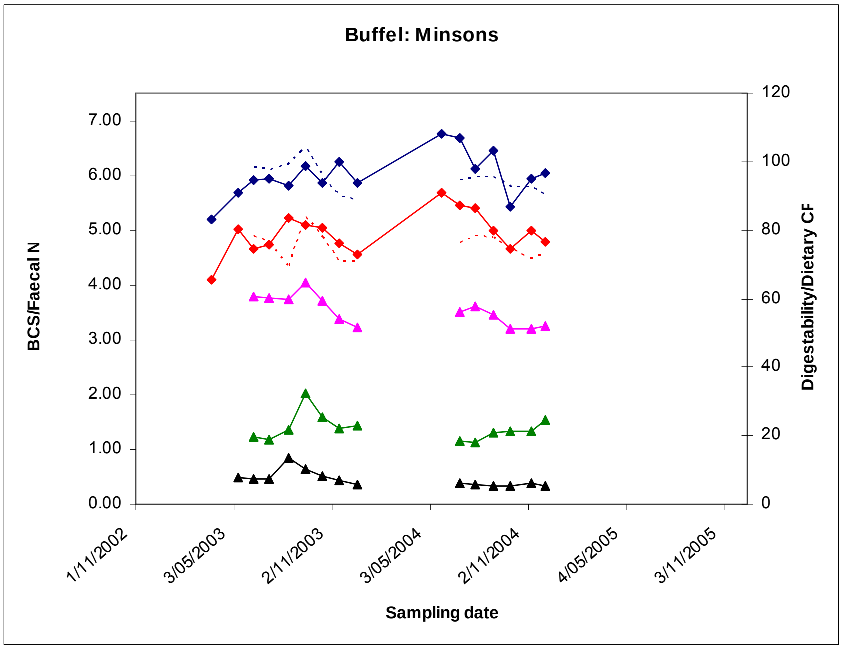
Table 4. For each paddock and pasture type variance of deviations from the regression model

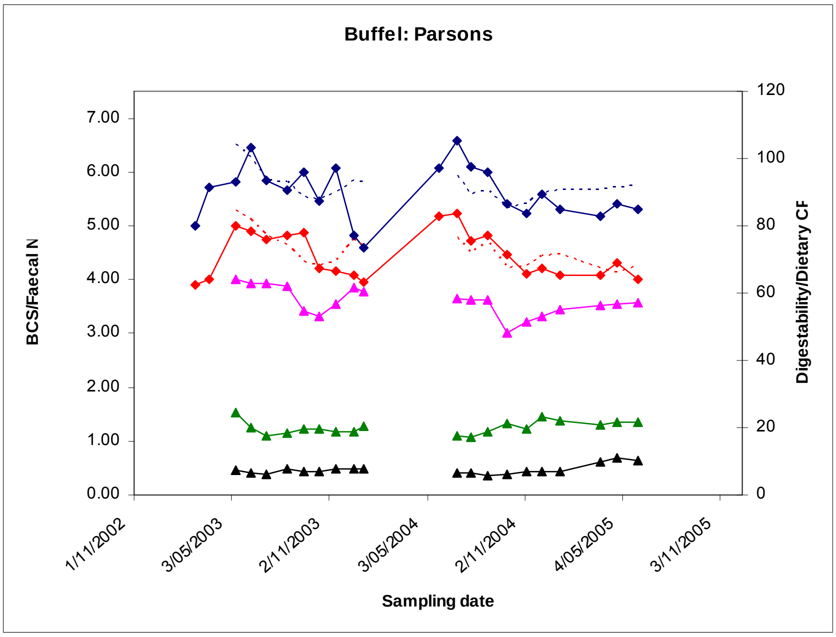
		Dry BCS – Model (2)			*Wet BCS – Model (1)*		
Pasture type	Paddock Name	No. observations	Residual variance within paddock	Residual variance within pasture type	No. observations	Residual variance within paddock	Residual variance within pasture type
Buffel	Minsons	13	0.69	0.77	13	0.82	1.00
	Parsons	19	1.11		19	0.68	
	River	20	0.47		20	1.14	
Buffel RPlains	Cliffs	12	1.56	1.31	12	1.59	1.48
	Horseshoe	17	0.89		17	1.00	
	No6	17	1.42		17	1.50	
Buffel marine couch	Victory mill	24	1.46	1.46	24	0.62	0.62
Buffel soft spinifex	Shaws	13	0.27	0.53	12	0.49	0.72
	Stewarts	19	0.56		19	0.57	
	Stirrup iron	15	0.69		17	1.06	
Hard spinifex	Nimmingarra	5	0.31	0.31	5	1.15	1.15
Mitchell	Manawar	4	1.92	0.89	4	1.20	1.20
	Yorks	14	0.57		0		
Soft spinifex	Christmas tank	18	1.13	1.27	18	1.63	1.20
	Midway	11	1.18		11	0.80	
	Ram quarry	22	1.31		22	1.12	
Tussock	Crossroads	9	0.54	1.37	7	0.65	0.87
	Tragedy	14	1.88		12	1.06	

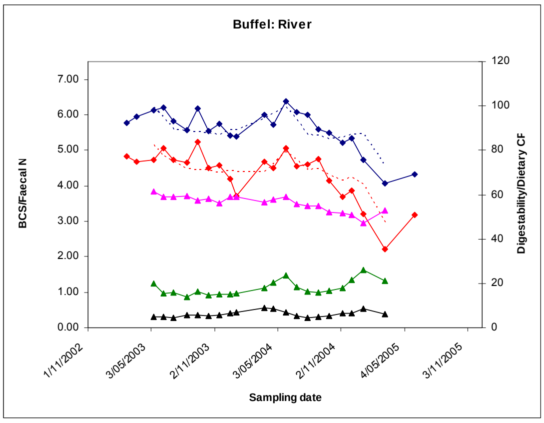
For every increase of one unit in faecal nitrogen 9 weeks before, average CS increased by 0.727±0.180 (assuming all other variables are unchanged). The effects of digesibility 9 weeks before CS measurement and dietary CP 6 weeks before vary with pasture type.

Buffel marine couch, Buffel soft spinifex and Tussock have the lowest residual variances and therefore fit model (1) best. Other pasture types are worse fits. Within pasture types the fit to Model (1) can vary considerably between paddocks.

Figure 3. Fitted models and independent variables






Buffel: River
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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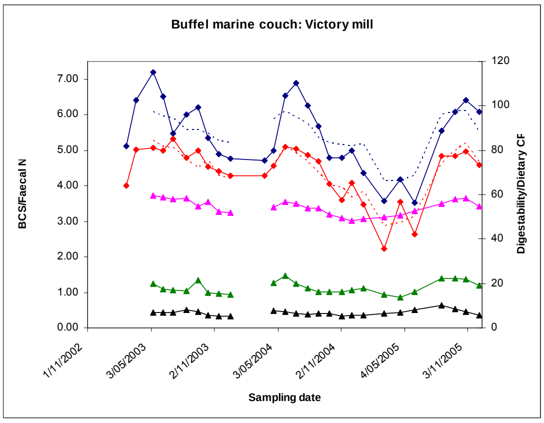
Buffel marine couch: Victory mill
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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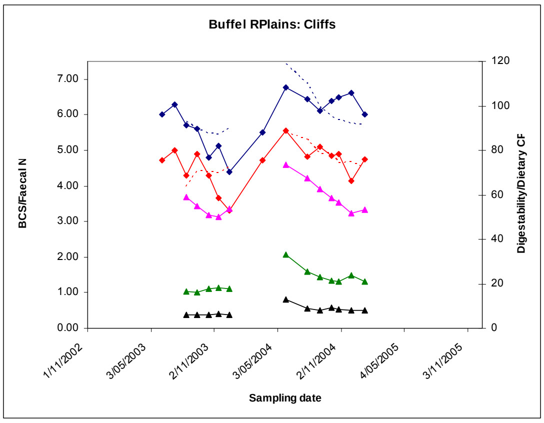
Buffel RPlains: Cliffs
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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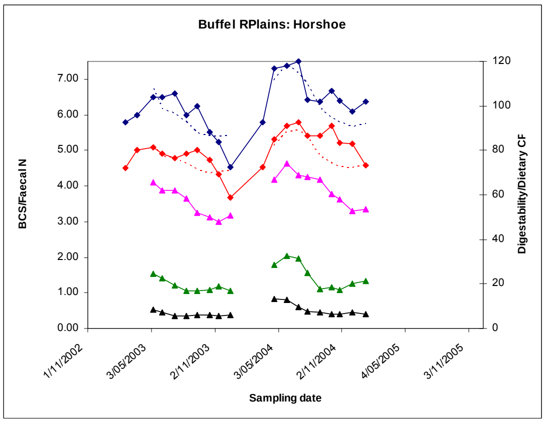
Buffel RPlains: Horshoe
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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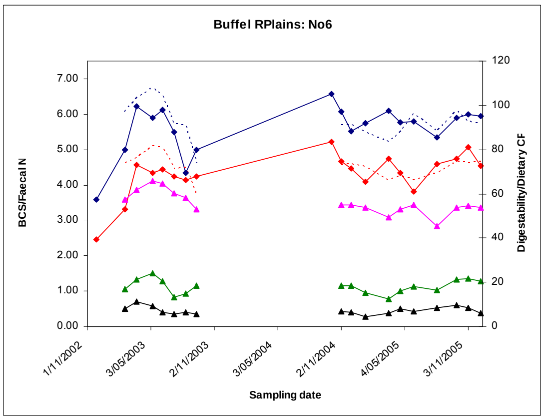
Buffel RPlains: No6
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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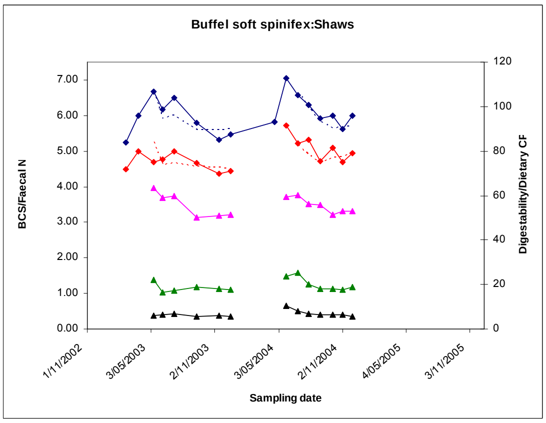
Buffel soft spinifex:Shaws
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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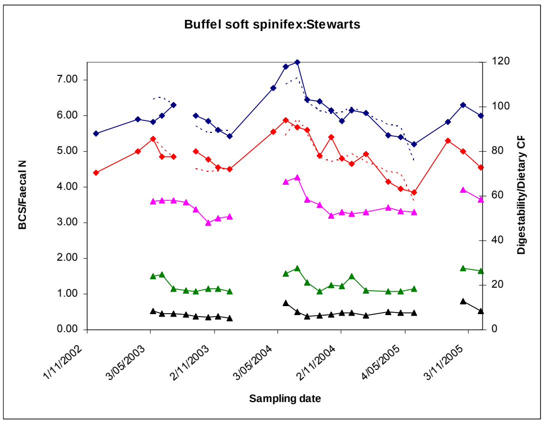
1/11/2002 3/05/2003 2/11/2003 3/05/2004 2/11/2004 4/05/2005 3/11/2005


Buffel soft spinifex:Stewarts
BCS/Faecal N
Digestability/Dietary CF
Sampling date
1/11/2002
3/05/2003
2/11/2003
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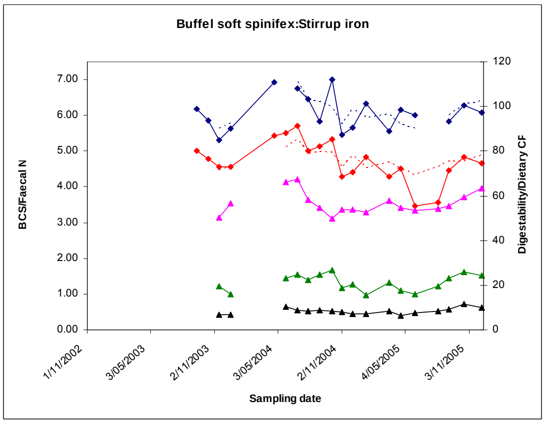
4/05/2005
3/11/2005


Buffel soft spinifex:Stirrup iron
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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3/05/2003
2/11/2003
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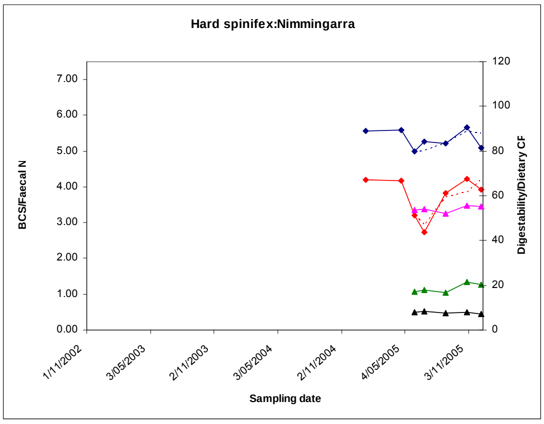
4/05/2005
3/11/2005


Hard spinifex:Nimmingarra
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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3/05/2003
2/11/2003
3/05/2004
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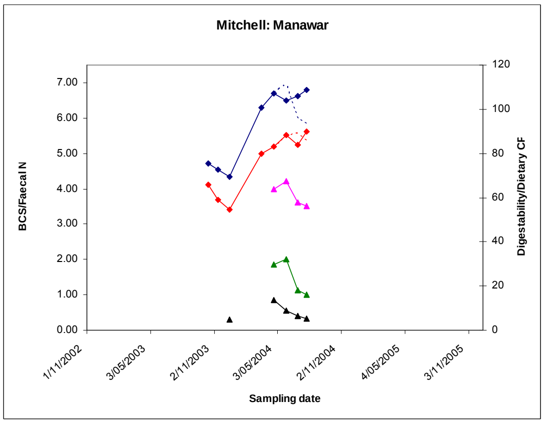
4/05/2005
3/11/2005


Mitchell: Manawar
BCS/Faecal N
Digestability/Dietary CF
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2/11/2003
3/05/2004
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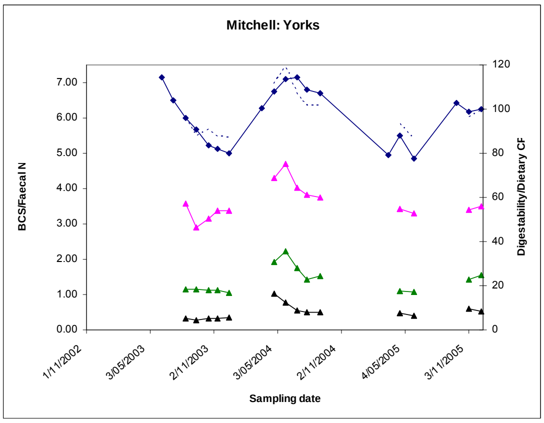
4/05/2005
3/11/2005


Mitchell: Yorks
BCS/Faecal N
Digestability/Dietary CF
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3/05/2004
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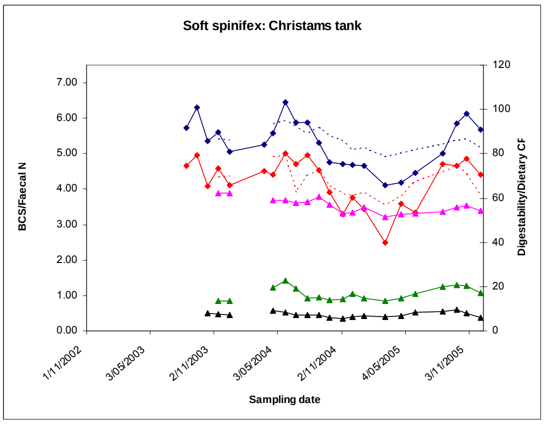
4/05/2005
3/11/2005


Soft spinifex: Christams tank
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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3/05/2003
2/11/2003
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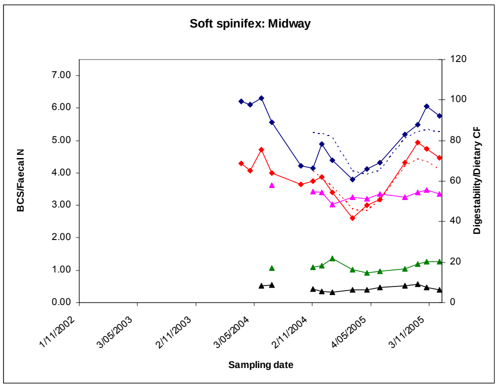
4/05/2005
3/11/2005


Soft spinifex: Midway
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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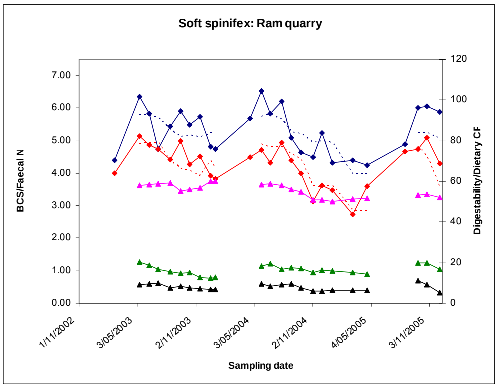
4/05/2005
3/11/2005


Soft spinifex: Ram quarry
BCS/Faecal N
Digestability/Dietary CF
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2/11/2003
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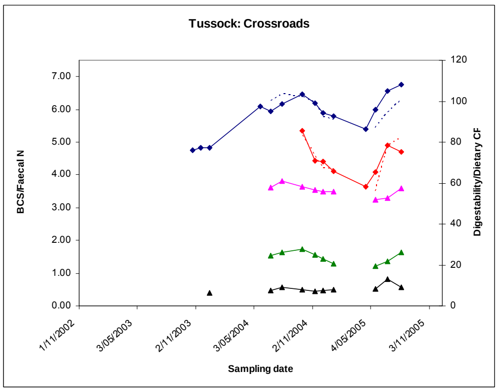
4/05/2005
3/11/2005


Tussock: Crossroads
BCS/Faecal N
Digestability/Dietary CF
Sampling date
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3/05/2003
2/11/2003
3/05/2004
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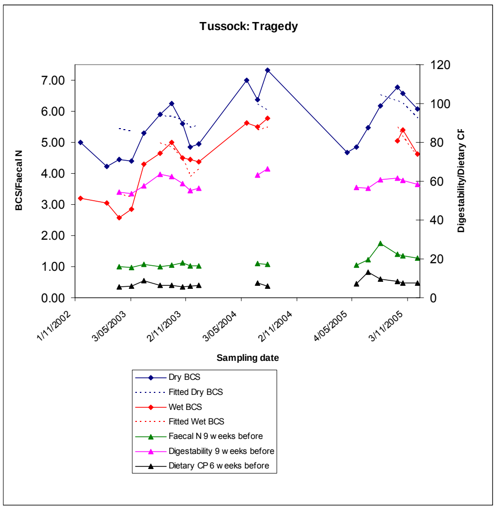
4/05/2005
3/11/2005


Tussock: Tragedy
BCS/Faecal N
Digestability/Dietary CF
Sampling date
1/11/2002
3/05/2003
2/11/2003
3/05/2004
2/11/2004
4/05/2005
3/11/2005
Dry BCS
Fitted Dry BCS
Wet BCS
Fitted Wet BCS
Faecal N 9 weeks before
Digestability 9 weeks before
Dietary CP 6 weeks before

Appendix 3 – Kimberley statistical report

Prepared by Jane Speijers, DAFWA, Perth
Diet Quality and the Performance of Grazing Cattle in the Kimberley

Method

Cattle data collection sites were established at stock watering points in 7 paddocks on properties in the Kimberley. Paddocks were classified into land types/pasture communities (Table 1).

Table 1. Sites with land systems and pasture types within a 3 km grazing radius

Paddock	Land system	Pasture types
Shephards	Loamy creeklines/rocky outcrops	Soft spinifex, black speargrass, bluegrass
Freneys bore Lakes McDonald springs* Pindan No. 1	Pindan	Soft spinifex, buffel grass, ribbon grass, wattles
Greenhide river Helens	River floodplains	Mitchell grass, bluegrass, mimosa, native sorghums

** This paddock was subsequently classified as Loamy creeklines/rocky outcrops*

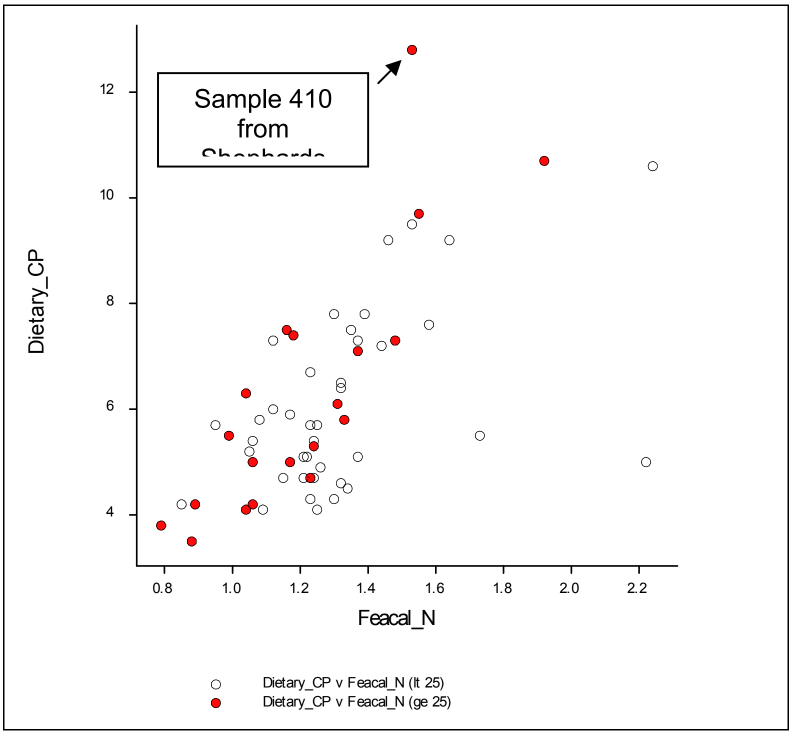
The following information was collected at 4-6 week intervals access permitting:

- Body condition (1 – 9 scale) of representative lactating, dry and growing animals present at each site. A minimum of 15 head of each status to a maximum of 30% of the cattle present was recorded.
- An estimation of females lactating as a percentage of mature age females present.
- An assessment of the current liveweight (condition) change of dry animals. This assessment was usually a combination of the perceptions of the pastoralist and project officer and recorded as Gaining, Holding or Losing.
- Rainfall that may have affected pasture quality or quantity.
- An assessment of quality of pasture on offer using pasture growth phases, leaf:stem ratio, % green leaf and an estimate of yield was recorded. The original six categories of pasture yield were recoded into three categories (< 1000 kg/ha. 1001 – 2000 kg/ha, >2000 kg/ha) for this data set because of the low number of samples in some of the original categories.
- A bulked faecal sample was submitted for NIR analysis which produced estimates of dietary crude protein (CP), faecal nitrogen (FN), % digestibility (D), % non-grass in diet (NG) and %ash (A).

Statistical analysis

The validity of high ash samples was examined by looking at the relationship between dietary CP and faecal nitrogen. Samples with high ash (>25%) were excluded if they had lower than expected faecal nitrogen relative to their dietary crude protein (Pers. comm.. David Coates CSIRO), i.e. outlying point above the dietary CP vs faecal N line with ash > 25%. Sample 410 from Shephards paddock with an ash content of 29% has been excluded on this basis (Figure 1).

Figure 1. Dietary CP vs faecal N for samples with low and high % ash



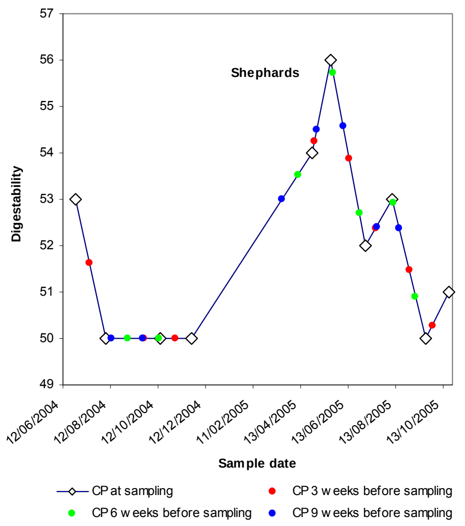
The relationship between animal production and diet quality was examined using regression analysis.

Dependent variables:	Average condition score of dry cows (Dry BCS) Average condition score of wet cows (Wet BCS)
Independent variables:	CP at sampling and 3, 6 and 9 weeks prior to sampling FN at sampling and 3, 6 and 9 weeks prior to sampling Digestibility at sampling and 3, 6 and 9 weeks prior to sampling NG at sampling and 3, 6 and 9 weeks prior to sampling pasture yield category pasture type category and interactions with diet variables % lactating cows

It should be noted that only a subset of the independent variables used for the Pilbara dataset has been used because the low number of records available for regression analysis.

Dietary measurement 3, 6 and 9 weeks prior to sampling were estimated from linear interpolation between previous measurements and measurements at sampling for each paddock provided that the gap between samplings was 84 days or less (Figure 1 shows estimated values for a selected paddock, *Shephards*).

Figure 2. Prediction of crude protein at Shephards



Sample date	Digestibility at sampling	*Predicted values* Digestibility 3 weeks before sampling	Digestibility 6 weeks before sampling	Digestibility 9 weeks before sampling
28/06/2004	53			
06/08/2004	50	51.6		
15/10/2004	50	50.0	50.0	50.0
24/11/2004	50	50.0	50.0	50.0
28/04/2005	54			
22/05/2005	56	54.3	53.5	53.0
06/07/2005	52	53.9	55.7	54.5
09/08/2005	53	52.4	52.7	54.6
21/09/2005	50	51.5	52.9	52.4
20/10/2005	51	50.3	50.9	52.4

One of the major causes of variability in average CS for wet and dry cows is animals moving between the two groups. Wet cows, particularly towards the end of their lactation, can have much lower CS than dry cows. If a large number of calves are weaned between sampling dates then this can lead to a drop in the average CS of dry cows and perhaps an increase in the average condition score of wet cows at the subsequent sampling date. Percentage of cows lactating reflects changes in the size of the wet and dry groups and may account for some of this variability.

Stepwise regression using GenStat for Windows was used to select the best multiple regression model. The process was constrained so that the principle of marginality was adhered to, i.e. if a particular interaction was significant then the main effects for factors or variables making up the interaction were also included. Plots of residuals were used to identify outlying points and affirm the assumptions underlying regression.

It should be noted that we might expect to account for a larger proportion of the variance in BCS in this dataset than in the Pilbara dataset on the basis of much smaller numbers of records in each regression. P-values denoting the significance of individual independent variables in each regression and residual variance are the most reliable way of assessing the goodness of fit of regressions.

Table 2. Correlations between condition scores and dietary parameters at sampling and 3, 6 and 9 weeks prior to sampling based on 23 samples with complete data (critical value for significance P<0.05 is 0.41). Correlations in blue are between same parameter at different times. Correlations in cream are between different parameters at same time.

	Dry BCS	Wet BCS	CP at sampling	CP 3 weeks before	CP 6 weeks before	CP 9 weeks before	D at sampling	D 3 weeks before	D 6 weeks before	D 9 weeks before	FN at sampling	FN 3 weeks before	FN 6 weeks before	FN 9 weeks before	NG at sampling	NG 3 weeks before	NG 6 weeks before	NG 9 weeks before
Dry BCS	1																	
Wet BCS	0.72	1																
CP at sampling	0.13	0.13	1															
CP 3 weeks before	0.26	0.25	0.84	1														
CP 6 weeks before	0.36	0.38	0.58	0.91	1													
CP 9 weeks before	0.37	0.39	0.49	0.77	0.90	1												
D at sampling	0.11	0.14	0.64	0.67	0.52	0.46	1											
D 3 weeks before	0.22	0.36	0.50	0.68	0.68	0.60	0.79	1										
D 6 weeks before	0.20	0.41	0.16	0.43	0.59	0.51	0.45	0.89	1									
D 9 weeks before	0.43	0.40	-0.01	0.26	0.47	0.57	0.37	0.66	0.73	1								
FN at sampling	0.30	0.23	0.21	0.11	0.02	0.00	-0.15	-0.09	-0.08	-0.07	1							
FN 3 weeks before	0.25	0.18	0.54	0.62	0.50	0.39	0.27	0.26	0.13	-0.01	0.73	1						
FN 6 weeks before	0.14	0.11	0.62	0.80	0.74	0.63	0.45	0.48	0.32	0.12	0.34	0.87	1					
FN 9 weeks before	0.12	0.17	0.57	0.76	0.76	0.77	0.48	0.50	0.33	0.25	0.22	0.71	0.89	1				
NG at sampling	0.33	0.04	0.09	0.00	-0.13	-0.27	-0.04	0.05	0.04	0.05	0.50	0.27	-0.01	-0.28	1			
NG 3 weeks before	0.27	-0.13	0.09	0.20	0.08	-0.03	0.13	0.08	-0.01	0.10	0.35	0.43	0.26	0.08	0.73	1		
NG 6 weeks before	0.17	-0.14	0.06	0.27	0.24	0.29	0.18	0.08	-0.04	0.17	0.13	0.38	0.38	0.39	0.14	0.75	1	
NG 9 weeks before	0.05	-0.04	0.20	0.32	0.30	0.46	0.27	0.20	0.05	0.12	0.04	0.32	0.40	0.55	-0.23	0.32	0.81	1

Results

Digestibility 9 weeks before sampling was the independent variable most highly correlated with the CS of wet and dry cows (Table 2). Many of the independent variable were highly correlated with one another. Values of the same measurement 3 weeks apart had correlations ranging from 0.73 to 0.91. Values of the same measurement 6 weeks apart had correlations ranging from 0.14 to 0.77. Correlations between different measurements at the same time were generally lower. Under these circumstances it will be difficult to identify which variables are having most effect on condition score and in particular we cannot expect to distinguish accurately between measurements of the same variable that are three weeks apart.

Of the 65 data records only 23 had data for all variables shown in Table 2. On nine occasions condition score for dry cows was not recorded and on 14 occasions condition score for wet cows was not recorded, possibly because cows in the relevant category were not present. Only 47 records have complete data for BCS for wet and dry cows as well as measurements of crude protein, digestibility, faecal nitrogen and non-grass at sampling. Most missing data was associated with the interpolated values 3, 6 and 9 weeks before sampling when the interval between sequential samples was more than 84 days or because there was no previous sample for interpolation. Thirty-three records have complete data when measurements 3 weeks before sampling are included and only 25 records have complete data when measurements 6 weeks before sampling are included. Correlations between BCS and NIR measurements do not change substantially as smaller subsets of the data which incorporate more variables are examined. For instance the correlation between Dry_BCS and digestibility at sampling remains low, ranging from 0.04 for the whole data set to 0.08 for the data set which incorporates measurements up to 9 weeks before sampling. This implies that any results based on a subset of the data should be applicable to the complete data set.

Table 3. Correlations with Dry_BCS and Wet_BCS for different subsets of data

	Dry_BCS				Wet_BCS			
No. records	*23*	*25*	*33*	*47*	*23*	*25*	*33*	*47*
Wet_BCS	0.73	0.73	0.74	0.65				
Dietary_CP	0.13	0.16	0.13	0.07	0.13	0.20	0.19	0.35
fCP[1]	0.26	0.28	0.22		0.25	0.29	0.31	
fCP[2]	0.36	0.38			0.38	0.41		
fCP[3]	0.37				0.39			
Digestibility	0.11	0.08	0.09	0.04	0.14	0.12	0.13	0.29
fD[1]	0.22	0.18	0.18		0.36	0.31	0.37	
fD[2]	0.20	0.17			0.41	0.35		
fD[3]	0.43				0.40			
Feacal_N	0.30	0.31	0.26	0.29	0.23	0.27	0.20	0.38
fFN[1]	0.25	0.27	0.17		0.18	0.23	0.15	
fFN[2]	0.14	0.15			0.11	0.15		
fFN[3]	0.12				0.17			
Non_grass	0.33	0.31	0.22	0.35	0.04	0.03	0.00	0.22
fNG[1]	0.27	0.30	0.21		-0.13	-0.02	-0.05	
fNG[2]	0.17	0.23			-0.14	0.05		
fNG[3]	0.05				-0.04			

Pasture yield was recorded as six categories: <500 kg/ha, 500-1000 kg/ha, 1001-2000 kg/ha, 2001-3000 kg/ha, 3001-4000 kg/ha and >4000 kg/ha. Because of low numbers of records in the highest categories pasture yield has been recoded into four categories: <500 kg/ha, 500-1000 kg/ha, 1001-2000 kg/ha, >2000 kg/ha.

McDonald springs was initially classified as Pindan but later reclassified as a loamy creekline/rocky outcrops. Analyses of BCS for wet and dry cows were carried out using both classifications. While the % variance in Dry_BCS accounted for changed slightly from 68.4% to 61.0% when McDonald springs was reclassified as loamy creekline the % variance in Wet_BCS accounted for was unchanged (65.1% vs 65.9% for Pindan vs loamy creekline). On this basis the Pindan classification has been used. Only a small number of records are available for this paddock (3 for dry cows and 4 for wet cows).

Average condition score of dry cows (Dry BCS)

A model including pasture type, pasture yield category and digestibility 9 weeks before the measurement of CS (Table 4) accounted for 68.4% of the variance in average condition score of dry cows (Figure 3) and is useful in understanding the effect of pasture type and pasture yield categories. The effect of adding each of the other dependent variables was not significant (P>0.05).

Table 4. Significance of terms selected using stepwise regression

Measurement	*Variance due to adding*	*d.f.*	*F pr.*
Dry BCS	+ Pasture type	3	0.145
	+ Pasture yield category	2	0.001
	+ Digestibility $_{\text{9 weeks before CS}}$	1	0.002
	+ *Digestibility $_{\text{9 weeks before CS}}$ x Past.Typ	7	0.038
	+ Lactation%		0.058
Wet BCS	+ Pasture type	2	0.031
	+ Pasture yield category	2	0.015
	+ Digestibility $_{\text{9 weeks before CS}}$	1	0.004
	+ Non grass $_{\text{6 weeks before CS}}$	1	0.006

As expected, average CS increased with increasing pasture yield. Relative to cows on paddocks with pasture yields < 500 kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores which were 0.959 (±0.617; P=0.142) higher, cows on pastures yielding 1001 – 2,000 kg/ha had condition scores which were 1.143 (±0.721; P=0.135) higher, cows on pastures yielding 2001 – 3,000 kg/ha had condition scores which were 2.440 (±0.817; P=0.010) higher, and cows on pastures yielding >3000 kg/ha had condition scores 1.091 (±0.979; P=0.284) higher. Estimates of CS for each pasture yield category can be calculated but have not been included because they would be averaged across pasture types and may not be relevant.

For every increase of one unit in digestibility 9 weeks before sampling, average CS increased by 0.486±0.255 (P=0.077) for loamy creeklines, increased by 0.114±0.074 (P=0.147) for Pindan and decreased by 0.339±0.168 (P=0.064) for river floodplains. While none of these effects are significantly different to zero (i.e. no effect of digestibility 9 weeks before sampling) we can say that the effect of digestibility 9 weeks before sampling was significantly different between loamy creeklines and river floodplains.

With average digestibility 9 weeks before sampling (52.93%) and medium pasture yield (1,001 - 2,000 kg/ha) cows on loamy creekline paddocks, Pindan paddocks and river floodplains had condition scores of (5.887±0.647), (4.673±0.290) and (6.326±0.471), respectively. However, Pindan (53.24%) and river floodplains (53.80%) had slightly higher digestibility than loamy creeklines paddocks (52.41%), while loamy creeklines had lower yield on average than Pindan paddocks which were lower yielding than river floodplains (Table 5). As a result average Dry BCS was lowest in loamy creeklines (4.271), followed by Pindan paddocks (5.443) and river floodplains (5.788).
The variance of deviations from the regression model (residual variance) indicate which pasture types and paddocks fit the model best (Table 6). Loamy creekline pasture type fits the model worst while McDonald springs is the paddock which fits the model worst.

Table 5. Pasture yield categories for each pasture type for samplings included in Dry BCS regression

	New_PastYld				
PastType2	< 500 kg/ha	500 - 1,000 kg/ha	1,001 - 2,000 kg/ha	2,001 - 3,000 kg/ha	> 3,000 kg/ha
Loamy creeklines	30%	50%	20%	0%	0%
Pindan	3%	11%	63%	17%	6%
River floodplains	8%	15%	23%	31%	23%

Average condition score of wet cows (Wet BCS)

A model including pasture type, pasture yield category, digestibility 9 weeks and non-grass component 6 weeks before the measurement of CS (Table 4) accounted for 65.1% of the variance in average condition score of wet cows (Figure 3) and is useful in understanding the effect of pasture type and pasture yield categories. The effect of adding each of the other dependent variables was not significant (P>0.05).

As expected, average CS increased with increasing pasture yield. Relative to cows on paddocks with pasture yields < 500 kg, cows on pastures yielding 500 – 1,000 kg/ha had condition scores which were 2.625 (±0.746; P=0.003) higher, cows on pastures yielding 1001 – 2,000 kg/ha had condition scores which were 2.447 (±0.856; P=0.013) higher, cows on pastures yielding 2001 – 3,000 kg/ha had condition scores which were 3.735 (±0.896; P<0.001) higher, and cows on pastures yielding >3000 kg/ha had condition scores 2.285 (±0.961; P=0.032) higher. It should be noted that there were only three records of Wet_BCS in the <500kg/ha pasture yield category. One of these, Shephards 9/8/2005, 100% of wet cows had CS 2.

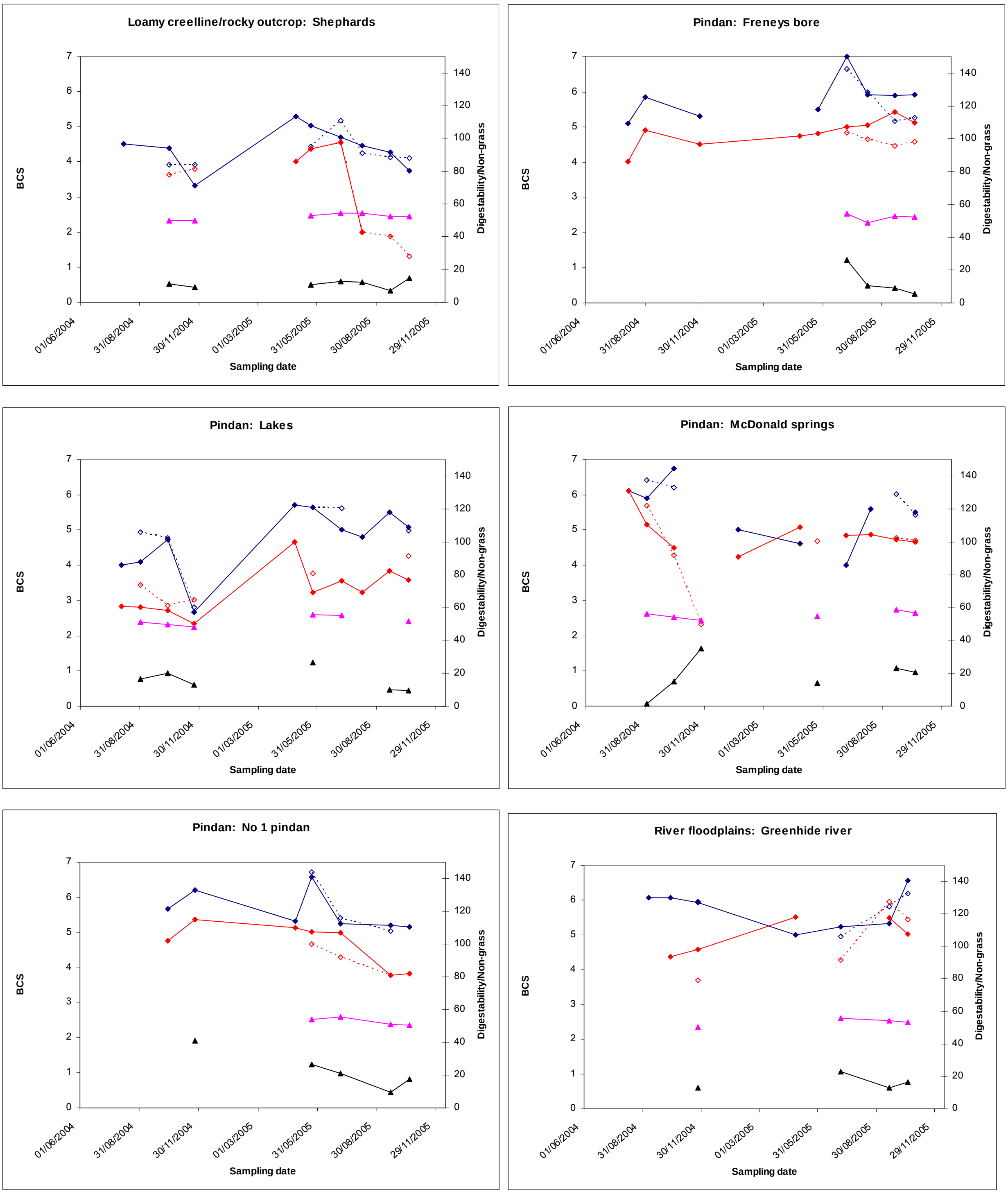
Relative to wet cows on loamy creeklines, wet cows on Pindan and river floodplains paddocks had condition scores which were similar but higher by 0.150 (±0.565; P=0.794) and 0.312 (±0.674; P=0.650), respectively. For every increase of one unit in digestibility 9 weeks before sampling, average CS increased by 0.229±0.053 (P<0.001) and for every increase of one unit in non-grass 6 weeks before sampling, average CS of wet cows decreased by 0.074±0.023 (P=0.006)

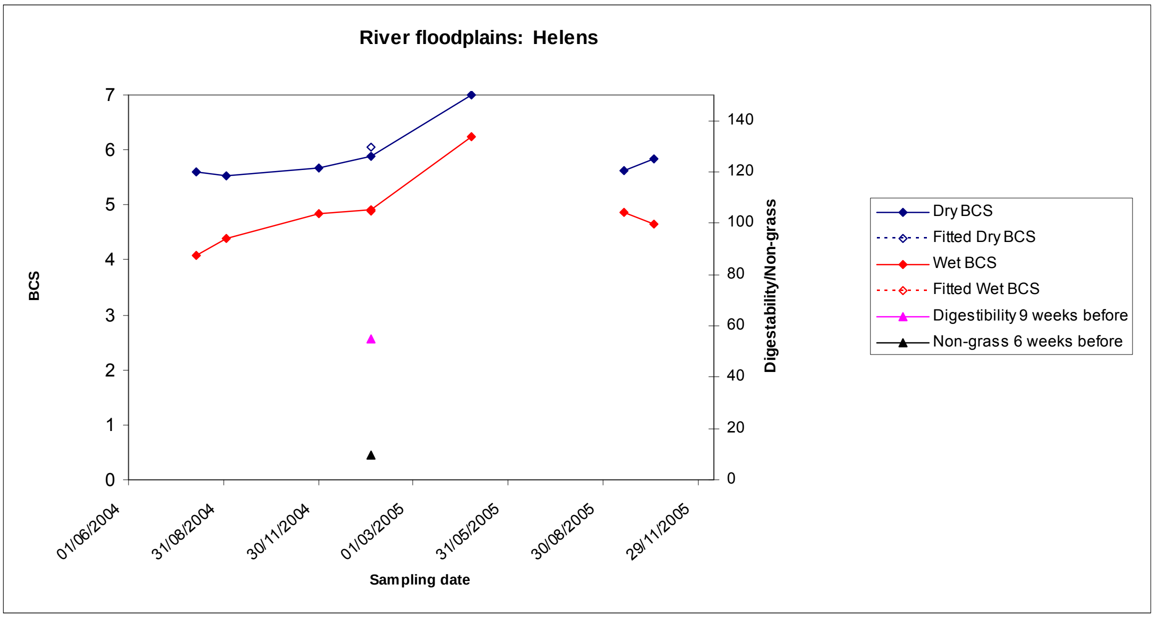
Greenhide river is a particularly poor fit to the model for Wet_BCS leading to a poorer fit for river floodplains than other pasture types (Table 6).

Table 6. For each paddock and pasture type variance of deviations from the regression model

		Dry BCS			*Wet BCS*		
Pasture type	Paddock Name	No. observations	Residual variance within paddock	Residual variance within pasture type	No. observations	Residual variance within paddock	Residual variance within pasture type
Loamy creeklines	Shephards	7	1.3911	1.318	2	0.0000	0.320
Pindan	Freneys bore	4	0.5623	0.836	4	0.3223	
	Lakes	6	0.5944		5	0.2280	1.244
	Mcdonald springs	3	1.7392		4	0.5041	
	No 1 pindan	3	0.3038		3	0.5635	
River floodplains	Greenhide river	4	1.2437	1.072	3	2.9453	1.964
	Helens	1	Na		1		

Figure 3. Fitted models and independent variables




River floodplains: Helens
BCS
Digestability/Non-grass
Sampling date
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
01/06/2004
31/08/2004
30/11/2004
01/03/2005
31/05/2005
30/08/2005
29/11/2005
Dry BCS
Fitted Dry BCS
Wet BCS
Fitted Wet BCS
Digestibility 9 weeks before
Non-grass 6 weeks before

Appendix 4 – Spinifex diet/faecal pair observation

Spinifex Diet - Faecal Pair Observation
Mallina Station Port Hedland

Hayley Turner and Peter Smith, Dept of Agriculture, Karratha. WA

Introduction:

The reliability of Near Infra-red reflectance Spectroscopy (NIRS) predictions of diet quality and animal performance relies largely on the development of calibration equations developed when known diets are fed to cattle and both the diet and faeces (diet/faecal pairs) are subject to NIRS determinations.

There is little data included in current data sets of Spinifex, *Triodia spp.* In an attempt to provide some information on these spp for inclusion in the development and interpretation of NIRS calibration equations a short term observation was initiated at Mallina Station, Port Hedland, WA during October and November 2003.

Due to the lack of suitable harvesting equipment and the spiny nature of Spinifex it was decided that the normal method of conducting a diet/faecal pair observation of harvesting feed material and feeding this to cattle confined to a yard would be impractical. This observation is an evaluation of an alternative technique of "taking the cattle to the Spinifex".

Materials and Methods:

Mallina station is located 100 km WSW of Port Hedland WA on the Pilbara coastal plain. The property includes large areas of sandy surfaced alluvial plains supporting soft spinifex *Triodia pungens* pastures.

In co-operation with the manager of Mallina, Mr Laurie Edwards, a small paddock 250 m x 250m was fenced on an area of soft spinifex, *Triodia pungens* pasture. The fenced area appeared to be totally devoid of other species with the exception of two small Eucalypt trees fenced into a corner for shade. The area had most recently been burnt during 2000.

A random transect, of 5 quadrats 5m apart, located in this paddock was harvested before the area was stocked to provide an indication of dry matter yield on offer at that time.

1. Plant measurements:

To determine the plant parts that cattle were selecting in their diet, two 30m fixed transects were established. Ground cover and a grazing score was recorded from .5 x .5m quadrats before, after and midway through an 11 day grazing period at 5 m intervals along these transects.

A grazing score of 1 (0-20% grazed) to 5 (80 – 100% grazed) was used to determine the degree of defoliation by grazing of each plant within each quadrat at the initial and final observations. At the observation on the 29/10/03 an average grazing score was recorded for each quadrat.

To assist in the identification of plant material that was being removed by grazing, photographs of each quadrat were taken at each observation. Photographs were taken of each quadrat from 1.5m above as well as from 1m to the side from an elevation of .75m. Previous photographs were compared with plant material on offer at subsequent observations.

After consideration of the grazing information observed from the transects, grab samples were harvested from other plants within the small paddock that had not as yet been grazed. These grab samples were selected to resemble as closely as possible the material that had apparently been removed from the recorded plants by the grazing animals.

2. Cattle and faecal sampling:
Four mature dry breeders were placed in the paddock on Sunday 26th October and remained in the paddock continuously until the 4th November. A fresh bulked faecal sample was collected from these cattle each day (with the exception of 28th October) and frozen for later drying and submission for NIRS determination.

Results:

Pasture measurements:

1. Yield was calculated as 1608 kg DM/ha from a random transect harvested from the grazing area before stock were introduced. This transect appeared to reflect the yield in this small paddock.
2. Grazing information recorded is shown in the Table 1.

Table 1: Ground cover, grazing score and photograph numbers recorded at Mallina

Transect 1

Distance along transect	Ground cover %			Mean grazing score 1 (0-20% grazed) to 5 (80-100% grazed)			Photo numbers		
Date	15/10	29/10	3/11/03	15/10	29/10	3/11/03	15/10	29/10	3/11/03
5m	20	20	20	3	3	4	8	20,19	22,21
10m	20	20	20	2.6	3	3	7, 6	18,17	20,19
15m	50	50	50	2.6	3	3.2	5, 4	16,15	18,17
20m	30	30	25	3	4	4.3	2, 1	14,13	16,15
25m	25	25	25	3.75	4	4.5	24, 23	12,11	14,13

Transect 2

Distance along transect	Ground cover %			Mean grazing score 1 (0-20% grazed) to 5 (80-100% grazed)			Photo numbers		
Dates	15/10	29/10	3/11/03	15/10	29/10	3/11/03	15/10	29/10	3/11/03
5m	40	40	40	3	3.5	3.7	22, 21	10,9	10,9
10m	40	40	40	2.5	4	4.3	19, 18	8,7	8,7
15m	10	10	10	2	3	3	17	6,5	6,5
20m	15	15	15	3.3	4	4.3	16, 15	4,3	4,3
25m	25	25	25	3	4	4.5	14, 13	2,1	2,1

NIRS determinations:

A bulked faecal sample collected from the cattle grazing the paddock each day was frozen until all samples were dried at 60 C and submitted to David Coates, CSIRO, Townsville for NIRS determinations. Samples determined to be representative of the plant material actually contributing to the diet of the grazing animals were collected on day 5 and again on day 9 of the observation. These samples were dried to determine dry matter before also being submitted for NIRS determinations.

Results of these determinations are shown in Table 2 and Table 3.

Table 2 Faecal NIRS predictions for diet CP and digestibility – soft spinifex *Triodia pungens*
Mean of samples day 5 – day 9 with range in ( ).

	Diet CP	Digestibility	Non grass
Faecal sample	5.0% (4.8% – 5.2%)	50% (48% – 50%)	< 1% (0% – 2%)

Table 3 Forage NIRS predictions – soft Spinifex *Triodia pungens*

Forage	Dry matter %	Crude protein NIRS	Crude protein Lab	Digestibility NIRS
Day 5	91.7%	5.3%	5.1%	55%
Day 9	94.1%	4.3%	4.2%	52%

David Coates commented on the NIRS determinations as follows: “Most of the predictions were double starred indicating that the samples were spectrally different from samples in the calibration sets. This is to be expected as there is no information from Spinifex based diets included in the calibration sets currently in use”.

Discussion:

This observation has been relatively simple to conduct and has provided useful background information to make better informed predictions from faecal samples from cattle grazing Spinifex based pastures.

Further development of this technique may prove useful in collecting diet:faecal pair information which more closely resembles the diet selected by cattle grazing poorer quality pastures in extensive grazing situations.

Acknowledgements:

The initiative and enthusiasm of Laurie Edwards, manager of Mallina in developing the concept of "taking the cattle to the spinifex" and Judy Norman of Mallina who collected the majority of the daily faecal samples made this observation possible.

Appendix 5 – The role of supplements in the Pilbara

The role of supplements for Pilbara cattle

Compiled by: P.C.Smith

Executive Summary:

The Pilbara region of Western Australia is a unique area of the northern Australian cattle industry. It is a hot, with an average of 20 days a month during the December to March period exceeding 35°C at Port Hedland on the Pilbara coast. Meanwhile at Marble bar in the east Pilbara the temperature exceeds 35°C for an average of 27 days each month for the 6 month period from October to March. Rainfall is unreliable and highly variable averaging around 255 mm a year in the east Pilbara to 315 mm a year at Port Hedland.

These climatic conditions together with the existing land and pasture systems result in low stocking rates with cattle dispersed over large areas making fencing to segregate classes of cattle for management purposes expensive and not always practical. Cattle management systems adopted by many pastoralists include mustering breeders once a year and conducting all husbandry practises at that time. Mustering is often scheduled to coincide with live export sale demands.

The combination of these factors make for a somewhat unique cattle industry when compared to other areas of northern Australia and the widespread adoption of dry season supplementation of breeders should be treated with caution.

The reasons for caution include:

- Research has indicated that breeders maintain body condition for extended periods following useful falls of rain.
- The logistical problems of supplying supplements to relatively small numbers of cattle on widely dispersed watering points.
- Achieving useful animal intakes on a range of pasture types where observation of individual groups of animals is difficult.
- Cost/benefit of supplements not yet demonstrated in the area.
- It would appear that pasture utilisation is a more valuable tool to manipulate breeder cow condition.

It is suggested that supplementation is likely to be most cost effective if specific groups of animals are segregated and supplemented as appropriate. While mustering breeders twice a year could improve herd productivity the economics of the system may be questionable on many enterprises. It would almost certainly be more cost effective for many enterprises to wean to a younger age and lighter weight at an annual muster and to direct the supplementation budget to feeding these young weaners than to supplement breeders for extended periods.

General recommendations for supplementing cattle in the Pilbara that are likely to improve herd productivity and produce the most favourable return include:

- Supplementing weaners – particularly young weaners if they are to remain on the property.

- Supplementing heifers and young breeders from the breeder herd until they wean their first calf . Segregating this group of cattle also provides the opportunity to conduct two weaning musters a year.
- Phosphorus supplementation during the growing season is likely to benefit these heifers and young breeders in some locations.
- Supplements including up to 30% urea in both block and loose mix form have been successfully fed to cattle in different areas of the Pilbara.
- Maintain available pastures at levels > 500- 1,000Kg/hecatre

Is the Pilbara 'different'? – (from other areas of northern Australia)
While herd sizes are similar to other areas of northern Australia (Pilbara range 3000 – 17,000 head) the pastoral leases are considerably larger and therefore the stocking rates are much lower. There are generally multiple watering points,and dispersion of cattle often leading to small numbers at any one watering site (often fewer than 100 head). This is one reason why the Pilbara could be considered different to most other areas of northern Australia.

The climate in the Pilbara is typically hot and dry with highly variable predominately summer rainfall, (Figure 1). Mean annual rainfall ranges from 315 mm at Port Hedland on the central Pilbara coast to 255 mm at Balfour Downs near Newman in the east Pilbara. Rainfall is highly variable both between and within years (Figure 2) and is usually associated with summer cyclonic influences. The probability of receiving more than 50 mm of rain in any month is highest in February when the probability is then only 50%.

Figure 1: Monthly rainfall (mm) Port Hedland

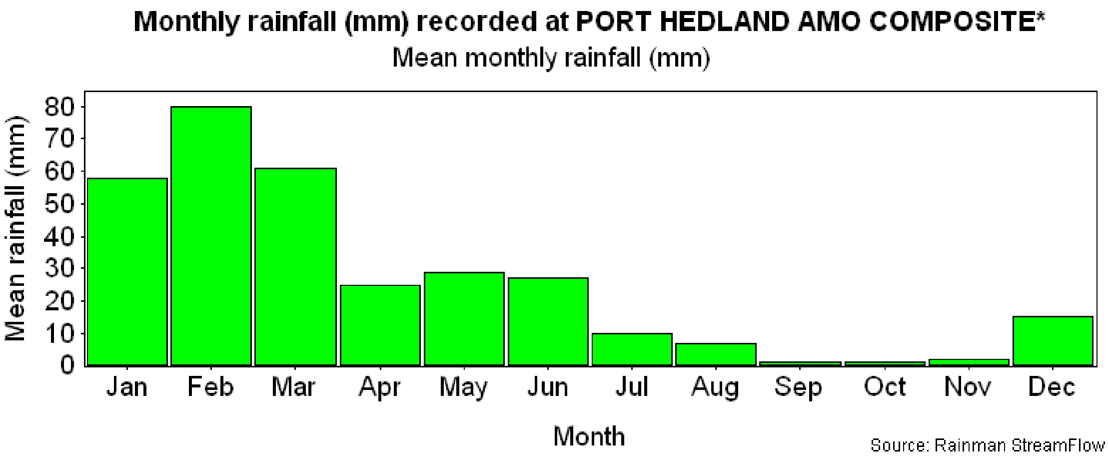
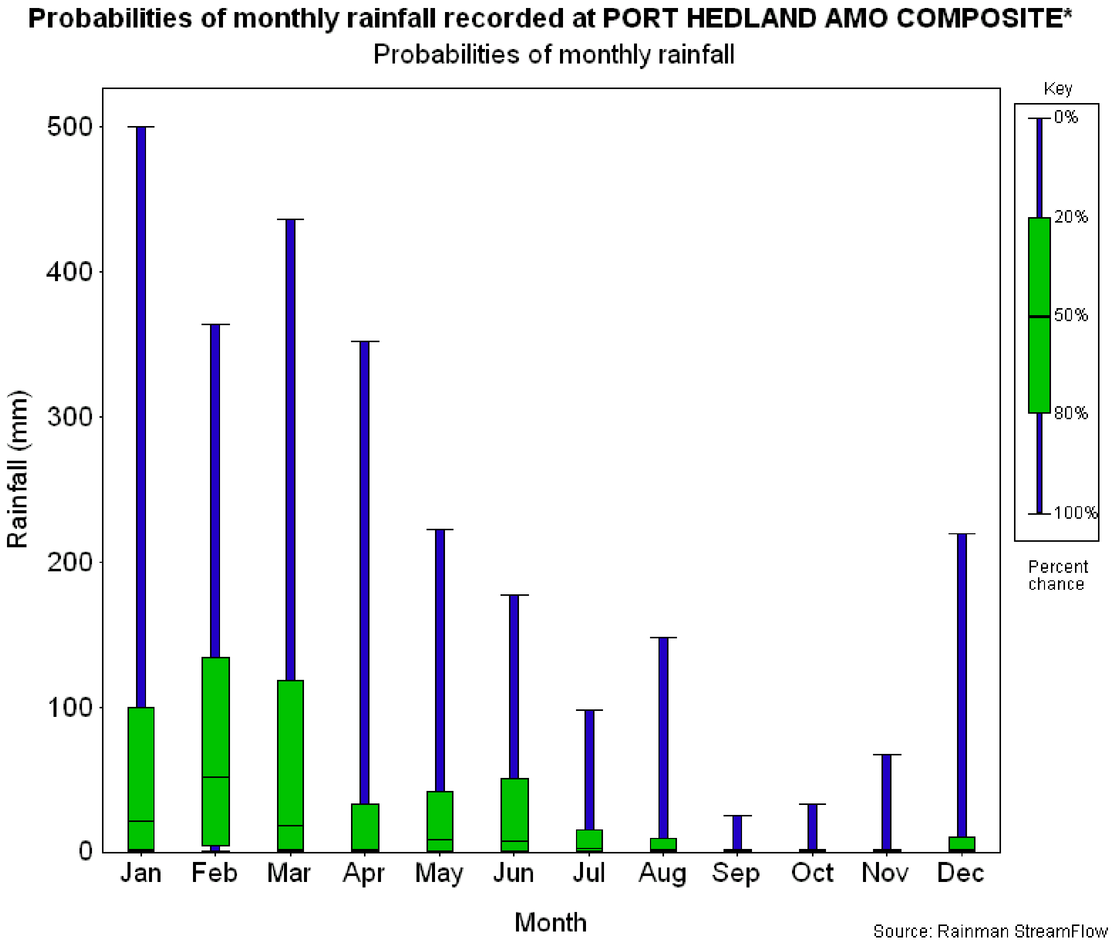


Figure 2: Rainfall probability – Port Hedland



Coupled with the low rainfall, significant areas of the Pilbara are either hills or stony plains supporting hard spinifex and Aristida grasslands of very low productive grazing potential. The productive areas of the Pilbara are associated with soft Spinifex sandy plains, the Roebourne plains and areas of ribbon, mitchell and buffel grasses. These areas contain drainage lines and watercourse frontages around natural waters and often include drainage lines within the grazing radius often around shallow bores. Buffel grass is present in many of these drainage lines and is widely dispersed throughout the Pilbara.

Due to the climatic constraints of temperature, rainfall and rainfall variability, pasture production and carrying capacity of the Pilbara in general is considered moderate when compared to other areas of northern Australia. This carrying capacity of the more productive areas of the Pilbara is estimated to average up to 4 – 5 adult equivalents (A/E)/square km. Coupled with the scatter of areas of low carrying capacity within many grazing areas, fencing to manage different groups of cattle or land systems is expensive. Due to the extended length of fencing to contain any group of cattle, fencing is also likely to be less effective; the longer the fence, the more opportunity for damage by feral animals and bulls, resulting in higher maintenance costs.

Cattle production is a relatively new enterprise in the Pilbara as sheep progressively disappeared from the region during the 1980's – 1990's. The last sheep only left the Pilbara in the early 2000's period. As a result, little information about cattle production had been documented and only anecdotal information was available prior to the early 2000's on which to base recommendations to improve productivity and cattle management.

Introduction:

Information on diet quality selected by grazing cattle, researched in areas of north Queensland in the 1960's, was not available for any of the Pilbara pasture systems. It is difficult to provide useful and relevant recommendations on management and supplementation practises without some understanding of diet quality and changes in cattle condition on different pasture systems during different seasons.

An MLA supported project "Diet quality selected by grazing animals in the Pilbara" (NIRS project for short) was initiated in 2002/03 to provide information on the quality of diet that cattle select at different times of the year. The project has provided information for several of the major pasture systems in the Pilbara and provides a basis for making more informed decisions about the role supplements may have in the Pilbara.

In addition to the results eminating from the NIRS project in the Pilbara these notes also include information from a number of publications and research reports as well as documentation on some experiences of producers and industry advisers from across northern Australia.

This publication has been prepared to help Pilbara pastoralists make better informed decisions about supplementation. It is intended as a summary of useful research information and experiences of particular relevance to the Pilbara cattle industry, not as a review of supplementation research across northern Australia.

The MLA publications "Beef cattle nutrition, an introduction to the essentials" and "Grazing land management, sustainable and productive natural resourse management", while not specifically targeted at the Pilbara, provide a good overview of the digestive anatomy and the principles of cattle nutrition and grazing management. These publications are recommended reading for Pilbara pastoralists considering a broadscale supplementation program.

1. NIRS project summary

This project was initiated to provide some background information on changes in the body condition of both lactating and non lactating breeder cattle during the year in respect to the quality of the diet that grazing animals select on various pasture types in the Pilbara. In addition to these broad objectives the project also provided information on the reliability of faecal Near Infra-red Reflectance Spectroscopy (NIRS) to predict body condition changes based on current diet quality predictions.

Faecal samples were collected from representative females at selected stock water 'collection sites' on a regular 4 – 6 weekly basis. Sites were selected on the basis of accessibility for regular sample collection, likelihood of having cattle grazing continuously throughout the year, the type of pasture within a 3 km grazing radius of the water and the willingness of pastoralists to be involved.

Table 1. Pilbara sites with land systems and pasture types within a 3 km grazing radius

Sites	Land systems	Pasture types
Cliffs Mill, Horseshoe, No6	Hooley, Brockman, Paraburdoo, Pindering.	Roebourne plains grass, buffel
Christmas Tank, Midway No3, Ram Quarry	Uaroo	Soft spinifex, Aristida spp.
Crossroads, Tragedy	Cane, Horseflat, River	Ribbon, roebourne plains, buffel grasses and spinifex
Fredericks, Yorks Mill, Manawar	Brockman, Hooley	Mitchell, roebourne plains
Minsons, River, Parsons	River, Mallina,	Buffel, soft spinifex,
Stirrup Iron, Shaws, Stewarts	Sylvania, River, Divide, Fortesque.	Aristida, buffel, soft spinifex, (east Pilbara)
Victory Mill	Yamerina.	Buffel, marine couch
Nimmingarra	Uaroo, River, Boolaloo.	Soft and hard spinifex (limited collections only)

Information recorded at the time of each collection included:

- Body condition of lactating and dry cows.
- Estimates of the quantity of feed on offer – within 3 km of water.
- Estimate of green leaf on available pasture
- Rainfall recordings for the period between sampling collection.

Note: *There are several methods of estimating feed on offer. Estimates for this project were determined using a combination of the project officer's experience with photo standards of yields from other areas and local pastoralists experience of edible plant species. Yield estimates were grouped in broad categories of less 500 kg/ha (very little edible feed); 500 – 1000 kg/ha (some useful feed); 1000 – 1500kg/ha (reasonable quantity of edible feed); and so on up to above 2500 kg/ha. Other useful methods include estimating an area capable of feeding an animal for a day and calculating the number of grazing days in a given area.*

A bulk faecal sample collected from at least 20 individual and fresh dung pats was sub sampled, dried and sent to CSIRO, Townsville for NIRS prediction of diet quality. NIRS predictions supplied included:

- Diet crude protein.
- Digestibility.
- Non grass (e.g. shrubs, herbs) in the diet.

The project commenced late in 2002 and continued for up to 3 years at some sites.

Key findings of the project included:

- Dry (non lactating) breeders gained and then maintained body condition for a considerable period following useful falls of rain. Lactating breeders were generally at least 0.7 of a condition score lower in body condition than dry cows.
- For the duration of the project, breeders generally maintained better body condition for longer periods following useful rain than might be expected in many other areas of northern Australia.
- During the years of the project, dry cow condition at the end of the dry season (Table 2) ranged from condition score 4.4 – 6.2 (1 – 9 scale) indicating a reasonable chance of conception during their following lactation.

Note: *Research in northern Australia has demonstrated that the body condition of dry pregnant cows at the end of the dry season is a key factor in determining the probability of them conceiving again during their subsequent lactation. Breeders in strong store condition (e.g. score 5 of 1-9 scale) have around a 60% chance of conceiving during their subsequent lactation while poorer conditioned cows have less than a 40% chance of conceiving again while lactating..*

- Based on information from other areas of northern Australia the dry matter digestibility:diet crude protein ratio indicated that there would likely be a response to nitrogen (urea) supplements for extended periods in some years.
- Breeders lactating late in the year were in strong condition in most years, (Table 3).
- Lactating breeder body condition declined rapidly late in the year; presumably reflecting declining diet quality, pasture availability and increasing daily temperatures.

Table2: Dry cow condition (1 – 9 scale) at the end of the dry season in the Pilbara

Pasture type	**Dry cow condition Dec 2002**	**Dry cow condition Dec 2003**	**Dry cow condition Dec 2004**	**Dry cow condition Dec 2005**
Buffel, roebourne plains grass		4.4	5.7	6.0
Soft spinifex, Aristida spp.	4.5	4.8	5.3	-
Ribbon, buffel, roebourne plains grasses and spinifex	5.0	5.0	-	6.1
Mitchell and roebourne plains		4.5	5.5	6.2
Buffel, soft spinifex (river frontages)	4.5	5.3	5.6	-
Aristida, buffel, soft spinifex, (east Pilbara)	5.5	5.6	5.9	6.1
Marine couch, buffel, (coastal plain)	4.8	4.8	5.0	-
Soft and hard spinifex	-	-	5.6	5.1

2. Cattle management Vs supplements

A survey to document current cattle management practises in the Pilbara conducted in 2003 indicated that around 60% of pastoralists mustered breeders once a year with all management practises (weaning, vaccinations, culling, sales etc) taking place at that muster. Depending on seasonal conditions, potential markets and other factors, mustering commonly commences around mid year and might continue into September/October or when pastoralists consider that it is too hot to handle large mobs of cattle. Anecdotal information combined with pastoralists' experience suggests that mustering efficiency seldom exceeds 90% at any muster.

Pastoralists mustering breeders more than once a year consider that it ensures that all breeders are handled at least once a year, thus receiving treatments including botulism vaccinations and weaning. Research in other areas of northern Australia indicated that weaning calves earlier in the year is likely to produce as much as twice the effect of supplementation in improving breeder condition during the dry season and subsequent reproductive performance.

The cost of mustering large areas for relatively few cattle is expensive. The majority of mustering in the Pilbara is conducted with a combination of either helicopter or fixed wing aircraft (or both) and people on the ground with motorbikes or 4 wheel drive 'buggies'. Few properties use horses for mustering and the presence of natural waters in many areas limit the effectiveness of trapping. With the cost of mustering ranging from <$10 a head to >$40 a head for some areas, the cost benefit of mustering all breeders twice a year on many more extensive leases may well be doubtful. Segregating young breeders from the main breeder herd and mustering them to wean their calves twice a year is more likely to produce economic and productivity benefits in these situations.

Table3: Lactating (wet) cow condition (1 – 9 scale) at the end of the dry season in the Pilbara

Pasture type	Wet cow condition Dec 2002	Wet cow condition Dec 2003	Wet cow condition Dec 2004	Wet cow condition Dec 2005
Buffel, roebourne plains grass		3.5	4.4	4.6
Soft spinifex, Aristida spp.	3.5	3.9	3.6	-
Ribbon, buffel, roebourne plains grasses and spinifex	3.2	4.4	-	4.6
Mitchell and roebourne plains	-	3.4	4.1	-
Buffel, soft spinifex (river frontages)	3.4	4.3	4.3	-
Aristida, buffel, soft spinifex, (East Pilbara)	4.4	4.5	4.5	4.6
Marine couch, buffel, (coastal plain)	3.5	4.2	4.1	-
Soft and hard spinifex	-	-	4.2	3.9

3. What are Supplements?

The diet that cattle can select from most of the pasture systems in this environment is generally only adequate in all nutrients to promote good growth rates in dry cattle for limited periods of any year. With few exceptions, lactating cows will seldom be able to maintain, let alone gain, weight during lactation.

Cattle can only perform up to the level of the limiting nutrient in their diet. The old story; “It makes no difference how much water and oil a vehicle has it will only go until the fuel runs out”, applies to cattle diets and cattle performance. e.g. Supplementing cattle with trace elements and minerals will not improve animal performance if energy or protein are the nutrients limiting performance.

Supplements are aimed at correcting deficiencies in diets. By correcting one deficiency, cattle will potentially perform up to the level of the next limiting nutrient. In general terms, supplementary feeding is about providing small amounts of a nutrient or nutrients in the diet of cattle to correct deficiencies and improve animal performance.

Intakes of supplements are typically measured in grams a head a day (g/hd/day).

4. Why Supplement?

Supplements are aimed at improving growth, condition and liveweight of cattle. There are a number of cattle and herd management practises that can also have a big effect on cattle condition, liveweight and growth. The effect of weaning on lactating breeders is a striking example. Removing a calf from a cow reduces her nutrient requirements by up to 50% immediately. It is just not possible to achieve the same result by supplementing the cow calf unit. Substantial levels of energy feeding, with grain or protein meals, would be required to ensure the same improvement in breeder performance as achieved by weaning a calf.

Supplementation has often been used as a substitute for making different management decisions and changing management practises. Cattle management changes may produce better long term results and be more cost effective than supplements in achieving improved herd performance.

Information in these notes will focus on the role of supplements in correcting nutrient deficiencies, reducing deaths and improving animal performance. Supplements have also been used in some areas of northern Australia to encourage cattle to congregate to improve mustering efficiency and to reduce the incidence of depraved appetites e.g. eating dirt and bone chewing.

5. How do supplements work?

Nutrient deficiencies often affect animal performance by suppressing rumen activity and rate of passage of feed through the rumen thus reducing feed intake. Common examples include protein deficiency and phosphorus deficiency.

Correction of these deficiencies seldom results in more efficient digestion i.e more of the feed eaten being actually digested and utilised by animals, but significantly increases the amount of feed eaten. Nutrient intake is improved because animals are eating more feed from which to extract nutrients.

The potential response to supplements depends to a large degree on the quantity and quality of pasture available. If the feed quality is adequate, say 50 - 55% digestible, reasonable responses to supplements to increase intake could be expected providing cattle have access to an adequate quantity of feed. As feed quality declines, 40% or less digestible, responses will be considerably less. It doesn’t matter how much intake increases in response to supplementation cattle are unable to digest enough of the feed to improve their performance.

As feed quality and digestibility decreases, nutrients available to rumen organisms decreases and rumen function declines. This results in decreased feed intakes of lower quality feed and so the spiral of declining rumen function and animal performance continues until the cycle is interrupted by supplements, or better still rainfall events and fresh pasture growth.

Supplementation with small amounts of urea and sulphur (S) can result in an increase in feed intake of up to 30% or more. This is largely achieved by improving the nutrient flow to rumen organisms and increasing their numbers. This results in a more rapid breakdown of feed and improved 'rate of passage' through the rumen. The increase in feed intake results in cattle accessing the nutrients from 30% or more of feed.

Depending on the quality of the diet this may be sufficient to improve liveweight gain or more commonly reduce the rate at which cattle lose weight. In either case supplements can improve animal performance. This may result in reducing breeder deaths, improved reproductive rates from breeders in better body condition or improving growth rates of weaners and growing cattle to meet market weights at a younger age.

6. Cattle responses to supplements

There has been a considerable amount of supplementation work carried out in many areas of northern Australia over a number of years. Unfortunately there has been little work in the Pilbara which has documented the cattle responses to various supplements. The findings of a number of the various supplementation trials from across northern Australia have been summarised in an MLA Report (DAQ .98) by Rob Dixon, a research officer with the QDPI. Many of the comments in this section are based on this review.

There are a number of opportunities to measure the response of cattle to supplements:

- **Reduction in deaths due to normal or prolonged dry seasons.**

From the research information and estimates based on sale records, the average mortality rate of breeders in northern Australia is probably around 10% pa. This figure may sound high but it is based on measured losses and females actually turned off from northern herds over a number of years.

Note: *The number of females sold (surplus heifers, cull and aged cows) as a percentage of total sales averaged over a period of years provides a good indication of female losses on individual properties. If the breeder numbers are not being built up then the female sales % should be approaching 50%. Female sales in excess of 45% are achieved in some northern Australian herds.*

There are a number of causes for breeder cow losses and these include poor nutrition, disease and age. Vaccination programs and age culling practises will reduce these losses but often changes to breeder management systems including supplemenation are required.

One Kimberley property with good records documented average breeder losses over a 9 year period of 11.5% with a range of 5.7 % to 24.5% in different years. When a breeder management system including supplementation, Botulism vaccination and twice a year weaning was introduced on this property and breeder losses were reduced to around 5% within 2 years.

Pilbara experience indicates that a combination of good weaning management, opening up waters in 'new' country and urea supplementation will markedly reduce breeder losses during prolonged dry seasons. In this instance breeders were fed a commercial block containg 30% urea (Uramol) from late August until storm rains were received at the end of November 2002.

Around 2500 breeders, including 500 'really old cows', were supplemented mostly with 100 kg blocks. The breeders consumed 8.2 t of blocks during the feeding period for a cost of around $9000 landed on the property.

Pastoralist comments on this supplementation program included:

Supplementation certainly substantially reduced cattle losses
Cattle left the waters earlier in the day
Cattle fed out further than in the past
Cattle took to the blocks and consumed them fairly steadily
Blocks were kept up to the cattle at all times
Lost a total of 8 head from suspected urea toxicity
Cattle really "bounced away" when it rained.

Note: *These examples are quoted to demonstrate that losses from poor nutrition can be reduced by supplementation. This is only one avenue to address potential breeder losses. Other options include moving cattle to more favoured country, changes to management practises e.g. weaning and feeding the weaners well, selling problem breeders, etc.*

- **Improved reproductive rates as a result of improved breeder live weights.**

Research in north Queensland has documented benefits of urea supplementation on breeder liveweight loss during the dry season ranging from nil, in years when there was some winter rain, to around 35kg in dry years. In areas with longer dry seasons (Pilbara) responses may be higher. The cost of the supplement to produce these responses must be justified in terms of increased sale values or more calves.

Research from a number of sites has shown that lighter breeders (below 340 kg) are likely to respond better in terms of higher reproductive rates than heavier breeders. Heifers lactating for the first time are more likely to respond than mature breeders. The information from several research projects indicates that reproductive rates are likely to increase by 5 percentage points for each additional 10 kg of liveweight for breeders less than 340 kg at mating. This means that if lighter breeders are say 30 kg heavier at mating as a result of supplementation or some management input, reproductive rates are likely to be increased by some 15%.

Younger breeders rearing their first calf will probably be in this 'lighter' category and therefore are likely to respond better to supplementation or management changes. To allow "best bang for the supplement $", it makes sense to manage these heifers as a separate group until at least they wean their first calf. Management options may include supplementation in the dry season prior to calving and P supplementation during the growing season depending on land type.

The increase in reproductive rates for breeders over 340 kg is likely to be less at around 3 percentage points with responses likely to cut out in breeders over 400 kg at the commencement of mating. The improvement in reproductive rate in a herd as a result of improved nutrition therefore largely depends on the profile of liveweights of individual animals in the herd.

Substantial increases in pregnancy rate are only likely to occur where a large proportion of the breeder herd is in the lower liveweight ranges.

- **Increased growth rates of sale cattle.**

Supplements are used in some areas of northern Australia to increase sale weight and/or reduce sale ages of growing cattle. On more favoured pasture types supplements have been used to ‘hold’ cattle for expected market price rises later in the year.

This can be a more attractive option as the cost/benefit of supplementation can be budgeted a lot more accurately. Supplementation with urea should be planned so that cattle are sold before rains are received. Compensatory growth following rain will often reduce the liveweight advantage supplemented cattle have over unsupplemented cattle. There is often little cumulative advantage of supplementing growing cattle in successive years as responses are likely to be reduced by compensatory growth each growing season.

The response to urea supplementation by growing cattle on reasonable dry feed is limited to around 0.25 kg/hd/day. In some situations as mentioned above this may allow cattle to gain more weight or to hold weight for longer to improve sale opportunities. In practise this 0.25 kg/hd/day is often a reduction in liveweight loss in the latter part of the dry season.

7. Supplement delivery options.

- Water medication is an option worth serious consideration and has a number of advantages. All cattle receive the targeted amount of supplement as all cattle must drink and intake is proportional to body size. Only the active ingredients of the supplement are included as there is no need for ‘carriers’ as in loose mixes or blocks.

  The disadvantage of water medication for many Pilbara situations is the small number of cattle on individual water points. Medication units cost in excess of $2500 installed (in 2006) so are most cost effective where they can be installed in a reticulation system watering a large number of cattle.

  The potential problem of providing medicated and non medicated water in the same paddock and mustering cattle from non medicated on to medicated waters needs to be considered.

  If using water medication it is essential to ‘get the sums right’ in mixing the concentrate solution and calibrating the medication unit.

  The MLA publication, *Water medication, a guide for beef producers*; is strongly recommended as a very useful reference and recommended reading for pastoralists considering water medication as a delivery system for supplements.

- Dry mixes: Mixes should be based around supplying 30 – 50 g/hd/day urea + S to breeders or 20 – 30 g/hd/day to weaners and growing cattle. These levels are generally regarded as “safe” levels for these classes of cattle.

  Intakes of dry mixes can vary widely between areas and within mobs of cattle. Intakes that are too low are unlikely to achieve target performance while intakes that are too high will be unnecessarily expensive and possibly dangerous. In the absence of local experience it is suggested that the following approach will be useful in developing a local 'recipe' for individual properties:

1. Feed a measured amount of salt at each water point in the paddock and monitor intake over at least a week and preferably longer. This will determine if salt is likely to be a suitable intake control agent. If satisfactory intakes of salt (50 g/day or more) are not achieved something else will need to be tried. e.g. add small amounts of grain or lupins to the salt.

2. Once a satisfactory amount of an intake controller is determined, for example salt, make up a mix of 10% urea, 2% sulphate of ammonia and balance salt or other intake controller as determined during the pre-feeding period. Feed this at each water point for at least a week or preferably longer and monitor intake.

3. A second mix containing 20% urea, 4% sulphate of ammonia and the balance salt (intake controller) can then be fed out. To achieve an intake of 30 g urea a day, intake of this 20% mix should be around 1 kg/hd/week.

Mixes containing 30% and higher levels of urea are commonly fed in many areas of northern Australia with good results and a corresponding reduction in freight cost of the intake controller. High levels of ground limestone products as fillers in dry mixes is not recommended as this may result in mineral imbalance problems particularly in marginal P country.

While developing a local 'recipe' will be a time consuming and possibly frustrating exercise it should result in a urea based supplement that will be potentially useful into the future. Once a 'recipe' has been developed it can be custom mixed by a supplement supplier to reduce on property labour commitments.

- Custom mixed loose mixes. These should be selected following discussion with people that have actually fed the specific products to their cattle and preferably on a similar land system. The basis of selecting these products should be on supplying urea + S to cattle safely. Low urea mixes, 10% or less, are usually more expensive on a nutrient supplied and freight basis than higher urea concentration mixes. High urea does not necessarily mean higher risk of toxicity. Many people in NE Qld have successfully fed mixes containing 50% urea for years. Others have killed cattle on 15% mixes.

- Blocks are a convenient method of feeding urea but achieving target intakes of urea can be a problem. Due to manufacturing inputs blocks are usually more expensive than loose mixes of similar urea content.

8. Feeding management:

Warning: Urea is highly toxic to cattle and can and will kill if consumed too quickly.

- The majority of deaths from urea toxicity have resulted from management problems. The most common problem is feeding cattle that have been on a supplement for some time and have been allowed to run out of supplement for as little as only a day or two. When refed there is a risk that some of the cattle may gorge the supplement to satisfy their appetite for supplement.

- Changes in urea concentrations in mixes should be made while there is still some of the previous mix at the feeding site. Mixes with different urea concentrations should not be mixed in the one trough – feed in separate troughs.
- All troughs should have good drainage through the bottoms or ends. Urea readily dissolves with saliva and rain. Urea in concentrated solution is particularly toxic as cattle can drink it and therefore these solutions should not be allowed to concentrate in troughs.
- Feeding 1000 breeders with a 30% urea supplement will require the transport to property and to the feeding sites of some 4 t of supplement each month.

9. Conclusions:

Based on current knowledge and experience the widespread adoption of urea supplementation of breeders in the Pilbara should be treated with caution. The supplementation of specific groups of cattle, e.g. weaners and young breeders, is most likely to produce economic benefits and the best responses to supplements during the dry season supplementation with urea based supplements.

Responses to supplements by these young breeders would include improved growth, improved survival and increased and earlier conceptions of lactating first calf cows. Effective supplementation is only one of the potential benefits of managing young breeders as a separate group. The segregation of these animals from the breeder herd should be encouraged.

The role of phosphorus supplements during the growing season in some areas of the Pilbara is likely to improve the productivity of particularly young breeders and possibly growing steers.

Careful consideration of the costs and potential benefits of supplementation is required before programs are commenced. This is probably best achieved by simple break even analysis. The cost of supplements is reasonably easy to calculate; the likely benefit in productivity is more difficult to calculate in this area.

The principles of practical urea based supplementation developed in other areas of northern Australia have been demonstrated to be relevant to the Pilbara.

MLA publications for more information:

Beef cattle nutrition - an introduction to the essentials
Managing the breeder herd – practical steps to breeding livestock in northern Australia
Grazing land management – sustainable and productive natural resource management
Water medication – a guide for beef producers

Above all remember that urea can and will kill cattle if they consume it too quickly!

9.3 Appendix 6 – The Relationship between predicted diet crude protein (diet CP), digestibility (DMD) and DMD:Diet CP ratio for representative Pilbara project sites.

The relationship between predicted digestibility and breeder body condition changes for representative pasture types have been presented in the body of the report. Further relationships of diet CP and DMD:Diet CP ratio and body condition changes are presented in figures 1 - 9 below.

Diet CP broadly follows digestibility predictions i.e. when diet CP is high digestibility is also generally high.

The relationship between dry cow body condition changes and DMD:Diet CP ratio were of particular interest. Rob Dixon, QDPI&F (pers com) has reported that for spear grass pasture types in Queensland responses to NPN supplements may occur in the ratio range of 8 – 10 while responses are most likely for ratios higher than 10.

Applying this finding to the Pilbara data indicates that there were few occasions when the ratio exceeded 10. Notable exceptions were the buffel grass pasture type (River) and the Mitchell, Roebourne Plains grass pasture type (Yorks) where the ratio exceeded 10 for considerable periods each year when animals were either maintaining or losing condition. Conversely it is also interesting that the ratio for cattle on the soft Spinifex pasture type (Ram Quarry) seldom exceeded 8 although cattle were maintaining or losing condition for considerable periods.

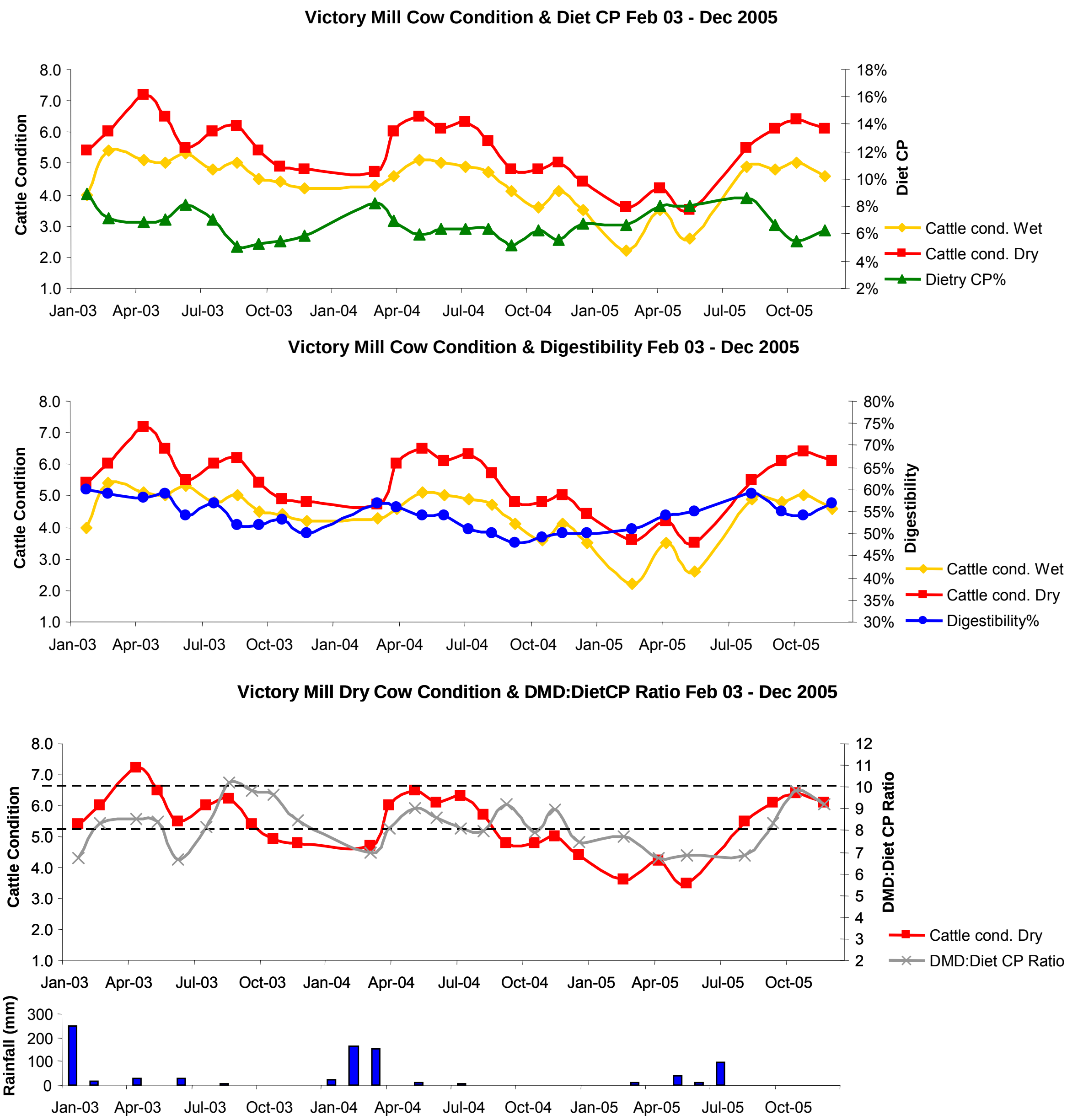


Figure 1 Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a buffel grass and marine couch pasture January 2003 to December 2005 (Victory Mill)

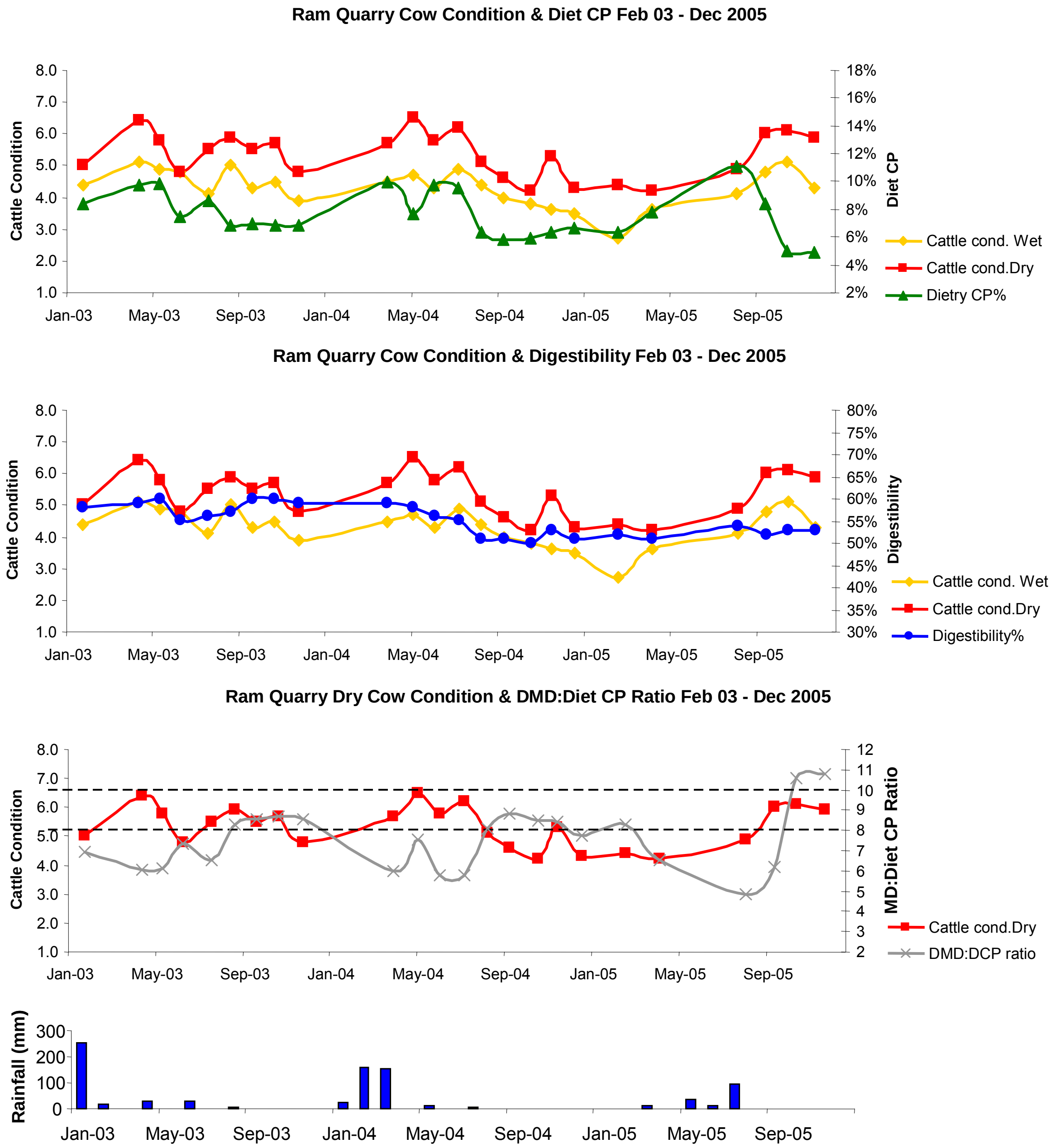


Figure 2. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP rario and rainfall on a soft spinifex pasture from January 2003 to December 2005 (Ram Quarry)

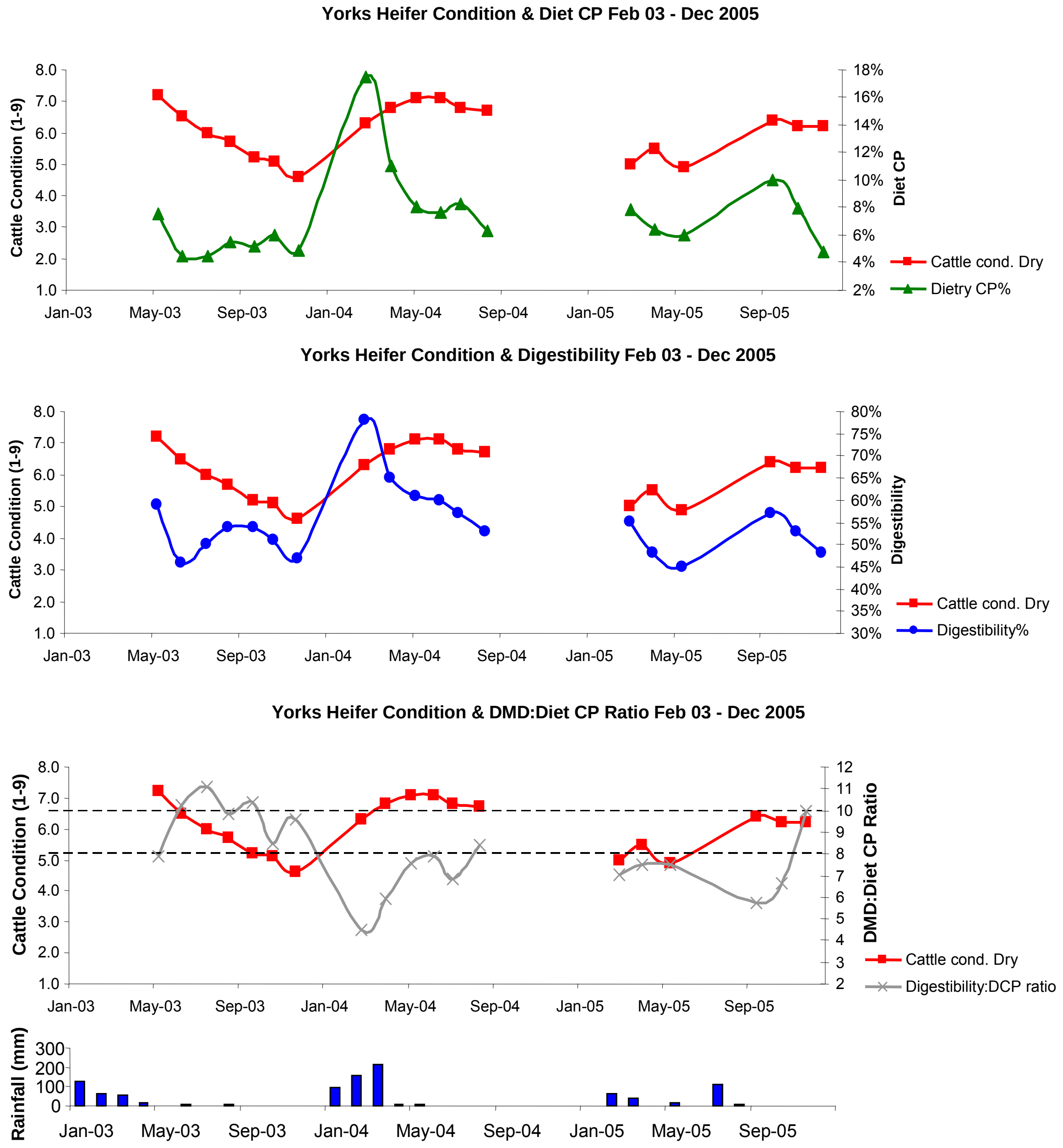


Figure 3. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a Mitchell, Roebourne Plains grass pasture January 2003 to December 2005 (Yorks)

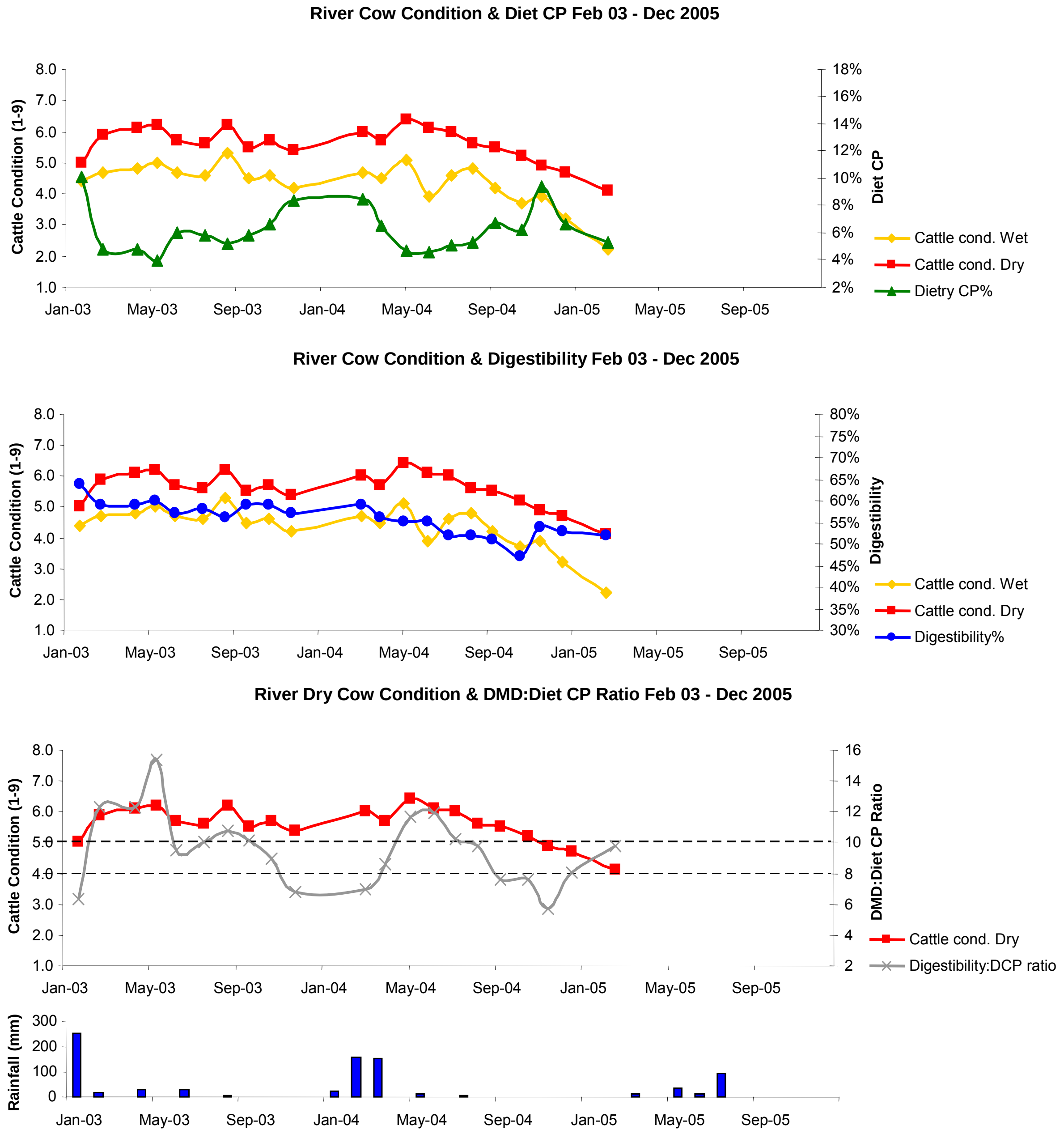


Figure 4. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a buffel grass pasture January 2003 to March 2005 (River)

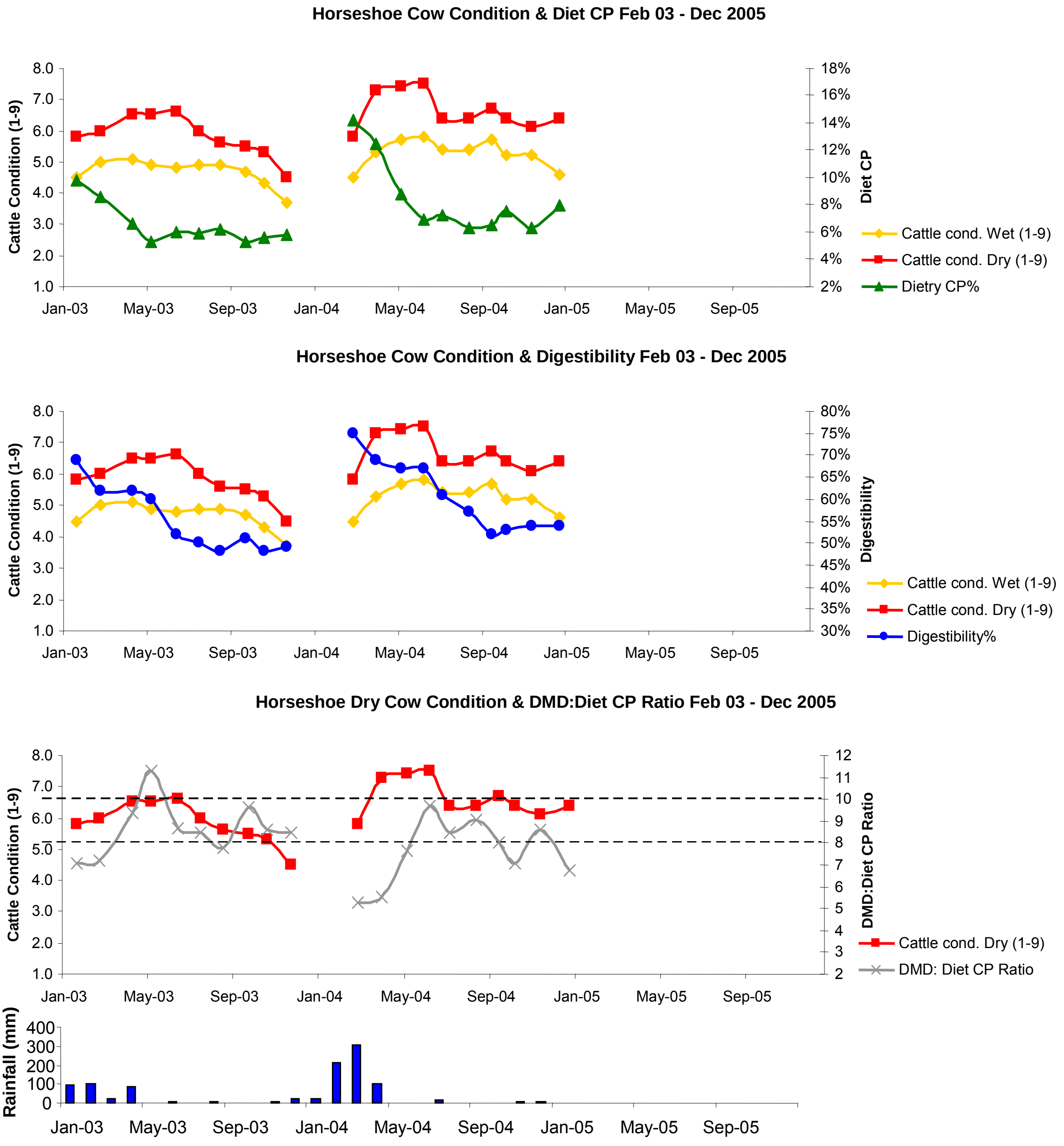


Figure 5. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a Buffel/Roebourne Plains grass pasture January 2003 to January 2005 (Horseshoe)

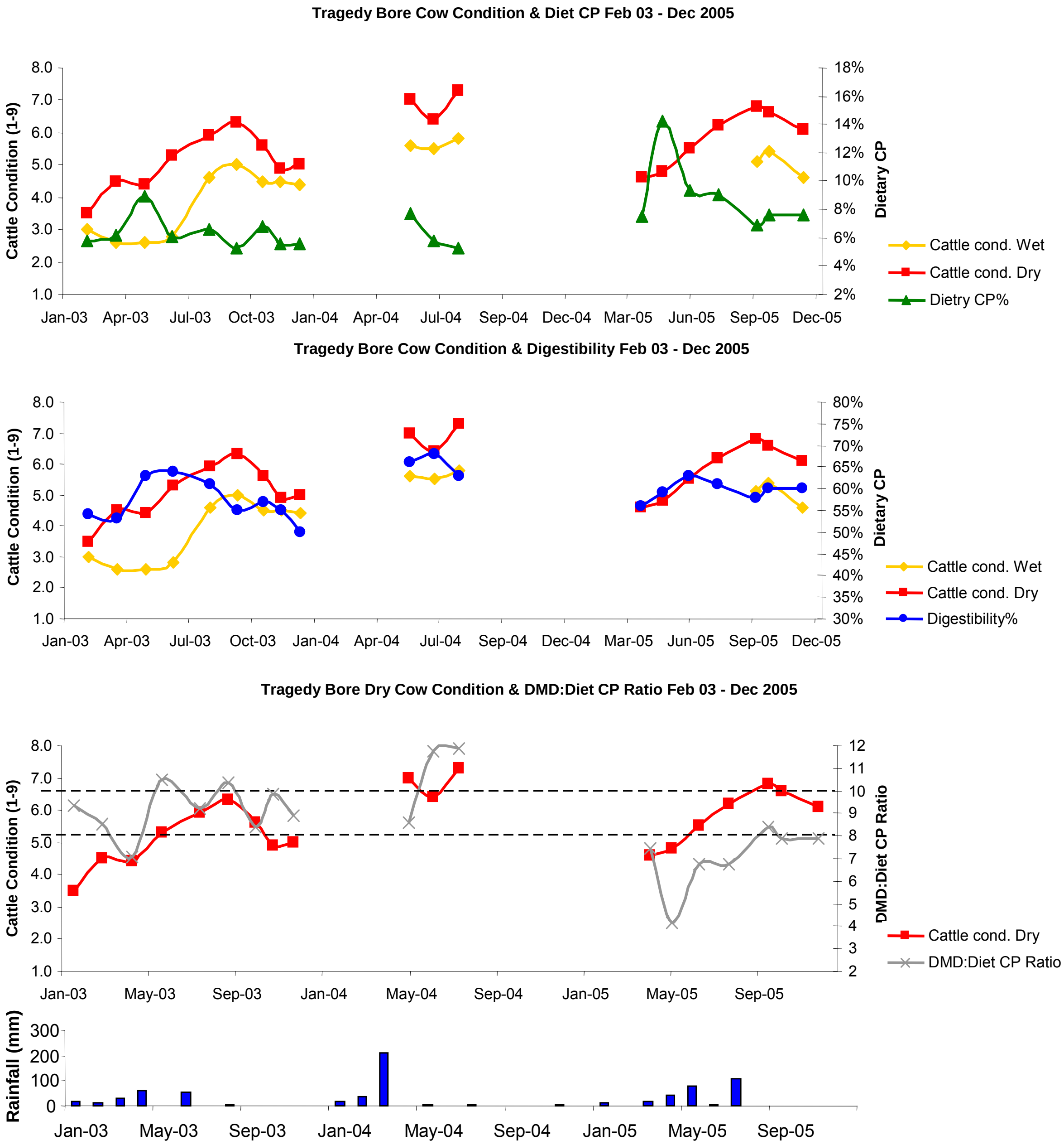


Figure 6. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a Ribbon grass, Buffel and Roebourne Plains grass pasture January 2003 to December 2005 (Tragedy Bore)

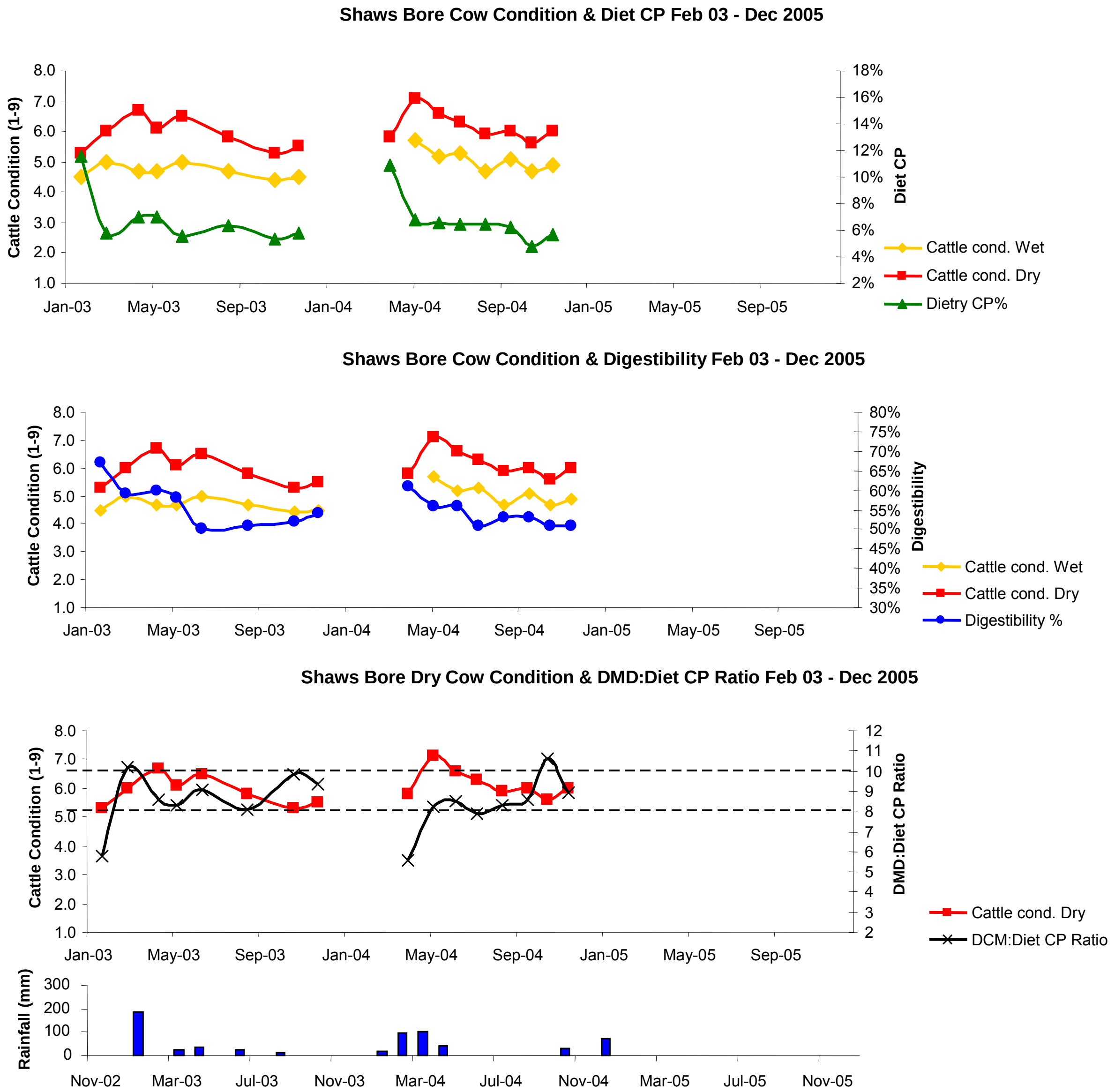


Figure 7. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a Buffel/Aristida grass and soft spinifex pasture January 2003 to December 2004 (Shaws Bore)

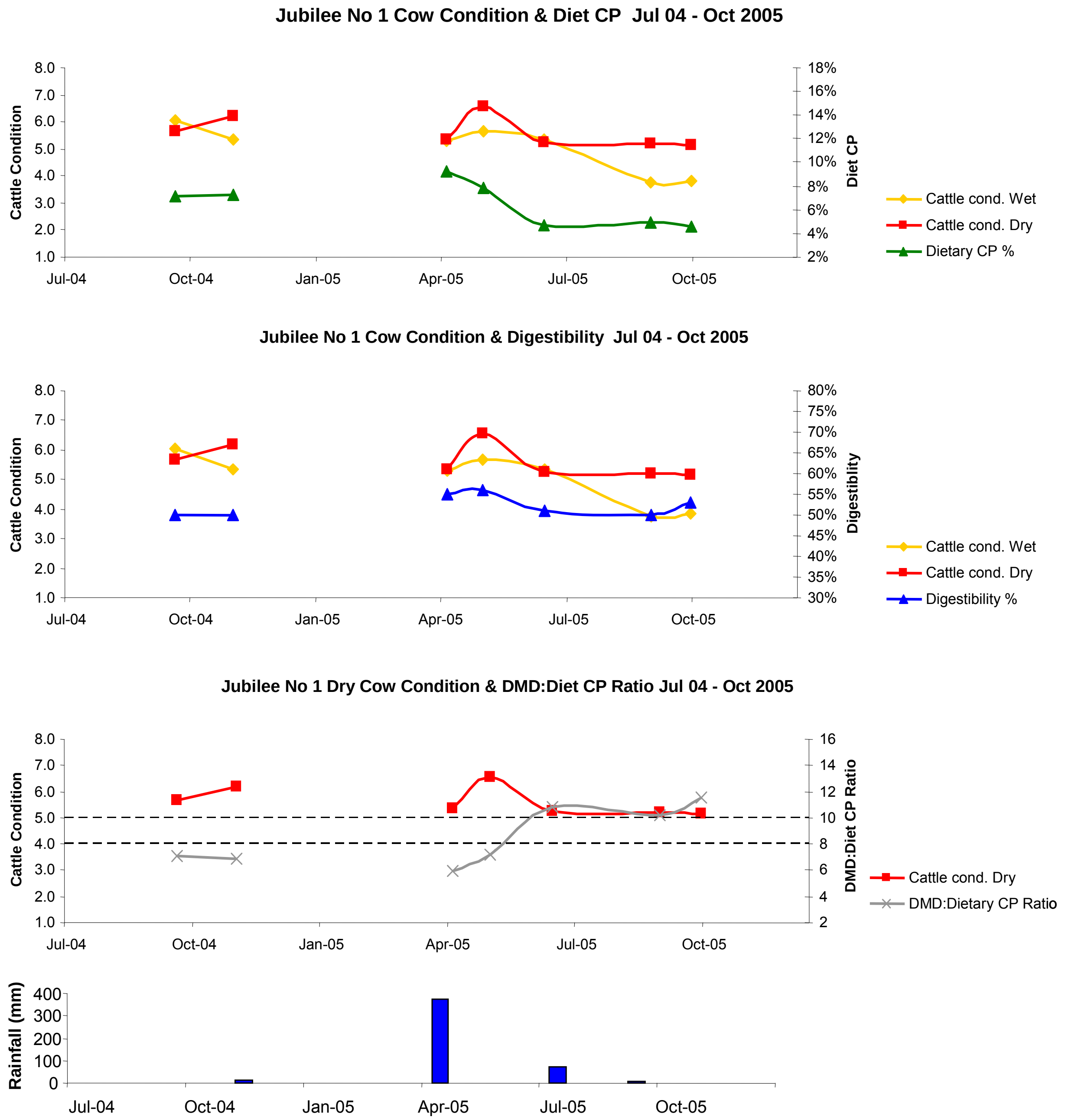


Figure 8. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a Kimberley Pindan land system pasture recorded from October 2004 to October 2005 (Pindan)

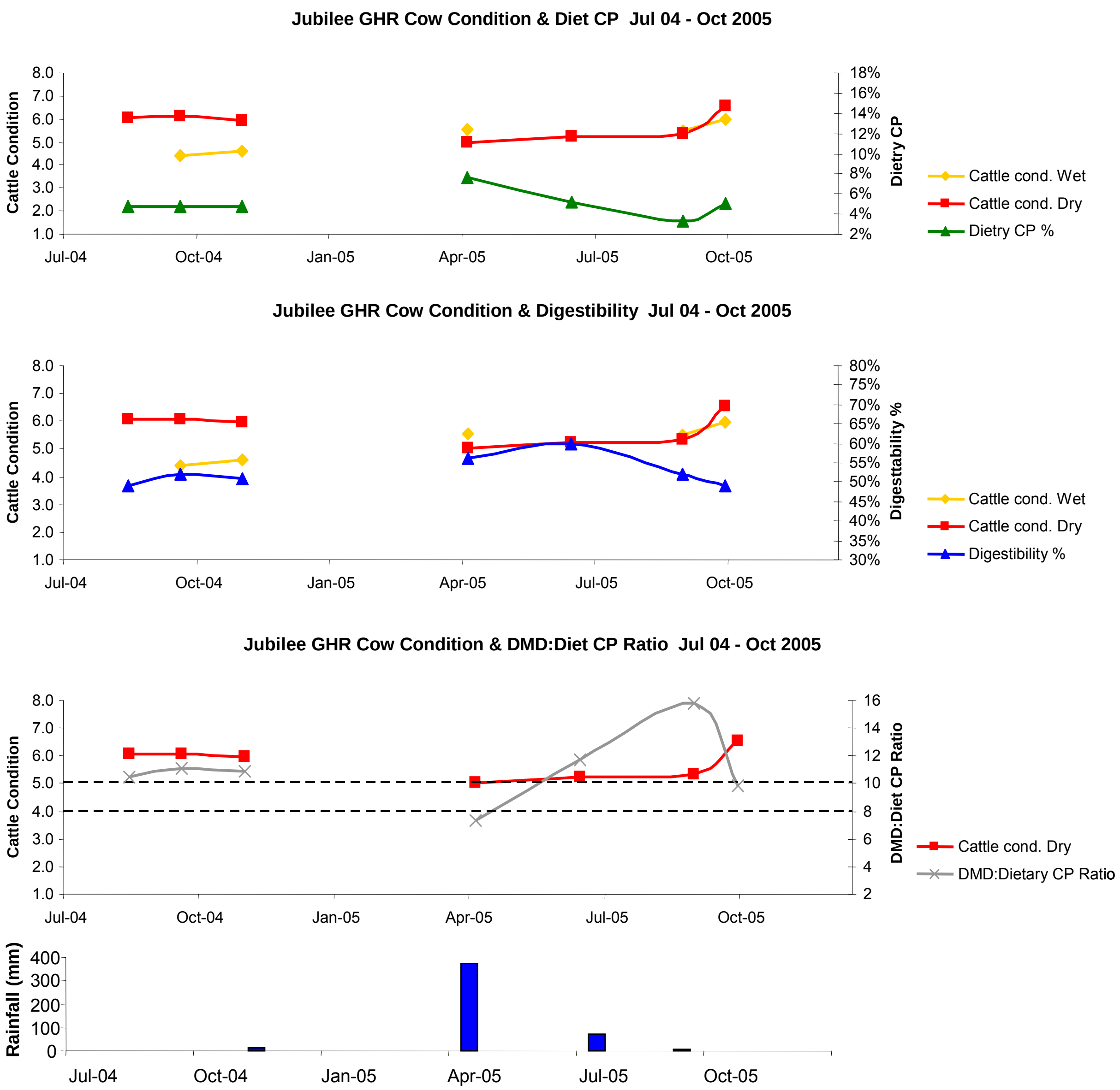


Figure 9. Cow condition (1-9 scale), digestibility, diet CP, DMD:Diet CP ratio and rainfall on a Kimberley river floodplain land system pasture recorded from September 2004 to October 2005 (Greenhide River)