# Final report

## Pardoo Beef Corporation Collaborative Innovation Program (Phase Two)

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# Abstract

This project sought to identify and address key production issues inherent in a northern Australian Wagyu beef production system incorporating pasture and crops from irrigated land. Robust data collected over 3 years, involving soils, pastures and crops, and cattle performance, enabled identification over time of improved practice in each area of management.

Key results included confidence in the sustainability of the irrigated agricultural production and the suitability of the Wagyu cattle genetics within the system. Benefits to the program and the wider northern beef industry included detailed information on pasture and crop inputs, monthly pasture growth rates, and cattle performance both grazing and in feedlot conditions. The costs of pasture, crop and beef production were identified, and practice modified in response.

Advantages of feedlot management were enhanced cattle growth rates not achievable under grazing tropical grass pastures and the ability to capture more efficiently nutrient inputs to the forage produced. In addition, enabling the practicable provision of shade to large numbers of growing cattle was seen as a significant production and welfare advantage.

The project has generated valuable information on a potential alternative production system and market for selected northern Australian beef production environments.

# Executive summary

## Background

The main question being asked in relation to this project was – can an underground water resource in the Pilbara of Western Australia be utilised for fodder production, supporting a rangeland Wagyu beef production system, sustainably and profitably?

The basis of this question was an ambition to identify and document such a system delivering high quality products to existing and alternative markets for the north-western beef industry. With troubling conditions arising with traditional live export markets over the course of the project, the identification of such markets became more pressing.

This project was preceded by a 3-year project (Bell 2020) which applied science and economics to an innovative and novel Pardoo Wagyu production program in the Pilbara region of Western Australia. This program was recognised as being truly innovative in its scale, location, feed-production base and marketing ambition. As such it had the potential to research, develop and demonstrate an alternative beef market for northern Australia. The initial Phase 1 project generated previously unavailable enterprise-level data and new knowledge around the viability of irrigated tropical fodder production and irrigated beef production systems in northern Australia.

This project continued and added to earlier research, including revising some earlier interim results.

The results of this research are a resource for key components of the Pardoo Wagyu production program and will apply to the wider northern Australian beef industry where related conditions exist.

## Objectives

The objectives of Phase 2 of this project were to build upon the foundation of Phase 1; maintaining focus on defining irrigated land capability in the Pilbara, the key differentiating agricultural resource around which a major research focus needed to remain. This would inform the Pardoo Wagyu production program and wider northern Australian beef production systems. Major areas of focus remained:

- Production system design (irrigated fodder optimisation, northern Australian feedlot operations).
- Environmental sustainability (soil, water and nutrient balance).
- Develop an innovation skills and resources plan to build capability to effectively implement the innovation strategies.
- Develop initiatives to support the cultural change required to deliver against innovation strategies.

Most of the objectives were achieved, in a timeframe considered small for agricultural and genetic activities; innovation is an ongoing process. Sufficiently robust data, physical and economic, was obtained to provide confidence in maintaining the program, implementing changes where indicated and provided a basis on which to continue innovation.

The last point, regarding achieving the cultural changes required to deliver, was a particular challenge in the face of rapid staff turnover associated with recurring skill deficiencies at all levels.

## Methodology

Over 3 years presence and connection on and off the pivot precinct was maintained. This was essential as staff changes were frequent and data needed to be personally collected and veracity confirmed.

Pursuing accurate data from pasture, crop and cattle activities provided the resource for the results and analyses forthcoming.

This was a commercial farming operation, not a research facility. Outcomes of all activities were documented and integrated with objective data recording and observations.

New program initiatives were carefully planned and implemented, building upon data analysis.

Analysis was attempted only where data was reasonably confirmed as accurate. The author has confidence in the results, that they reflected reality. Any conjecture, theoretical modelling or opinion is described as such.

## Results/key findings

Key findings of the project are grouped into the beef production components, being those identified as most significant for sustainable forage and livestock production in the environment.

High levels of dry matter production were sustained over at least 6 years whilst maintaining optimum plant nutrient levels with a constantly reviewed fertiliser program. Over time major nutrient levels were reduced as soil levels stabilised and irrigation was optimised. Beneficial nutrient attributes of the Wallal aquifer included potassium, sulphur, magnesium and boron plus sufficient neutralising carbonate to maintain favourable soil pH in association with high production.

There remained circumstantial evidence that for grazed (as opposed to mechanically harvested) pastures, significant amounts of potassium and nitrogen were unaccounted for. Potassium most likely was accumulating in soil. Volatilisation from urine patches and pasture litter was considered a major pathway of nitrogen loss. Apart from the recognised translocation by cattle excretion off the pastures the roles of leaching and particularly volatilisation of nitrogen requires quantifying.

Pasture growth rates, achievable in practice, under cattle grazing or pasture conservation as hay or silage were identified over 4 years of measurement.

Attention to grazing guidelines remained critical for pasture persistence and productivity. Utilising pasture growth rates, pasture quality and cattle growth rates, modelling indicated typical pasture utilisation was of the order of 50%, with up to 60% achievable with adherence to guidelines. For Wagyu cattle beef production of 1400 kg/ha was indicated.

Under grazing management, for Panic and Rhodes grass as the species available, a single species is recommended.

The average respective average daily gains (ADG) of Pure Bred Wagyu (PB) and Wagyu x Bos indicus cross (KB) growing cattle grazing separately were 0.52 and 0.72 kg/day, representing 0.24% and 0.25% of bodyweight. Values for cattle grazing together were 0.40 and 0.56 kg/day ADG and 0.17% and 0.20% of bodyweight. For PB cattle these growth rates were insufficient for replacement heifers to reach a targeted joining weight of 300kg in 14 to 15 months.

Using pasture production costs from 2020-2021, respective costs of liveweight gain (CoG) for PB and KB growing cattle were $3.95 and $3.08/kg.

Under demonstrably achievable management, gain was 10% higher and CoG, 10% lower.

Productive performance for PB cattle was documented in a feedlot environment in the Pilbara. Ration components included maize or grass silage, corn or barley, and lupin kernel meal. In the absence of shade, for programmed weaner backgrounding, average ADG was 0.98 kg/day, feed conversion rate (FCR) 6.1 and feed cost $2.89/kg gain ($3.54 including yardage).

Consideration and analysis of the major factors influencing irrigated forage and cattle production in the Pilbara environment gave confidence for investment in a feedlot facility. These factors were:

- To enable growth rates sufficient for a high proportion of replacement heifers to reach a joining weight of 300 kg at 13 to 15 months of age.
- To provide shade for large numbers of cattle, not practicable under grazing management, with recognised performance and welfare advantages.

For cropping, other than tropical grass, the only crop sufficiently evaluated was maize, for silage and grain. Early crops were superior associated with skilled management and prior to Fall armyworm (FAW) infestation. Achieved yields were 20 t/ha dry matter (DM) at a cost of $166/t, with good quality and a cost of 1.6 cents/MJ ME. Loss of managerial skill combined with increasing impact of FAW led to a pause in maize production. It was replaced by large scale production of tropical grass (Panic) silage during summer, recognising the summer growth potential of tropical grasses and the challenges of pasture management by grazing at that time. Although management oversight was not ideal, successive crops of high growth rate and yield were harvested and ensiled at an average cost of $240/t DM, to provide energy at between 2.5 and 3.0 cents/MJ ME.

Over two summer seasons a syndrome of diarrhoea and transient loss of production was observed in grazing young weaner cattle, accompanied by moderate but increasing faecal worm egg counts. Both Cooperia spp. and Haemonchus contortus were implicated. The syndrome was not typical of Cooperiosis and remained unresolved. PB cattle were more affected than KB.

## Benefits to industry

For the beef industry in northern Australia, significant practical information on forage production from irrigated tropical grasses in the Pilbara together with soil and fertiliser interactions was generated. Associated with this was the physical and economic performance of Wagyu and Wagyu cross cattle under grazing and feedlot management. This has relevance to beef production systems in related challenging northern Australian environments, particularly those seeking markets alternative to live export.

For the Pardoo Wagyu program, confidence to proceed with expansion and investment was enabled given the associated data and analyses produced.

## Future research and recommendations

Other than maize primarily for silage, crops other than tropical grass were not evaluated. The opportunity exists for a variety of crop rotations over the summer/winter seasons to exploit the resources of water and temperature more fruitfully. Potential crops as components of rotations might be winter cereals (barley, oats) and herbs (chicory, plantain) as well as tropical legumes such as Cavalcade (*Centrosema pascuorum*) and newer varieties of Sorghum.

Incorporating legumes into tropical grass pastures has been suggested as beneficial, but yet to be demonstrated in practice; this clearly would require research before investment in adoption.

Nitrogen loss particularly in grazed pastures is likely to be at the higher end of published estimates, given the environment of climate, soils and management aligning to favour volatilisation. Identification of this is recommended if grazing of tropical pastures becomes more common.

The ecology of gastrointestinal parasites and any associations with diarrhoea and production loss for young cattle grazing at high stocking rates on irrigated tropical pastures were not explained. The attributes of Wagyu cattle compared with other breeds in this regard is of interest.

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# 1. Background

## 1.1 Phase 1 2017/18 – 2019/20 Collaborative innovation project

This project was preceded by a 3-year project (P.PSH.0829) which applied science and economics to the innovative and novel Pardoo Wagyu production program in the Pilbara region of Western Australia. This was recognised as being truly innovative in its scale, location, feed production base and marketing ambition. As such it had the potential to research, develop and demonstrate an alternative beef market for northern Australia.

The project was deemed successful in generating previously unavailable enterprise level data and new knowledge around the viability of irrigated tropical fodder production and irrigated beef production systems in northern Australia. The opportunity was available to continue this approach with the same author, utilising and considerably improving early data collection systems and revising some early findings with further research. The foundation of the initial project was seen as extremely valuable as being a base from which to maintain ongoing data collection and research on some complex production areas at the time impeding progress.

## 1.2 Phase 2 2020/21 - 2022/23

The aim of Phase 2 was to focus on key areas affecting production and business success for the Wagyu production program in the Pilbara. These were identified in Phase 1 but remained to be fully identified, defined and resolved. Amongst other knowledge gaps the following were considered key to informing the Pardoo Wagyu program investment and potential related northern Australian beef production systems:

- The optimum combination of pasture utilisation by grazing or fodder production and feeding alone or in association with other ration ingredients, imported or home grown, remained an elusive subject. Cattle growth rates and factors affecting this and cost of production under these systems were not fully understood, particularly for grazing.
- Fodder crops other than pasture had been researched to only a minor degree and the opportunity arose to investigate further. Nutrient budgets indicated than forage production was significantly more efficient in preserving applied plant nutrients, seen as a critical issue.
- For grazing cattle issues included translocation of nutrients off the irrigated pastures, and both internal and external parasite management.
- The capacity to provide practically and economically for the necessary growth path from birth to steer exit/heifer joining weight in the associated rangeland/irrigated pasture resource became apparent during Phase 2 and a system proposed and evaluated.

The Pardoo Wagyu production program evolved over the 6 years of the Phase 1 and Phase 2 projects, encountering major obstacles including a devastating Category 5 cyclone, yet continued to pursue the goal of high-quality elite Wagyu beef production from a northern Australian landscape. Coincidentally the urgency to develop, evaluate and extend the physical and economic background of production systems aligned to alternative markets for the northern Australian beef industry has become significantly greater over this time, with additional threats to the live export market from a variety of external and internal factors.

# 2. Objectives

The key objectives of the program were to implement innovation strategies as identified, building upon, and adding to, the subject of the initial collaborative program (Bell 2020). The broad scope was to include initiatives in identified key business areas:

- Innovation resource planning and people management
- Production system design (irrigated fodder optimisation, northern Australian feedlot operations
- Genetic design optimisation designed from a northern Australian irrigation system
- Environmental sustainability
- Supply chain innovation

Within this suite of objectives, to:

- Develop baselines and measurement systems to monitor progress
- Develop an innovation skills and resources plan to build capability to effectively implement the innovation strategies
- Develop initiatives to support the cultural change required to deliver against innovation strategies

It was recognised that, at the core of the overarching Pardoo Wagyu production program, the irrigated land development in the Pilbara continued as the differentiating agricultural resource around which a major research focus needed to remain. A key target objective was to provide Pardoo and the wider northern Australian beef industry with rigorously obtained information – data, results, analysis and key benchmarks – in order that it could be applied to the sustainable and profitable production of high-quality beef in such environments, agricultural and economic.

# 3. Methodology

## 3.1 Activities

The author remained associated with the enterprise throughout the 3 years, maintaining personal connection on and off the pivot precinct and related agricultural and rangeland resources. Familiarity gained during the three years of the Phase 1 project was a great advantage for observing, recording, and interpreting results with an understanding of the context. Things were not always as seen, spoken, or written! Science and social skills were both valuable.

### 3.1.1 Planning and research

With experience gleaned During Phase 1, the author could contribute meaningfully to the program planning; however, within the rapidly expanding and changing enterprise the possibility of controlled research as such became unrealistic. Pursuing accurate data from pasture, crop and cattle activities (which in practice does not always go to plan) provided the resource for the results and analyses forthcoming.

### 3.1.2 Data recording

As discussed in Phase 1, comprehensive data recording was seen as vital to the novel project. A satisfactory system was not achieved then, and data recording was high on a list of priorities for Phase 2. In its absence and until a satisfactory system could be established, the author invested much time and effort pursuing many sources of data, frequently obscure, to obtain rigorous information on which to base meaningful analysis. This was maintained over the course of frequent staff changes, inevitably associated with change of data recording process.

### 3.1.3 Analysis

Analysis was attempted only where data was reasonably confirmed as accurate. The author has confidence in the results, that they reflected reality. Any conjecture, theoretical modelling or opinion is described as such.

# 4 Results

## 4.1 Soil, fertiliser and irrigation

### 4.1.1 Key messages

- Unaccounted-for potassium (K) and nitrogen (N) flows were identified under grazed pastures, for N circumstantially associated with volatilisation from pasture litter and urine patches. K surplus to plant uptake was most likely accumulating in soil. Recovery of these nutrients with mechanical harvesting was high.
- The Wallal aquifer water provided significant economic advantages with the essential plant nutrients K, sulphur (S), magnesium (Mg) and boron (B)), and also possessed advantageous neutralising properties with soluble lime sufficient to maintain satisfactory soil pH over 6 years of high biomass production.
- For grazed pastures fertiliser levels were reduced with ongoing soil and plant tests guided by an interim nutrient budget.

- Ongoing objective measurement of soil nutrient levels beyond the typically sampled 10cm depth is recommended to further inform nutrient flows and monitor any effects of the elements considerably surplus to plant uptake (S, Mg and B) supplied by the irrigation water.

### 4.1.2 Background

Fertiliser and water were the major inputs to the fodder production resource. The use of each of these initially was informed by some industry experience but research applied to the relatively unique Pardoo environment was minimal. A fertiliser response trial reported in Phase 1 (Bell 2020) provided a much sounder base on which to proceed after 2019, but after some years production it became evident that some changes were justified and that significant knowledge gaps existed. On occasions there appeared to be conflicting responses from all major nutrients, and phosphorus responses diminished as plant levels rose over time. This had been reported for Cockatoo sands under horticulture (Smolinski et al 2016). The 2019 trial recorded no response to potassium, understandable with the relatively high levels in uncleared soil (Smolinski et al 2016).

### 4.1.3 Fertiliser

During 2022, there arose some discussion regarding nutrient content of fertiliser. Correct and incorrect assumptions were made at the time. The outcome was a decrease in P and an increase in K content of the grass mix used.

A review of plant and soil test data from 2017 to 2023 provided some insight into the effects of fertiliser application over that time (Figure 1 to Figure 9). The 2023 figures were included but noted in the context that only 5 samples were obtained, and they followed 200 mm of cyclonic rain in April.

Plant P levels noticeably increased since 2017, and K levels remained similar, possibly marginally increasing (Figure 2). In the Pindan soils, P levels had likely built up to an adequate level from near zero, and K requirements had been met by the large store of K in virgin Pindan soil but needed to be maintained (Figure 7). The need to increase K level in plants was not supported by trial and commercial experience. Limited soil sampling up to 2 metres, although random, revealed the magnitude of soil K in native soil and if anything an increase over time.

**Table 1. Soil Colwell potassium levels (mg/kg) to 2 metres depth**

| Depth (m) | 2019 native soil | 2019 pivot 8 | 2019 pivot 7 | 2023 pivot 4 |
|---|---|---|---|---|
| 0-0.5 | 47 | 37 | 84 | 84 |
| 0.5-1.0 | 86 | 70 | 64 | 74 |
| 1.0-1.5 | | | | 93 |
| 1.5-2.0 | 66 | 37 | 52 | 63 |

The levels of S were noted with reference to the relatively high content in the water. Soil levels did increase (Fig. 9) but plant levels did not follow suit, if anything reducing to a minor degree (Fig. 3).

The maintenance of satisfactory soil pH was noted (Fig. 6). Minimal change in soil organic matter was apparent, in spite of continual high plant litter levels in most grazed pastures (Fig. 6). Litter levels of 5 t DM/ha were frequently recorded in the tropical pastures, a concern as a nitrogen sink (Robbins et al 1989).

**Figure 1: Grass nitrate-nitrogen and total nitrogen levels 2017-2023**

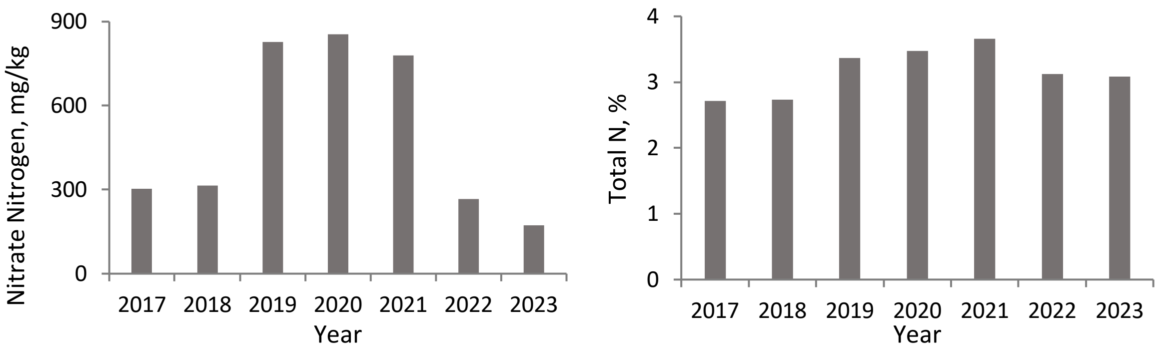



**Figure 2: Grass phosphorus and potassium levels 2017-2023**

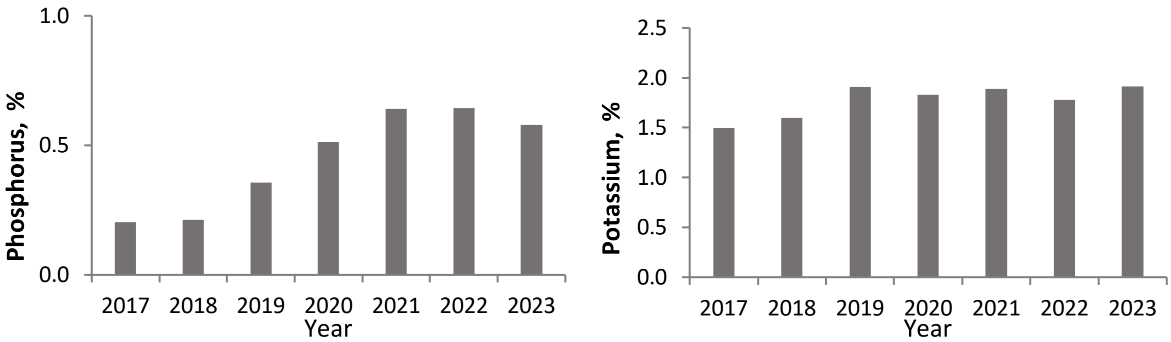



**Figure 3: Grass manganese and sulphur levels 2017-2023**

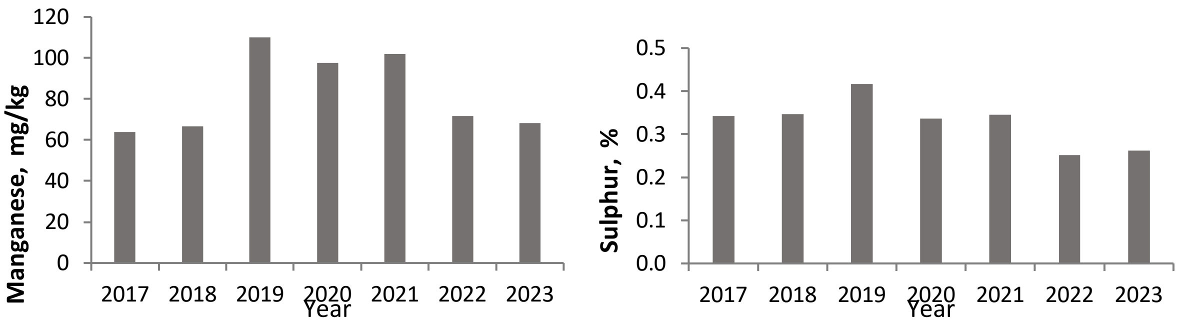


**Figure 4: Grass zinc and copper levels 2017-2023**

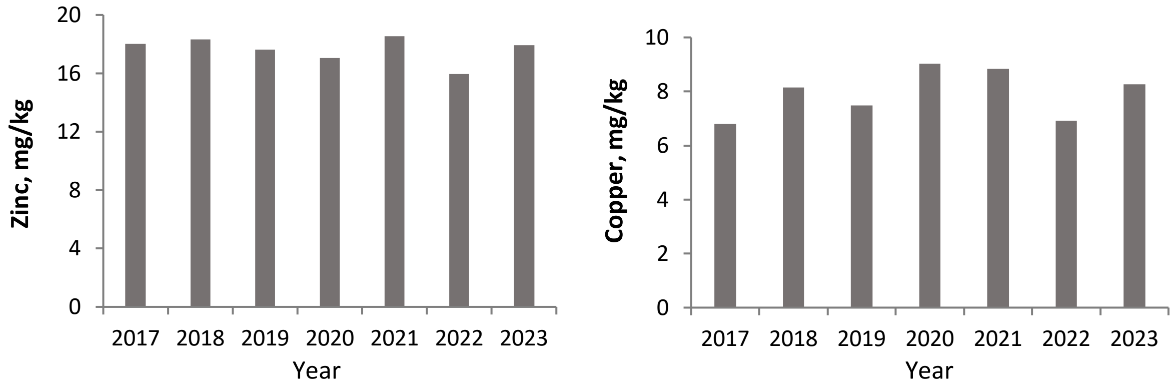



**Figure 5: Grass iron and boron levels 2017-2023**

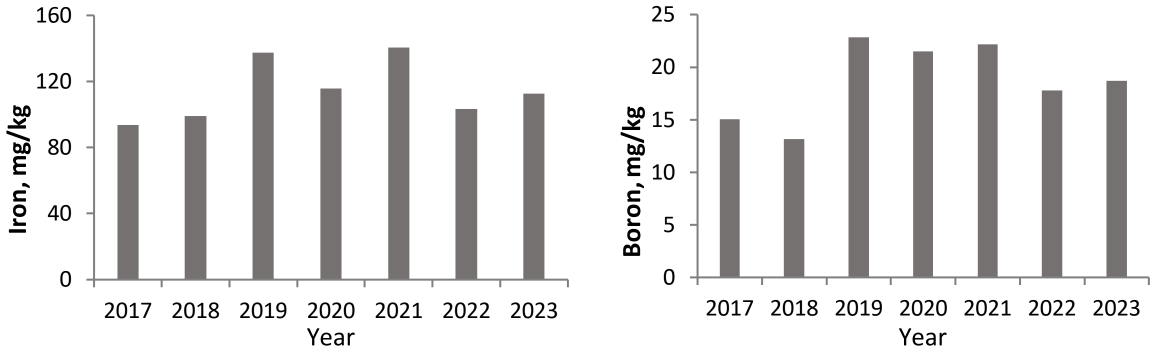



**Figure 6: Soil 0-10 cm pH and organic carbon levels 2017-2023**

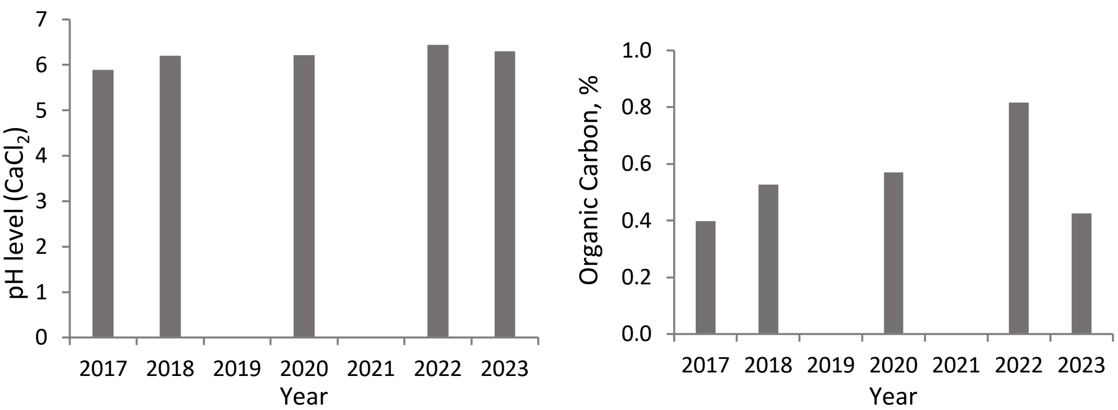


**Figure 7: Soil 0-10 cm phosphorus and potassium levels 2017-2023**

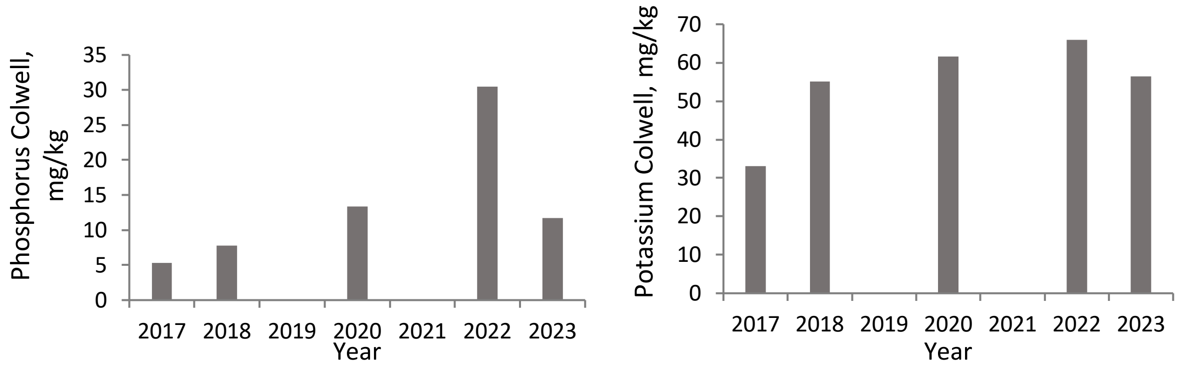



**Figure 8: Soil 0-10 cm copper and zinc levels 2017-2023**

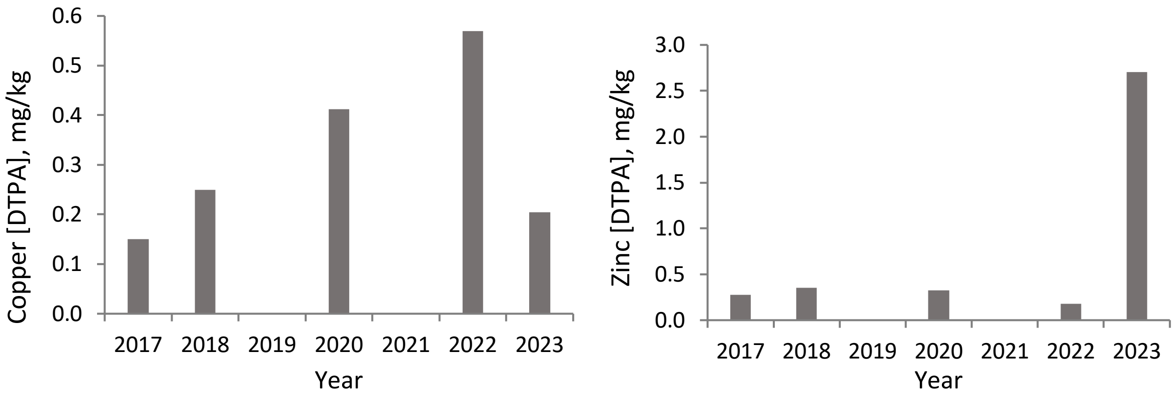
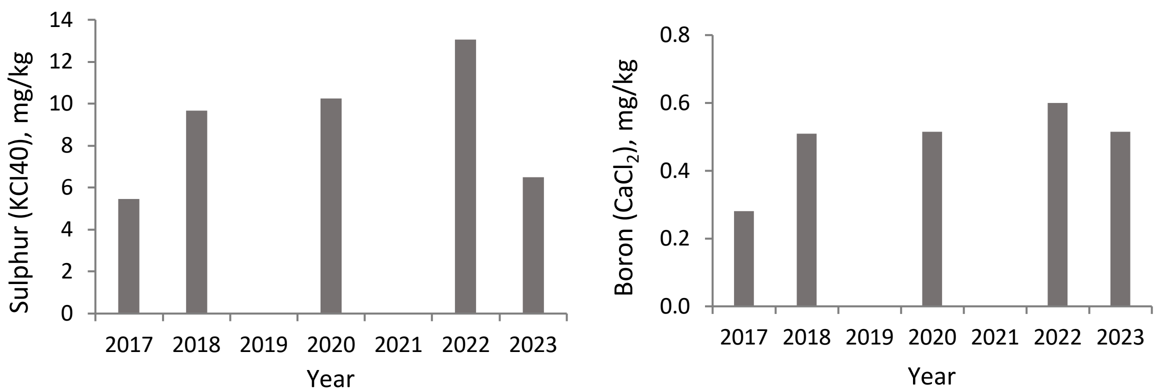



**Figure 9: Soil 0-10 cm sulphur and boron levels 2017-2023**




Based on a soil nutrient audit incorporating nutrient inputs and offtake, a revised fertiliser program for grazing was instituted and monitored. It considered history, evolving plant and soil levels, and pasture production from either grazing or conservation. As was demonstrated, grazed or harvested pastures had a significantly different fertiliser requirement. Nutrients surplus to calculated requirements were still applied until satisfactory responses could be confirmed and there was confidence in water management. Assumptions were made for nutrient loss, probably reasonably close but needing to be investigated if at all possible.

Nutrient supply was from the fertiliser applied and that available in the irrigation water (Appendix 0). Loss was from cattle camping for an estimated 50% of time off the grass, N volatilisation from urine patches, and potentially unknown amounts of K and N from leaching. Minor amounts were calculated to be removed as cattle liveweight (Appendix 2).

**Table 2. Fertiliser and water nutrient input – grazed pasture**

| Grazed pasture nutrient supply annual | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Nutrient content, % | | | | Annual supply kg/year | | |
| | N% | P% | K% | Daily fert usage, L or kg/d | N | P | K |
| Yara 26 | 26 | | | 8.0 | 759 | | |
| Grass mix | 4.2 | 8.7 | 30.7 | 2.4 | 37 | 76 | 267 |
| K in water 17 ML/year | | | 110 | | | | 110 |
| Total supplied | | | | | **796** | **76** | **377** |
| Application loss | | | | | **40** | **4** | **19** |
| Nutrients to pasture net | | | | | **756** | **72** | **358** |

For grazing, the application of 100 kg/ha of a granular product mix every 6 weeks and liquid fertiliser at a rate of 2 kg N/day was proposed to maintain adequate soil nutrient levels and promote optimum pasture growth whilst balancing supply and demand (this was significantly less than earlier practised; an apparent surplus of N and K remained, but caution was applied until plant growth rates responses could be confirmed). Plant growth rates and nutrient levels continued to be monitored. The budget (Table ) highlighted that with grazing management significant amounts of nitrogen and potassium were unaccounted for, for N the most likely explanation being volatilisation. K surplus to plant uptake very likely was accumulating in soil, difficult to identify with the significant level in native soils (Table1). With research into nutrient losses and with attention to irrigation it should be possible to further reduce fertiliser inputs.

**Table 3. Grazed pasture estimate of nutrient loss / annual removal.**

| Pasture | N | P | K |
|---|---|---|---|
| Nutrient % DM | 3.0 | 0.40 | 2.00 |
| Translocated | 315 | 42 | 210 |
| Excreta leached & volatilised | 83.2 | 3.5 | 10.4 |
| Livewt removal/year | 37.8 | 7.3 | 2.9 |
| Pasture leached & volatilised | 126 | 5.6 | 14 |
| **Total removal/loss/year** | **562** | **58** | **237** |
| **Nutrients supplied** | **756** | **72** | **358** |
| **Unaccounted for loss** | **194** | **14** | **121** |

For hay or silage management, 200kg grass mix/ha and 3kg N/ha/day per harvest at 4.0 t DM/ha was recommended. The applied nutrients were largely captured in the harvested forage (Table  and 5).

**Table 4. Fertiliser nutrient supply conserved pasture (36 days 4.0 t/ha yield).**

| | Nutrient content, % | | | | Nutrient supply/harvest | | |
|---|---|---|---|---|---|---|---|
| | N% | P% | K% | Daily fert usage, L or kg/d | N | P | K |
| Yara 26 | 26 | | | 11.0 | 103 | | |
| Grass mix | 4.2 | 8.7 | 30.7 | 5.6 | 8 | 17 | 61 |
| K in water | | | | | | | 11 |
| Total supplied | | | | | 111 | 17 | 72 |
| Application Loss | | | | | 6 | 1 | 4 |
| Nutrients to pasture net | | | | | 106 | 17 | 69 |

**Table 5. Conserved pasture estimate of nutrient loss/removal per harvest.**

| Pasture | N | P | K |
|---|---|---|---|
| Nutrient % DM | 2.5 | 0.35 | 1.75 |
| % removal | 100 | 100 | 100 |
| **Removal/harvest** | **100** | **14** | **70** |
| **Nutrients to pasture net** | **106** | **17** | **69** |
| **Unaccounted for loss** | **6** | **3** | **-1** |

### 4.1.4 Soil major nutrient monitor 2022

In conjunction with soil salinity samples collected in early 2022 for environmental compliance, the opportunity was taken to monitor pH, N, P, K, and S.

Four pivots were represented, each sampled at two sites on the irrigated pasture – inner half and about mid radius, and an “outer” sample from bare ground outside but relatively close to the irrigated area.

The results for each of the soil attributes were averaged, and compared thus (Table 6):

1. Bare ground compared with irrigated pastures fertilised since November 2018.
2. 0-10 cm compared with 10-30 cm depth.

**Table 6. 2022 Pivot samples for environmental compliance.**

1. Average Outer values compared with the all the others combined (half and inner).

| | pH ($CaCl_2$) | P mg/kg | K mg/kg | S mg/kg | N- NO3 mg/kg |
|---|---|---|---|---|---|
| Outer | 7.2 | 15 | 311 | 6 | 28 |
| Pasture half and inner | 6.7 | 23 | 73 | 12 | 29 |

2. 0-10 compared with 10-30 values, for outer and other pasture values combined (half and inner).

| | pH | P | K | S | N- NO3 |
|---|---|---|---|---|---|
| **Outer** | **7.2** | **15** | **311** | **6** | **28** |
| 0-10 cm | 7.0 | 17 | 355 | 7 | 34 |
| 10-30 cm | 7.3 | 13 | 267 | 6 | 21 |
| **Pasture half and inner** | **6.7** | **23** | **73** | **12** | **29** |
| 0-10 cm | 6.5 | 35 | 72 | 14 | 44 |
| 10-30 cm | 6.9 | 12 | 75 | 10 | 15 |

### 4.1.5 Observations

**pH**: There was evidence that pH had declined to a very small degree after 4 years of intensive production. This was good news and confirmed the extremely beneficial effect of the Calcium carbonate in the Wallal aquifer water.

**Phosphorus**: Under irrigated pastures, there was a high level in the 0-10 cm layer, reducing substantially in the 10-30 cm depth sample. For bare soils, the levels in both soil horizons were similar and lower than in the 10-30 cm horizons of the pastured areas. This would reflect an inevitable peripheral throw of granular fertiliser (P and K) marginally beyond the irrigated area supporting pastures. A build up without use by plants except in the wet season was not unexpected.

(P levels in virgin pindan are usually <2 mg/kg. 23 mg/kg were observed under the high producing pastures).

**Potassium**: Good levels were observed on pastures, similar in both horizons. Very high levels in both horizons under bare ground, reflecting (as for P) a build up over time on unutilised K from granular fertiliser. This would be in addition to significant K levels in virgin Pindan, and possibly occasional throw from the irrigation water.

(K levels in virgin Pindan soils are typically 40-60 mg/kg; 73 mg/kg under high producing pastures).

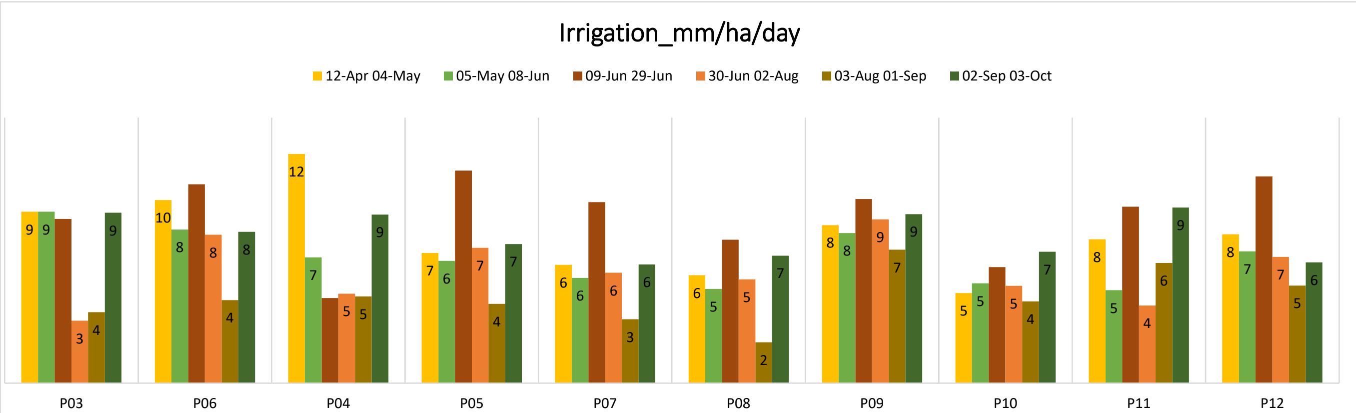
### 4.1.6 Irrigation

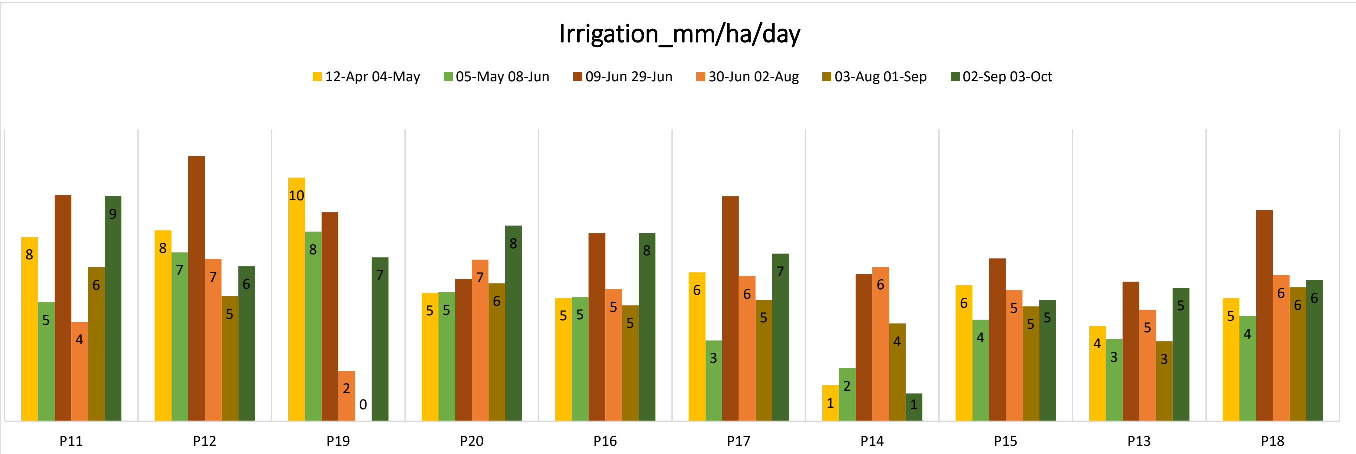
For irrigation, the extreme climate tested the capacity to maintain precise water application and monitoring failed to be sufficiently accurate to detect aberrations. Identifying this and restoring rigour into the process became an ongoing activity.

Despite specialist management at stages, variations from aspired to irrigation, most often overwatering, were observed. Underwatering was more easily perceived for example by pasture wilting, but excessive application was clearly a greater risk and documented not infrequently. This was highlighted when a nutrient audit of grazed pastures indicated unaccounted-for soluble nutrient losses. Although unresolved, the most likely losses included leaching beyond plant root growth.

Concern over water usage and irrigation led to more intensive monitoring of pivot bore flowmeters and documentation of water application each month. This revealed quite haphazard irrigation exemplified in (Figure 10) in spite of a planned program. It highlighted the strict attention required to manage irrigation in a sub-tropical environment, particularly associated with soils of minimal water-holding capacity (estimated to be about 50 to 80 mm/metre, (30 to 50 mm readily available water) in the Cockatoo sands.

**Figure 10 : Historical analysis of irregular water application with potential for water loss and nutrient leaching.**




## 4.2 Pastures

### 4.2.1 Key messages

- Pasture growth rates (PGR), achievable in practice, under cattle grazing or pasture conservation as hay or silage were identified over 4 years of measurement.
- Under grazing management, a single grass species is recommended.
- Attention to grazing guidelines is recommended for pasture persistence and productivity.
- Rhodes grass and Panic were highly resilient under extremes of management.

### 4.2.2 Pasture costs

Pasture costs (Table 7) were analysed as a basis from which to calculate beef cost of production, and also to calculate fodder costs.

Costs were sourced from company actuals aligned as much as possible with active pivot irrigated pasture areas. Costs were allocated as fertiliser, labour, variable running and maintenance, and depreciation. A rounded figure relating to average annual costs 2019-2021 was utilised, $5000/ha or $13.70/ha/day.

Costs were allocated in several appropriate categories common in farm management accounting. These were tailored to the inputs identified as of major significance for pivot-irrigated pasture:

- Fertiliser
- Labour
- Variable equipment running and maintenance
- Depreciation

Capital and interest costs were not included.

Fertiliser application frequency and rates were obtained from farm records. Over the period 2019 – 2021 these fluctuated around aspirational targets, and from late 2020 to early 2021 irrigation and fertilising of some pivots was discontinued. The costs varied to some degree but did not have a major impact on the figures used. Similarly, labour units and cost varied significantly throughout the year, but relationship between labour requirements and pivot numbers and activity were noted.

For depreciation, a figure of 10% was applied to vehicles, machinery and equipment, and 5% for pivot infrastructure.

**Table 7. Indicative irrigated pasture production costs 2020-2021**

| Input | Basis | Cost/year $ | Cost $/ha/day |
|---|---|---|---|
| Fertiliser (freight included) | N<br>P,K<br>TOTAL Fertiliser cost | 1400<br>1050<br>2450 | 6.74 |
| Labour | Payroll plus accommodation allowance, staff numbers linked to common pivot activity, constantly varying but consistency noted.<br>Approximately 1 FTE/2 pivots | 1060 | 2.90 |
| R&M, variable running costs | | 910 | 2.50 |
| Depreciation | | 580 | 1.60 |
| | TOTAL COSTS (rounded) | 5000 | $13.70 |

Three reviews of costs were made during the period 2019 – 2021 and essentially confirmed the assumptions used. Costs were observed to understandably increase, particularly from late 2021 to mid-2022 (mainly due to a substantial increase in fertiliser cost). In addition, maintenance and running costs increased by an inordinate amount in 2022, identified with extraordinary factors and not expected to be maintained. Fertiliser costs were contained by a nutrient budget review and reduction of nutrients in line with attention to irrigation amounts and timing.

### 4.2.3 Pasture growth rates

Knowledge of seasonal pasture growth rates (PGR) at Pardoo on irrigated pastures was essential to successfully manage pastures by grazing or mechanical conservation.

Clearly PGR was influenced by any or all of season, fertiliser and water application, stage of growth, grass species, disease, not to mention grazing management. PGR as documented in this report was discerned as applying to pasture of satisfactory plant density and ground cover, and more representative of Panic – either Gatton Panic or the *Megamax* variety. It also assumed adequate soil nutrient and water status. At any stage not all of these in practice could ever be classed as ideal but considered realistic and achievable over time for an irrigated grazing or forage production. In controlled plot trials PGR could exceed the results here and (for example) inform nutrient response curves; in practice, nutrient application was informed by earlier such trials at Pardoo and a range of industry experience.

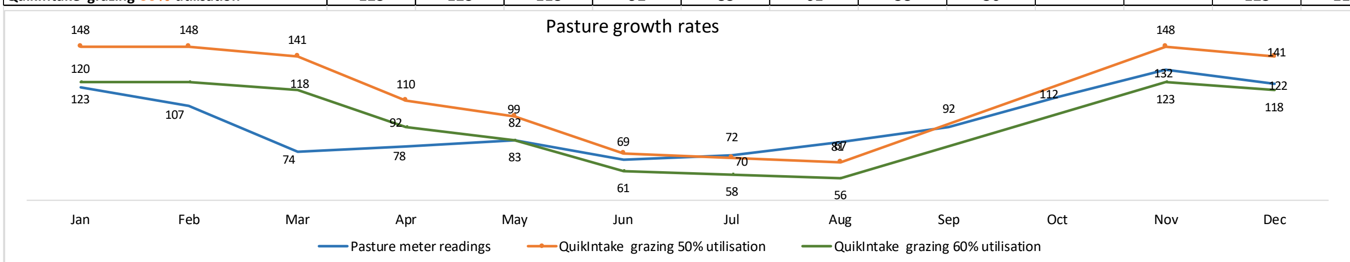
Over the time of the project PGR was assessed primarily by reference to plate meter readings over 2 years on generally well grazed pastures, verified to a degree by back calculation of cattle intakes from QuikIntake (Fig. 11). Measurement of production associated with hay or silage yields provided support for the annual growth curve at the same time providing information for forage budgets (Fig. 12). Opportunistic quadrat cuts provided further information to build confidence in the monthly figures used.

Growing degree days for Rhodes grass (base temperature 12$^{o}$) were calculated using weather data from the Pardoo weather station 2020-2023 and supported the annual curve data (Figure 13).

Measurements and estimates under grazing were summarised in Figure 14. Pastures were well fertilised and under reasonable grazing management; plate meter estimates lined up with 50 to 60% pasture utilisation (Quikintake predictions).

**Figure 11 : Estimates of pasture growth rates from plate meter and grazing cattle intake calculations.**

| Basis | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pasture meter readings** | 120 | 107 | 74 | 78 | 82 | 69 | 72 | 81 | 92 | 112 | 132 | 122 |
| **QuikIntake grazing 50% utilisation** | 148 | 148 | 141 | 110 | 99 | 73 | 70 | 67 | | | 148 | 141 |
| **QuikIntake grazing 60% utilisation** | 123 | 123 | 118 | 92 | 83 | 61 | 58 | 56 | | | 123 | 118 |




Pasture yield and growth rates under hay and silage management were also variable depending on history and management (as was growth rate under grazing management) but typically were 20% greater (Table ). The extra pasture mass was associated with a higher stem proportion and less leaf and therefore quality. As a guide, grazed pastures would regrow to FOO biomass of 2000-2500 kg/ha, hay and silage harvest targeted at 3500-4000 kg/ha (4 to 4.5 t/ha of hay).

**Figure 12 : Pardoo hay production monthly pasture growth rates.**

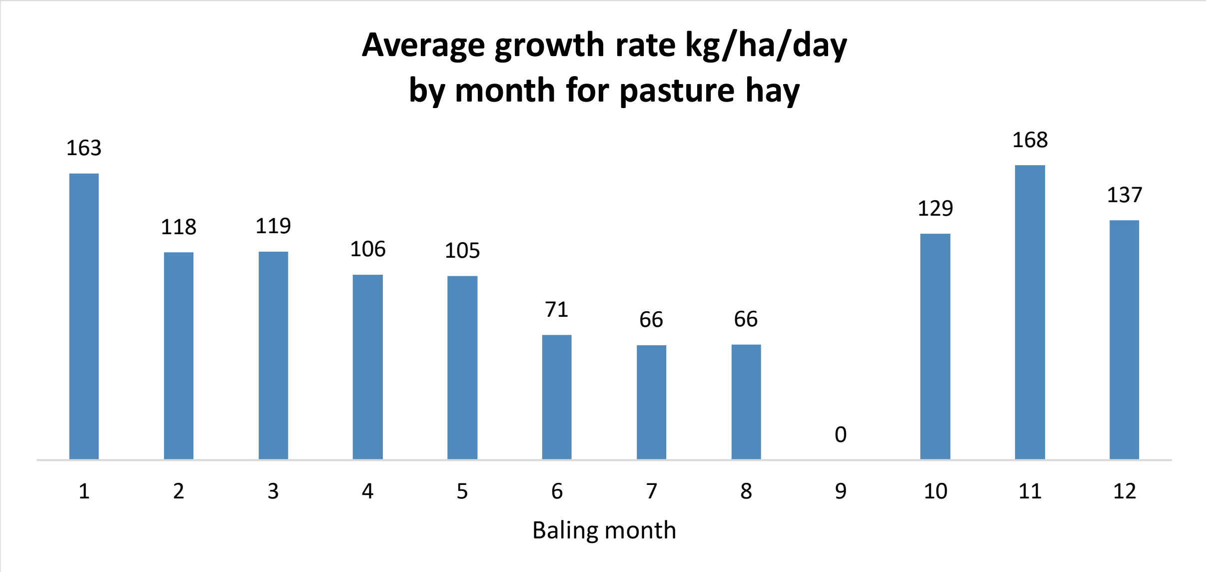
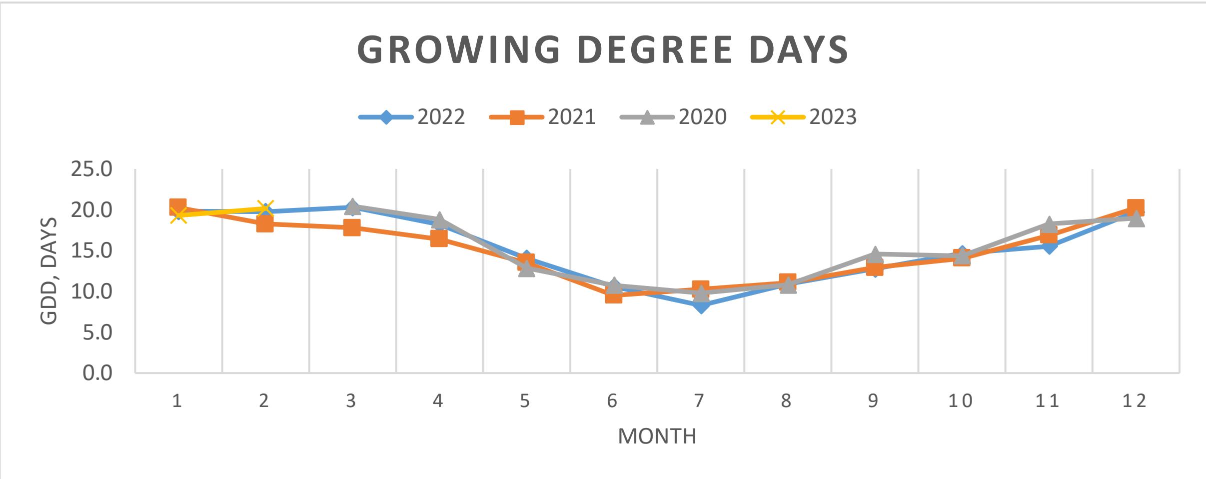



**Figure 13 : Growing degree days for Rhodes grass 2020 – 2023 Pardoo.**

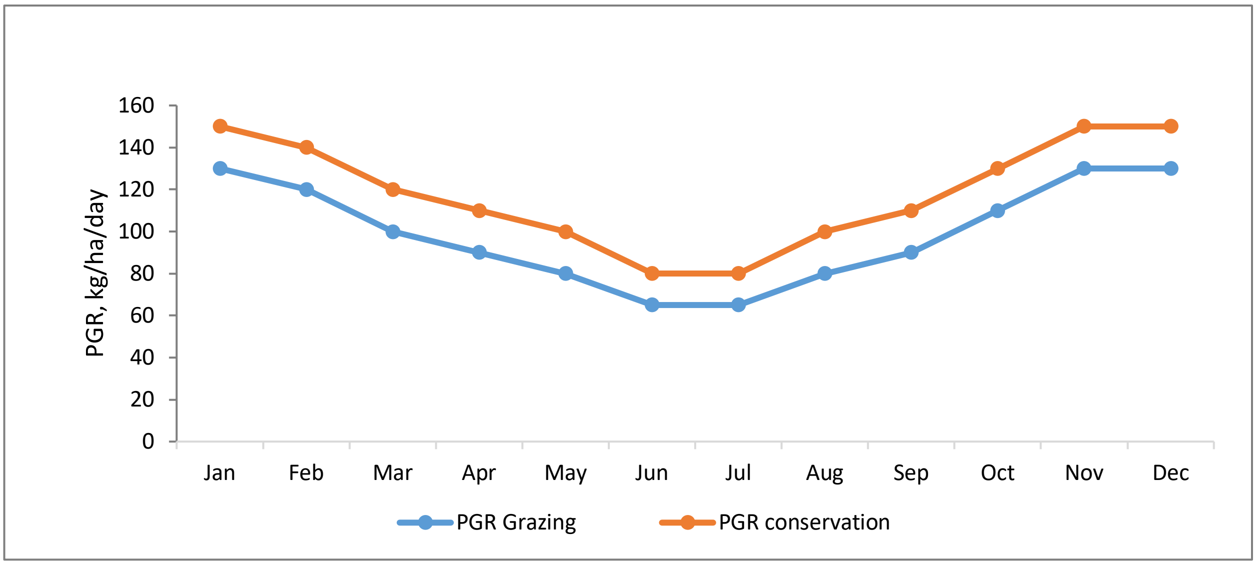



Based on a consensus of this data monthly growth rates used as a guide are shown in Table  and Figure 14. These growth rates were the basis of annual growth estimates and an essential component of pasture budgeting and pasture utilisation.

**Table 8. Pasture growth rates (kg/ha/day) estimated under grazing and conservation management**

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PGR grazing | 130 | 120 | 100 | 90 | 80 | 65 | 65 | 80 | 90 | 110 | 130 | 130 |
| PGR conservation | 150 | 140 | 120 | 110 | 100 | 80 | 80 | 100 | 110 | 130 | 150 | 150 |

**Figure 14 : Pasture growth rates under grazing and conservation.**




### 4.2.4 Pasture species and management

Over the 3 years 2020 – 2023, pasture quality and quantity deteriorated, largely because of lack of attention to grazing management, in association with seasonal Rhodes grass loss from fungal root disease. Despite well-established grazing guidelines under- and over-grazing was documented (Figure 15) with persisting unfortunate consequences. Cattle performance obviously suffered the same fate.

**Figure 15 : Examples of (L) sequential delayed exit and over-grazing and (R) delayed entry with trampling of poor-quality pastures.**

Largely due to fungal root disease, selective loss of Rhodes grass in mixed pastures continued each year from February until April or May. Sudden death seemed to take place with poor plant recovery, the affected area recovering only slowly. Even mature and established Rhodes grass plants could always be easily uprooted from these areas, indicating poor root health.

Panic was unaffected, and over time replaced the Rhodes grass. The disadvantage of this was that Panic colonisation of the area was by new seedling germination, not favoured under grazing management. The lesions and death of the Rhodes grass plants and stolons were diagnosed as caused by the fungal pathogen *Drechslera. Fusarium* was also present, considered a commensal organism feeding on the dead roots. It was presumed that an accumulation of dead material and excessive litter provided an environment favouring fungal growth, as was a consequence of poor grazing management. An observation was that the ongoing effects did not seem as severe in monocultures of Rhodes grass, recovery being more complete and stolon recolonisation of denuded areas restoring production.

The selective nature of the disease over time created difficulties in grazing management, as with the weakening of Rhodes grass, at the pasture growth stage favourable for grazing (as indicated by Panic grass), the Rhodes grass component was at an earlier stage of growth compared with Panic, and therefore selectively grazed and further setback.

To restore pasture balance, two cycles of mowing for conservation as hay or silage over summer were required.

With regard to tropical pasture composition comprising grasses, it became clear that mixtures of two grasses such as Panic and Rhodes grass could not be recommended, particularly where utilisation was by grazing. Rhodes grass well managed was very productive even though slightly less digestible than Panic (Table 9). Stoloniferous growth aided pasture density in cases of plant loss, quickly restoring pasture density. Gatton Panic sown at high seeding rate and well managed likewise retained high performance with higher nutritional qualities. For both, timely management of harvest interval related to plant stage of growth was the key. With a mixture, for much of the year ideal stage of growth at entry time for each of these grasses could differ, and as has been emphasised, one or two days longer than ideal could have profound and long-lasting impacts on pasture quality, quantity, and sustainability of the pasture.

| | CP % | ADF% | NDF% | DDM% | ME MJ/kg |
|---|---|---|---|---|---|
| Typical (range) | 13 (8 – 23) | 31 (21 –33) | 65 (50 – 70) | 58 (56 – 63) | 8.3 (7.9-9.1) |

**Table 9. A summary of Rhodes grass and Panic feed quality analyses 2018-2022**

Quality was influenced mostly by stage of growth and proportion of leaf for both species. Hence the necessity to follow grazing guidelines for optimum cattle performance. Test results should be carried out by the same source to avoid variability between testing houses as reported in Bell (2020). Comparisons between results from different laboratories should be viewed with caution. Sample management is critical to obtaining sufficiently reliable analysis. For example, uniform sample and random gathering, recording species/growth stage/proportion of plant, and care of samples after collection recognising the deleterious effect of heat on sample quality.

In pastures with both grasses at similar growth stages, Panic was preferred and selectively grazed. However, in association with the root disease affecting Rhodes grass in mixed swards, the palatable and attractive new growth of recovering Rhodes grass was selectively grazed by cattle at each grazing cycle, significantly impacting pasture productivity.

Until the Rhodes grass was all gone and replaced slowly by Panic, pasture density was reduced. The impact was in cases severe in its effect on fodder production and carrying capacity (Figure 16).

Despite these deleterious issues, two cycles of conservation followed by attention to grazing guidelines restored pasture health and performance. The resilience of the grasses was demonstrated by rapid recoveries after a severe locust plague in 2018, severe over- or under-grazing and numerous instances of water absence for up to 6 months.

**Figure 16 : Severe Rhodes grass loss, areas of pivot 6 (L) and pivot 10 cell 1 (R) March 2022.**

## 4.2.5 Grazing irrigated tropical pastures on Pardoo pivots

The grazing guidelines developed over time were a compromise between recognised ideal management and the reality at the time of facilities, infrastructure and staff resources.

It was emphasised that all points were considered equally important to maintain sustainable pasture and cattle performance.

### 4.2.5.1 Grazing guidelines

1. Estimate total area required for each cattle mob. (See Pardoo grazing management model)
    a. Using cattle number and cattle weights, estimate daily intake of pasture (kg/head Dry Matter, DM) as cattle number x weight x 2.2% (PB) or 2.4% (KB).
    b. Double this as presuming 50% utilisation.
    c. From best estimates of monthly pasture growth (kg/ha), calculate area needed (ha).

2. Estimate a suitable cell area for the cattle involved – pasture needed for 2 days.
    - (a + b) above, x 2 days, divided by (entry FOO – exit FOO).
    - Grazing period may be altered over the range 1 to 3 days to accommodate cell area changes.

3. Plan an ongoing grazing rotation taking account of pasture growth rate.

An example for Pardoo:

1. Introduce cattle at the amount of pasture (Feed on Offer kg/ha DM, FOO) best suited to both cattle and pasture growth. This stage is identified by any of:
    a. 2000 – 2500 kg/ha dry matter FOO, above the stem layer, as estimated visibly after eye calibration. Boundaries 1500 to 3000 kg/ha FOO. Pastures

with FOO greater than 3000 should not be grazed but mechanically harvested.

   b. Pasture meter readings.
   c. The 3½ - 4-leaf stage of the plant. Boundaries 3 to 5 leaf stage. Pasture with leaf stage greater than this must not be grazed but mechanically harvested.
   d. (Height is not a good indicator, 20 to 30 cm would be a target range.)

2. Remove cattle to leave a minimum residue of pasture, above the stem layer, for rapid regrowth, identified by
   a. 500 kg/ha dry matter FOO.
   b. A minimum of 3 to 5 cm of green pasture
   c. This does not apply to dung patch areas. They should be only lightly grazed.

3. Grazing period 2 days or less, a maximum of 3 days.

4. If dung patch areas or excessive stem residues more than 20%, mulch the day after cattle removed.

5. Observe and record FOO at least two planned cells ahead of current area being grazed.

6. Management of developing variations in entry FOO
   - Vary grazing time around the optimum 2 days, by no more than I day. Think in half day, or grazing sessions.
   - Silage or hay supplementation within that day if grazing period being extended by a day.
   - Add extra cell(s).
   - Harvest cell(s) for hay or silage.

Comments

The guidelines were essentially those applying universally to efficient utilisation of pastures. For the tropical grasses Rhodes grass and Panic, it was identified that FOO boundaries or leaf stages of 2000 to 2500 kg/ha DM or at the 3 to 4-leaf stage were close to meeting the criteria. Variations outside of these boundaries (if inevitable) were far better at the early rather than late stage; as described the latter typically had destructive consequences for the pasture and poorer cattle and economic outcomes. Daily rotations would be preferred but the scale of the enterprise made this generally hard to achieve in practice. The quicker the pasture allocation was eaten the better the performance of pasture and cattle.

Grazing at an earlier stage had few disadvantages (marginally lower growth rate and extra labour) but the advantages were better utilisation, higher pasture digestibility, and less pasture treading and manure fouling damage.

Entry at FOO levels above 2500 kg/ha resulted in higher stem proportions with selective rejection and lower utilisation. Manure fouling and treading damage progressively exacerbated pasture damage and rejection. The requirement to mechanically reset (mowing to remove stem and rejected pasture) pasture was increased and if not done pasture quality deteriorated. Minor amounts of stem and rejected pasture could by mulched and returned to the land but excessive uneaten pasture needed to be removed, an inefficient operation.

Where maintenance or restricted feeding of cattle is required grazing of intensively-managed tropical pastures is not possible in practice without pasture damage. Cattle can be restricted by severely overgrazing pastures, grazing either a mature stand with a high proportion of stem, or a pasture of low FOO where both cattle bite size and pasture growth rate are restricted with clear damage to pastures.

Where cattle maintenance is required for management purposes, (eg AI programs, muster, sale) conserved forage is far more practical and economic. Pastures can be managed sustainably and economically for conservation as hay or silage, to be supplied as appropriate.

In the case of overgrazing with low FOO, utilisation is high – 70% compared with typical 50%, – the cattle diet is all leaf and of high quality but intake low, PGR is low and cost of gain high. Pasture damage inevitably occurred with prolonged recovery.

In theory a system of leader and follower grazing can provide for inferior diet and restricted growth whilst still providing intensive management; Stobbs (1977) demonstrated that for lactating cows grazing either Rhodes grass or Gatton panic those having the first opportunity to graze (leaders) had a 38% advantage in milk production and maintained greater liveweight compared with those offered the remaining herbage (followers). In practice, however, the level of management including infrastructure and labour to achieve this was not likely to be available.

#### 4.2.5.2 A model of grazed irrigated tropical grass pastures at Pardoo

A grazing rotation and associated cattle production was modelled using monthly pasture growth rates estimated from measurement, growing to a repeated biomass of 2200 kg/ha FOO and grazed to a residual of 500 kg/ha FOO above the stem horizon, from which growth recommenced. From the total annual pasture production, cattle production was fitted. (Table).

**Table 10. Example of conceptualised annual pasture growth, cattle production and costs relating to Pardoo grazing model.**

| | | |
|---|---|---|
| **Annual FOO & Pasture available** | Total days per annual | 365 |
| | Regrowth days | 326 |
| | Grazing days | 40 |
| | Growth cycles | 21 |
| | Average regrowth days | 15.5 |
| | Pasture production each cycle (kg DM) | 1700 |
| | **Total pasture production (kg DM)** | **35700** |
| | **Cost of pasture produced, ($/kg DM)** | **$ 0.14** |
| | Pasture utilisation (%) | 50 |
| | **Pasture available, kg/ha** | **17850** |
| | **Cost of pasture under 50% utilisation, $/kg** | **$ 0.28** |

| | | |
|---|---|---|
| **Cattle** | Cattle breed | PB |
| | Cattle weight | 270 |
| | Cattle intake, %/bwt | 2.2% |
| | **Cattle intake, kg/day DM** | **5.9** |
| | ADG, %/bwt | 0.17% |
| | **ADG, kg/day** | **0.46** |

| | | |
|---|---|---|
| **Grazing** | Grazing head days/ha | 3005 |
| | Average stocking rate, head/ha | 8.2 |

| | | |
|---|---|---|
| **Cattle gain** | Annual gain per hectare, kg | 1379 |
| | Annual gain per head, kg | 168 |

| | | |
|---|---|---|
| **FCR & COG** | **FCR, kg pasture DM/ kg weight gain** | **12.9** |
| | **Cost of gain, $/kg** | **3.63** |

*Change inputs highlighted in blue as appropriate

## 4.3 Performance and cost of gain of cattle grazing irrigated pastures.

### 4.3.1 Key messages

The average ADG of PB and KB cattle growing grazing separately was 0.21% and 0.22% of bodyweight, respectively, measured as 0.48 and 0.65 kg/day, respectively.

Respective CoG for PB and KB growing cattle was $3.95 and $3.08/kg.

Grazing management had the most influence on performance and cost of gain.

Under demonstrably achievable management, gain was 10% higher and CoG 10% lower.

### 4.3.2 Background

Preliminary estimates of cattle performance were recorded at the end of the first 3 years of the project. These were based on only 5 data sets of grazing cattle, and the methodology of cost calculation was explained. The next 3 years provided a total of 65 data sets, comprising separate or mixed mobs of Purebred Wagyu (PB), Crossbred Wagyu (KB), both steers and heifers, and some Bos indicus-cross cattle (B.i. cross), mainly Droughtmaster. Mobs generally were of similar ages and weight range.

### 4.3.3 Methodology

Over 3 years (December 2019 – December 2022), as part of normal management, approximately 65 opportunities presented where significant numbers of identified cattle could be weighed with calibrated scales in yards, immediately before and after accurately recorded grazing movements with grazing times, cell areas and regrowth intervals. The average time between weighing was 50 days, and cattle were most commonly weighed following an overnight fast on water. Any variation on this was noted and allowed for where applicable. A spreadsheet “Pivotmaster” was developed to record and analyse cattle movements whilst grazing.

It is emphasised that many unavoidable variables existed in the circumstances, but the results reflected reality. Grazing management was clearly a major factor difficult to control with the scale of the operation and very frequent staff changes, although aspired-to grazing guidelines existed. Significant ranges in cattle mob numbers and paddock sizes made rigorous grazing management impossible.

By the time recording commenced pivot cell areas were a range of 10, 12.5, 20, 40, and 50 ha. Grazing rotations as a result were regularly variable in terms of time per grazing allocation, inevitably associated with poorer pasture quality and lower utilisation. The grazing performance documented therefore needs to be viewed with this in mind. This is, however, a good insight into reality; from comparison with smaller subsets of satisfactory pasture grazing management it is considered that cattle performance as represented by average daily gain (ADG) could be 10% higher – grazing between recommended feed on offer (FOO) boundaries – and cost of gain (CoP) 10% lower with better management. The basis of the latter would be improved pasture utilisation, from an estimated 40 to 50% to possibly 60% of pasture grown. From experience, a subjective comfortably achievable figure is put forward as indicative of cattle and pasture performance.

In order that this data demonstrate the performance of yearling growing cattle grazing irrigated tropical pastures, of the 65 data sets referred to, 7 records of older cattle including pregnant cows, bulls and cattle being maintained or held for sale or transport were excluded. Also included in this excluded group was a data set where it was clearly observed and confirmed that management or husbandry incidents had caused aberrations, in this case clinical parasitism.

For a description of the basis of pasture production costs see Table 7. A rounded figure of $5000/ha or $13.70/ha/day was used, representing approximate costs over the period 2020-2021.

### 4.3.4 Results

Selected performance indices of cattle grazing irrigated tropical pastures over the four years 2019 – 2022 are reported. Table 10 records the major component of measurements where PB and KB cattle were grazing as single mobs.

From the records there was a small data set of 8 occasions when PB and KB cattle were grazing together (Table 2). Two records of these were excluded from this analysis as they were occasions of weight loss (it is pertinent that in each of these PB cattle lost weight but KB cattle gained a small amount of weight). The superior performance of the KB cattle was confirmed. Their weight was typically 20% greater than that of PB cattle which may have been associated with a social grazing advantage, although as a breed they were observed to be more actively grazing; an insight into breed differences was afforded from one example of Optiweigh data (Table 12). Within a co-grazing mob KB cattle visited the unit at twice the frequency of PB cattle (43 % of the group compared with 21%).

The weight difference between yard and Optiweigh aligned with that associated with an overnight fast.

**Table 10. Selected performance indices of cattle grazing irrigated pastures at Pardoo 2019-2022**

| Breed | Av. Weight (kg) | ADG kg/day | ADG % Bwt | FCR Pasture DM:Lwt | Intake % Bwt | Bwt gain kg/ha/day |
|---|---|---|---|---|---|---|
| PB* | 236 | 0.48 | 0.21 | 13.4 | 2.22 | 4.8 |
| KB* | 303 | 0.65 | 0.22 | 11.5 | 2.42 | 6.2 |
| B.i. cross | 362 | 0.70 | 0.21 | 12.4 | 2.29 | 4.7 |

*Grazing in separate mobs

**Table 11. ADG and ADG as % of Bwt for co-grazing PB and KB growing cattle**

| Breed | ADG kg/day | ADG / Bwt % |
|---|---|---|
| PB* | 0.40 | 0.17 |
| KB* | 0.56 | 0.20 |
| PB: KB ADG | 0.71 | 0.85 |

*Grazing together

**Table 12. Optiweigh recording of weight and cattle breed characteristics.**

| Breed | Group number | Number visiting | Proportion of group (%) | Optiweigh weight (kg) | Yard weight (kg) | Weight difference (kg) | Weight difference (%) |
|---|---|---|---|---|---|---|---|
| PB | 565 | 120 | 21 | 236 | 222 | 14 | 5.9 |
| KB | 508 | 218 | 43 | 348 | 333 | 15 | 4.3 |
| Santa | 81 | 30 | 37 | 364 | 346 | 18 | 4.9 |
| TOTAL | 1154 | 368 | 32 | 313 | 298 | 15 | 4.8 |

Comment

Although PB cattle appeared to have a significantly lower daily gain than KB and B.i. crossbred cattle, it was not as unfavourable as might appear from ADG data– looking at ADG as a % of bodyweight PB performance was only slightly lower than that of KB. Clearly KB cattle were heavier in more grazing evaluation opportunities, partly because a heavier lead was being regularly drafted from PB mobs for final feedlot entry.

The B.i. cross cattle appeared to have good FCR, but the relatively few mobs evaluated were substantially heavier and older; weight gain although comparatively high was similar to Wagyu cattle as a proportion of bodyweight.

Using predicted feed intake from pastures and predicted monthly PGR from the variety of techniques to which reference has been made, pasture intake and therefore FCR was calculated. (Associated with the QuikIntake data, plate meter and other pasture growth rate records indicated pasture utilisation of approximately 50%. This would align with conventional expectations of tropical pastures, but 60% or greater would be expected utilising recommended grazing practice). KB cattle appeared to have a better FCR as calculated from QuikIntake, backed up by alignment with pasture intake-growth rate relationships.

### 4.3.5 QuikIntake

The spreadsheet QuikIntake (McLennan and Poppi 2019) was utilised in connection with grazing cattle records to great effect as an analytical tool.

Based on trial data predominantly with tropical pastures over many years, pasture intake was predicted based on inputs all available or predicted with reasonable accuracy:

Cattle weights and weight change, breed, sex, standard reference weight, distance walked (pivots 2 km/day), terrain (level), pasture diet digestibility (MJ ME), supplement DM and MJ ME.

From the list of breed alternatives, as the best breed alignments, PB Wagyu were represented as Shorthorn, and Kimbara as 50% *Bos indicus.*

The pasture intake was calculated and proved a valuable adjunct in predicting pasture growth rates and degree of pasture utilisation at the time. Presuming plate meter readings over two years would be the most reliable and direct source of PGR data, estimates of pasture eaten to generate the weight change typically aligned with utilisation of 50 to 60%.

In addition, QuikIntake calculations served as a valuable tool to verify or in cases to cast doubt upon cattle grazing performance records, if pasture growth rates, clearly botanically impossible in the circumstances, were predicted as required to support the recorded cattle performance.

An example of grazing analysis and the application of Quikintake is discussed (Figure 17). The performance of a mob of 961 PB heifer weaners grazing from the end of October till mid-February was recorded. A small amount of molasses (0.10 kg/day, 3% of energy intake) was provided as a supplement. Pasture regrowth was clearly minimal referring to regrowth days and FOO provided for low ADG (0.26kg/day). There was evidence of very high utilisation (> 70%) of what would have been all high-quality leaf, resulting in CoG remaining relatively low at $3.06/kg. However, the ADG was insufficient to meet growth path requirements.

**Figure 17 : An example of grazing analysis and the application of Quikintake.**

| COST OF BODYWEIGHT GAIN GRAZING | | | | | | |
|---|---|---|---|---|---|---|
| Location | | Pardoo | | | | |
| Cattle | Type | PB 20 Heifer wnrs | | | | |
| | | Start | Finish | Average wt | ADG | ADG % Bwt |
| Date | | 27/10/2020 | 13/01/2021 | | | |
| | Weight(kg) | 191 | 210 | 200.6 | 0.26 | 0.13% |

| | | | PREGRAZING | | | GRAZING TIME | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pivot/cell | Area (ha) | Cattle no. | Regrowth date from | Days | Ha.regrowth days | Date in | Date out | Days | Ha.Grazing days | ADG | Total gain(kg) | Contributing Ha. days |
| P5C1 | 20 | 961 | 26-Oct | 1 | 20 | 27-Oct | 30-Oct | 4 | 80 | 0.26 | 992 | 100 |
| P4C2 | 20 | 961 | 22-Oct | 9 | 180 | 31-Oct | 4-Nov | 5 | 100 | 0.26 | 1240 | 280 |
| P4C1 | 20 | 961 | 25-Oct | 11 | 220 | 5-Nov | 9-Nov | 5 | 100 | 0.26 | 1240 | 320 |
| P5C1 | 20 | 961 | 31-Oct | 10 | 200 | 10-Nov | 12-Nov | 3 | 60 | 0.26 | 744 | 260 |
| P5C2 | 20 | 961 | 3-Nov | 10 | 200 | 13-Nov | 14-Nov | 2 | 40 | 0.26 | 496 | 240 |
| P4C2 | 20 | 961 | 4-Nov | 11 | 220 | 15-Nov | 19-Nov | 5 | 100 | 0.26 | 1240 | 320 |
| P1C3 | 10 | 961 | 11-Nov | 9 | 90 | 20-Nov | 23-Nov | 4 | 40 | 0.26 | 992 | 130 |
| P1C4 | 10 | 961 | 14-Nov | 10 | 100 | 24-Nov | 24-Nov | 1 | 10 | 0.26 | 248 | 110 |
| P5C1 | 20 | 961 | 20-Nov | 5 | 100 | 25-Nov | 26-Nov | 2 | 40 | 0.26 | 496 | 140 |
| P1C1 | 10 | 961 | 16-Nov | 11 | 110 | 27-Nov | 30-Nov | 4 | 40 | 0.26 | 992 | 150 |
| P1C2 | 10 | 961 | 17-Nov | 14 | 140 | 1-Dec | 5-Dec | 5 | 50 | 0.26 | 1240 | 190 |
| P1C3 | 10 | 961 | 24-Nov | 12 | 120 | 6-Dec | 8-Dec | 3 | 30 | 0.26 | 744 | 150 |
| P1C4 | 10 | 961 | 25-Nov | 14 | 140 | 9-Dec | 14-Dec | 6 | 60 | 0.26 | 1488 | 200 |
| P1C2 | 10 | 961 | 6-Dec | 9 | 90 | 15-Dec | 16-Dec | 2 | 20 | 0.26 | 496 | 110 |
| P1C3 | 10 | 961 | 9-Dec | 8 | 80 | 17-Dec | 18-Dec | 2 | 20 | 0.26 | 496 | 100 |
| P1C4 | 10 | 961 | 15-Dec | 4 | 40 | 19-Dec | 20-Dec | 2 | 20 | 0.26 | 496 | 60 |
| P1C2 | 10 | 961 | 17-Dec | 4 | 40 | 21-Dec | 23-Dec | 3 | 30 | 0.26 | 744 | 70 |
| P1C1 | 10 | 961 | 17-Dec | 7 | 70 | 24-Dec | 24-Dec | 1 | 10 | 0.26 | 248 | 80 |
| P1C2 | 10 | 961 | 24-Dec | 1 | 10 | 25-Dec | 26-Dec | 2 | 20 | 0.26 | 496 | 30 |
| P1C3 | 10 | 961 | 19-Dec | 8 | 80 | 27-Dec | 27-Dec | 1 | 10 | 0.26 | 248 | 90 |
| P1C4 | 10 | 961 | 21-Dec | 7 | 70 | 28-Dec | 28-Dec | 1 | 10 | 0.26 | 248 | 80 |
| P1C2 | 10 | 961 | 27-Dec | 2 | 20 | 29-Dec | 31-Dec | 3 | 30 | 0.26 | 744 | 50 |
| P1C3 | 10 | 961 | 28-Dec | 4 | 40 | 1-Jan | 2-Jan | 2 | 20 | 0.26 | 496 | 60 |
| P5C2 | 20 | 961 | 24-Dec | 10 | 200 | 3-Jan | 6-Jan | 4 | 80 | 0.26 | 992 | 280 |
| P5C1 | 20 | 961 | 1-Jan | 6 | 120 | 7-Jan | 8-Jan | 2 | 40 | 0.26 | 496 | 160 |
| P5C2 | 20 | 961 | 7-Jan | 2 | 40 | 9-Jan | 11-Jan | 3 | 60 | 0.26 | 744 | 100 |
| P5C1 | 20 | 961 | 9-Jan | 3 | 60 | 12-Jan | 12-Jan | 1 | 20 | 0.26 | 248 | 80 |
| | | | | 202 | 2800 | | | 78 | 1140 | | 19339 | 3940 |

| | | |
|---|---|---|
| | Pasture cost @ $13.70/ha/day | 53978 |
| Pasture | CoG ($/kg) | 2.79 |

| Supplement | | | Amount fed (L) | Amount (kg/hd.d) | Energy% supplement |
|---|---|---|---|---|---|
| Silage | Cost ($/T) a | $ 135.00 | | | |
| Molasses | Cost ($/L) a: | $0.70 | 7480 | 0.14 | 3.1% |

| | |
|---|---|
| Supplement total cost ($) | $5,236.00 |
| TOTAL COST $ | 59214 |
| TOTAL CoG ($/kg) | 3.06 |
| Beef production kg/ha/day | 4.91 |

| | | | at 2.5% Bwt | QI sh'hn |
|---|---|---|---|---|
| at % Bwt | | | 2.50% | 2.14% |
| Cattle intake/day kg pasture DM | | | 5.0 | 4.3 |
| Total intake | | | 376001 | 322023 |
| PGR required | | | | |
| | 40% util'n | 40% | 279 | 239 |
| | 50% util'n | 50% | 223 | 191 |
| | 60% util'n | 60% | 186 | 159 |
| | 70% util'n | 70% | 159 | 137 |

From all records, the average estimated daily beef production per hectare of 4.8 kg/day or 1750 kg/year for PB cattle appears high, as is that of the KB cattle (6.2 kg/day or 2260 kg/year). For a proportion of the data sets this figure included the contribution of supplements, mostly molasses, whilst grazing. This may have contributed to an apparent overestimate (this beef production per year from grazed pastures appeared greater than the production in the model of pasture production from simulated grazing with estimated growth rates and utilisation).

### 4.3.6 Cost of gain

Using the costs (Table 7) as a basis, the average cost of gain was calculated:

**Table 13. Effect of breed on selected indices of cattle performance and CoG. PB and KB grazing separately.**

| Breed | Average wt (kg) | ADG kg/day | ADG % BWt | FCR | Av CoG ($) |
|---|---|---|---|---|---|
| PB | 236 | 0.48 | 0.20 | 13.4 | 3.95 |
| KB | 303 | 0.65 | 0.21 | 11.5 | 3.08 |
| B.indicus X (DM) | 362 | 0.70 | 0.19 | 12.4 | 3.38 |

### 4.3.7 Seasonal variation in pasture costs

#### 4.3.7.1 Introduction

The costs used relate to inputs over an annual period, on reflection, related very much to pasture growth rate. An increase in growth rate as influenced by season, predominantly temperature and overall solar radiation, drives increased fertiliser uptake (given its availability), together with pivot costs to supply water. Associated increases in labour and machinery maintenance and running costs inevitably followed this.

If irrigation is monitored to retain water beneficially within the root zone of pasture plants, typically not below 1.5 meters, applied nutrients surplus to uptake in one period can be retained and used later.

It can be argued that true cost of production at any given time relates to costs incurred concurrently with cattle production, that is weight gain. Therefore, at times of increased pasture growth rate as over the summer period, all daily costs associated with pasture growth increase. Conversely, with cooler temperatures over winter, pasture growth decreases and with it associated daily costs.

With the above comments in mind, it was hypothesized that seasonally responsive costs of pasture production may provide an improved figure on which to calculate true cost of gain for cattle grazing irrigated pastures at different times over an annual cycle.

#### 4.3.7.2 Method of seasonally adjusting pasture costs

By reference to the estimated PGR for each month (Table 8), costs were adjusted for season (Table 14).

These monthly growth rates were used to calculate an updated calculation of cost of production reflecting costs related in time to the beef produced, as opposed to when the costs were incurred (Table 15). Cost of production records included that of both KB and PB mobs.

**Table 14. Effect of adjusting daily average pasture costs in relation to monthly pasture growth rate.**

| **Year : 2019 – 2021[1]** | **Annual average** | **Warm season 1/10-30/4** | **Cool season 1/5-30/9** |
|---|---|---|---|
| Pasture cost/day $ | 13.70 | 14.87 | 12.43 |

**Table 15. Effect of adjusting beef liveweight CoG for season using monthly pasture growth rates.**

| **2019 – 2021** | **CoG $/kg** | **CoG $/kg** |
|---|---|---|
| Cost basis<br>$/ha | Warm season<br>1/10-30/4 | Cool season<br>1/5-30/9 |
| Pasture Costs<br>$13.70/ha/day unadjusted | $3.28 | $3.86 |
| Pasture costs adjusted for estimated PGR | $3.67 | $3.28 |

Points to note (Table 15)

1. Using an average daily cost ($13.70) from annual actuals ($5000/ha, unadjusted across the year), warm season CoP is lower than in the cool season. More grass growth means a higher carrying capacity.
2. Adjusting the costs in proportion to measured pasture growth rate increases summer CoP whilst lowering winter CoP, to the extent that the cost of beef production is calculated as less in winter. Factors associated with this in theory would include higher daily gain and better pasture DM conversion rate. This should be associated with more favourable winter environment – less heat load, more easily-managed pastures with consequent improvement in quality. However, from relevant files there was minimal difference in ADG, although from QuikIntake estimates, feed conversion rate was better in winter (Table 16). This was calculated to reduce of production in cooler months. As for CoP, these figures included both KB and PB mobs.

**Table 16. Effect of season on cattle ADG and FCR.**

| Season | ADG kg/hd/day | ADG % Bwt | Pasture FCR |
|---|---|---|---|
| Warm 1/10-30/4 | 0.58 | 0.22 | 12.8 |
| Cool 1/5-30/9 | 0.58 | 0.21 | 11.3 |

## 4.4 Feedlot

### 4.4.1 Key messages

- Performance for PB Wagyu cattle was documented in a feedlot environment in the Pilbara. Programmed backgrounding growth rates were 0.9 to 1.0 kg/day with a ration cost of $2.80 to $3.50/kg, cost of gain being greater in summer.
- Utilisation of locally produced tropical forage into a TMR enabled enhanced cattle growth rates and improved nitrogen utilisation, compared with a diet of pasture under grazing management.

[1] See Table  for full calculations.

- A major performance and welfare advantage of a feedlot in the environment is the ability to provide shade practically and economically to a large number of cattle.

### 4.4.2 Background

As a complement and alternative to grazing pasture, the provision of feed to cattle in a feedlot was increasingly researched during the project. Ideally as much of this would be produced on the irrigated pastures, and as well as the maize crops initiated during Phase one, corn grain and tropical grass silage were evaluated in a variety of rations (see Section 5 : Crops).

Imported ingredients included lupins, lupin kernel meal, and vitamin/mineral premixes. Grains were imported as influenced by cost, corn being the most common. Barley and wheat were also used at times.

Over time the utilisation of a feedlot in the Pardoo Wagyu program was considered from a number of aspects:

- Backgrounding of steers prior to final 400-day feed in southern feedlot.
- Short-term feeding simply as preparation / bunk training prior to southern feedlot dispatch.
- Where steer growth rates had been inadequate to meet feedlot entry targets, to accelerate growth rates.
- To enable heifer growth rates sufficient to meet weight targets for joining at 15 months of age. This became the most significant imperative for ongoing and large scale feeding of Wagyu cattle. As clearly documented in the study of grazing performance, regardless of cost growth rates grazing would be insufficient to achieve a weight of 300 kg at 13 to 15 months of age for a high proportion of heifers. This was considered imperative for the time frame of herd build up and for the economics of beef production in an intensive operation (Table 17).

**Table *17.* Weaner growth path**

| Weaner growth path | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Birth to weaning | | | | | | | Weaning to joining | | | |
| Kimberley weaners | | | | | | | | | | | ADG wean to join | ADG wean to join |
| | Period | Time (days) | weight birth | weaning wt | ADG to wean | Joining weight | Join date | Join date | Days wean-join | Days wean-join | Kimberley | Pardoo |
| | | | kg | kg | kg/day | kg | Kimberley | Pardoo | Kimberley | Pardoo | kg/day | kg/day |
| | Dec-Jun | 180 | 25 | 100 | 0.42 | 300 | Jan | Mar | 210 | 270 | 0.95 | 0.74 |
| | Nov-Jun | 210 | 25 | 135 | 0.52 | 300 | Jan | Mar | 210 | 270 | 0.79 | 0.61 |
| | Oct-Jun | 240 | 25 | 170 | 0.60 | 300 | Jan | Mar | 210 | 270 | 0.62 | 0.48 |
| Pardoo weaners | | | | | | | | | | | | |
| | Feb-Jul | 150 | 25 | 90 | 0.43 | 300 | Jan | Mar | 180 | 240 | 1.17 | 0.88 |
| | Jan-Jul | 180 | 25 | 120 | 0.53 | 300 | Jan | Mar | 180 | 240 | 1.00 | 0.75 |
| | Dec-Jul | 210 | 25 | 150 | 0.60 | 300 | Jan | Mar | 180 | 240 | 0.83 | 0.63 |

### 4.4.3 Results

#### 4.4.3.1 Backgrounding

The data has been grouped into two periods: August 2019 to April 2020; and April 2021 until January 2023, two distinct times when the feedlot was operational. The earlier period had limited data and with few exceptions rations fed to limit growth rates (Table 18). Most of the records relate to period of high heat load for cattle, from December to March, additionally contributing to lower FCR and higher CoG.

Grouping of mixtures of cattle class was responsible for the paucity of FCR and CoP for KB class cattle. Weight gain was able to be calculated but not intake.

**Table 18. August 2019 – April 2020 performance of PB steers**

| Cattle | Number | ADG (kg/day) | FCR |
|---|---|---|---|
| PB steers | 1702 | 0.89 | 7.9 |
| KB m/s | 1099 | 0.69 | 14.1 |

From April 2021 PB steers were routinely fed for higher backgrounding ADG, and a high proportion of PB weaners from the 2021 and 2022 musters were similarly fed. The improvement in performance for steers was notable, and weaner performance achieved targets with favourable ADG, FCR and COG (Table 19).

The consistent improvement of growth rates was a key factor in reducing CoG (Table 10). To provide a meaningful comparative CoG, ration ingredient costs were standardised separately to representative figures (Table 20). In particular, silage production costs varied greatly as yield fluctuated. Other ingredient costs understandably varied, though increasing over time. Yardage costs were calculated from actual figures each year, and variations reflected scale as influenced by cattle numbers.

**Table 19. April 2021 – January 2023 performance of PB steers**

| Cattle | Number | ADG | FCR | CoG *($/kg) | CoG* ($/kg) incl. yardage* |
|---|---|---|---|---|---|
| PB steers >1Yr | 3674 | 1.16 | 7.6 | 3.45 | 4.00 |
| PB weaners | 7805 | 0.98 | 6.1 | 2.89 | 3.54 |

*refer Table 20 for standardised costs

**Table 20. Standardised costs of animal feed**

| Component | Standardised cost ($/t as fed) | Range ($/t as fed) |
|---|---|---|
| Silage | 100 | 60-300 |
| Lupin kernel meal | 700 | 700-710 |
| Grain (corn, barley, wheat) | 500 | 329-590 |
| Hay | 200 | 200 |
| Wrapped silage | 200 | 200-230 |
| Premix | 1000 | 980-1050 |
| (Yardage | $0.60/day | $0.45-$1.00) |

Performance over the time was encouragingly good given the interim facilities. Summer performance was understandably reduced (Table 21) but was considered favourable, particularly in the absence of shade at the time. The figures give confidence to the planned construction of a custom-built feedlot facility which will certainly improve performance and reduce cost of gain.

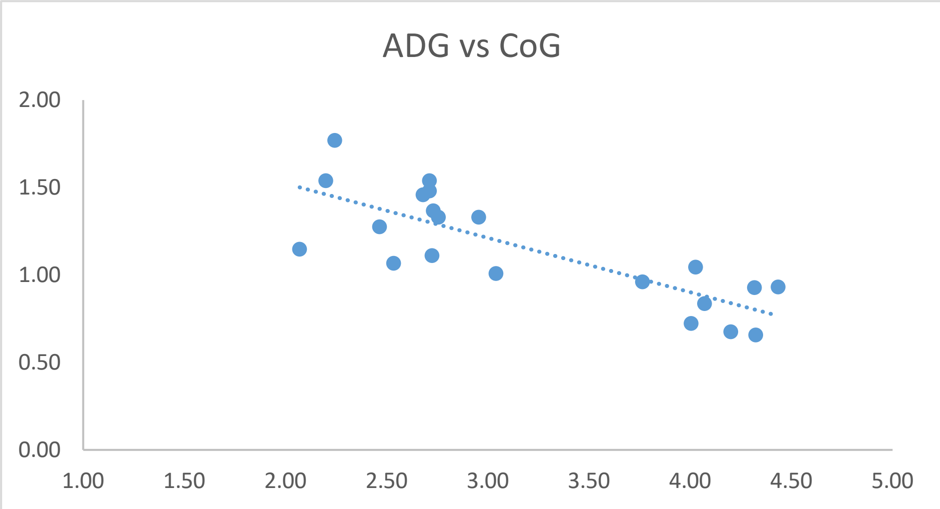
**Table 21. Seasonal difference in CoG figures**

| Period | Number | ADG | FCR | CoG *($/kg) | CoG* ($/kg) incl. yardage* |
|---|---|---|---|---|---|
| Apr-Nov | 7677 | 1.06 | 6.3 | 2.92 | 3.52 |
| Dec-Mar | 5541 | 0.95 | 7.7 | 3.60 | 4.26 |

Imported ration ingredient costs were inevitably more expensive in the Pilbara associated with freight; up to $150/t applied to most materials and must be factored in ration formulation and in management decisions related to location of ultimate finishing and slaughter (see Appendix 8.6 as example of ration formulation with grass silage).

**Figure 18 : Pardoo feedlot Cost of gain vs ADG**

Transition feeding of lighter (<130 kg) weaners




### 4.4.3.2 Transition feeding of light weaners

An example is documented of feeding to PB weaners immediately following muster from rangeland (Table 22). It was often typically impractical to obtain FCR and CoG figures as weaners would be added and removed with regular drafting. In this case, a stable group of weaned calves below 130 kg bodyweight were fed a high energy/protein concentrate primary diet, accompanied by hay and silage. Their performance was documented, the group attaining satisfactory weight and development to transition either to grazing or a silage-based TMR.

**Table 22. Performance of PB weaners transitioning from weaning to grazing or Silage based TMR 2021.**

| | Number | Bwt start (kg) | Bwt end (kg) | ADG (kg/day) | CoG *($/kg) | CoG* ($/kg) incl. yardage* |
|---|---|---|---|---|---|---|
| Horse paddock weaners | 555 | 128.5 | 170.2 | 0.77 | 3.32 | 4.10 |

**Table 23. Ingredients of weaner transition feeding rations**

| Feed | Intake/day (kg) | Feed DM estimate % | Kg DM daily | Kg utilised (Estimate) | Energy intake est. (MJ ME) |
|---|---|---|---|---|---|
| Pellets 13 MJ/kg, 21% CP | 2.7 | 90 | 2.4 | 2.3 | 29.9 |
| Hay ME 8.0 MJ/kg | 2.5 | 88 | 2.2 | 1.1 | 8.8 |
| Silage ME 10.5 MJ/kg | 1.7 | 35 | 0.6 | 0.5 | 5.2 |
| TOTAL | | | 5.2 | 4.9 | 43.9 |

The intakes of hay and silage can only be rough estimates, but clearly the diet was more than sufficient to be associated with the observed performance (Table 23). Wastage was estimated.

## 4.5 Crops

### 4.5.1 Key messages

- Maize silage was an ideal crop in the environment but Fall armyworm management had not been consistently achieved.
- Tropical grass silage from summer growth utilised the simple management of a perennial pasture to provide large quantities of relatively cheap forage for inclusion in TMR cattle rations.
- Research on other summer and winter crops and sustainable cropping rotations is indicated.

### 4.5.2 Background

Over the last half of the project the production of forage from the irrigated pastures was increasingly explored. It was recognised that grazing could not utilise tropical pastures efficiently across all seasons, and tactical and strategic harvesting of pasture grasses was essential. In addition it was recognised that nutrient losses with grazing inevitably were substantial. Maize as a dedicated silage crop and to a lesser extent grain was attempted over 4 years with mixed success but the potential was clear. Large scale production of tropical pastures for silage was evaluated given the high summer growth and the difficulty of managing and utilising this by grazing.

### 4.5.3 Crop analysis

#### 4.5.3.1 Maize

Analysis of maize crop performance was documented, in a situation of often incomplete and potentially confusing records. This included the first maize crop in November 2020, maize crops harvested in December 2021, June/July 2022 and November 2022. It was considered important for each crop to identify and record accurate data for the benefit of subsequent managers, as these crops (maize for silage and grain) would likely be a significant component of an increasing TMR feeding program heavily reliant on high-quality, low-cost ingredients.

It is recommended that priority be given to adequate documentation of inputs and activities.

It is considered that the figures used in these analyses provided a robust record being carefully sourced from dissected company actuals, with checks provided by a consultant's recommended program. A period of four months pivot allocation was used, including time involved in pivot land preparation. Yields were as recorded, and storage volumes align well with these. Feed quality analysis accompanied silage crops.

**November 2020 maize crop**

Pivots 15 and 17, 101 ha.

**Table 24. Actual costs incurred in growing Maize on Pivots 15 and 17 in November 2020**

| **Maize Nov 2020** | **(revised)** | | | | |
|---|---|---|---|---|---|
| Silage P15, P17 | | | | | |
| | | | | | |
| | **Costs** | **$** | | | |
| | **Total** | 101 | | | |
| | | per ha | | | |
| Fertiliser | 106831 | 1058 | | | |
| Seed | 47030 | 466 | | | |
| Herbicides and pesticides | 6820 | 68 | | | |
| Harvest | 94960 | 940 | | | |
| Labour and on costs | 33660 | 333 | | | |
| Operational incl pivots | 30300 | 300 | | | |
| Depreciation | 20200 | 200 | | | |
| TOTAL ($) | 339801 | 3364 | | | |
| TOTAL/ha ($) | 3364 | | | | |
| YIELD (tonnes) | | 5100 | | | |
| Yield/ha as harvested | | 50.5 | | | |
| DM % | | 40 | | | |
| Yield/ha DM | | 20.2 | | | |
| **Cost/tonne ($) as fed** | | **66.63** | | | |
| | | | | | |
| Notes | | | | | |
| Labour, operational and depreciation calculated from actuals 2021 and 2022 | | | | | |
| Allows alignment with cost calculations 2021 and 2022 | | | | | |
| | | | | | |

**Comment:** This revision resulted in a minor increase in estimated costs, up 15% from the figure calculated at the time using hourly labour and machinery costs and times. This would have included a depreciation factor for the machinery use. Lower fertiliser costs and less requirement for insecticides were evident. High nitrogen application would have been a factor in the excellent yield. High harvest costs absorbed in yield, less per tonne (Table 24).

**December 2021 maize crop**

Pivots 19 and 20, 40 ha to maize silage, 40 ha harvested as corn grain.

**Table 25. December 2021 Maize Crops**

| | | | | | |
|---|---|---|---|---|---|
| **Maize Dec 2021** | | | | | |
| Silage P20 | | | | | |
| Corn P19 | | | | | |
| | | **Costs** | **$** | | |
| | **Total** | | **silage** | **corn** | |
| | | per ha | per 40 ha | per 40 ha | |
| Fertiliser | 76081 | 951 | 38041 | 38041 | |
| Seed | 17590 | 220 | 8795 | 8795 | |
| Herbicides and pesticides | 25288 | 316 | 12644 | 12644 | |
| Harvest | 41912 | 524 | 41912 | 5600 | |
| Labour and on costs | 24332 | 304 | 12166 | 12166 | |
| Operational incl pivots | 19853 | 248 | 9927 | 9927 | |
| Depreciation | 15467 | 193 | 7734 | 7734 | |
| TOTAL ($) | 220523 | 2757 | 131218 | 94906 | |
| TOTAL/ha ($) | 2757 | | 3280 | 2373 | |
| YIELD (tonnes) | | | 1419 | 360 | |
| Yield/ha as harvested | | | 35.5 | 9 | |
| DM % | | | 35 | | |
| Yield/ha DM | | | 12.4 | 9 | |
| **Cost/tonne ($) as fed** | | | **92.47** | **263.63** | |
| Corn harvest Pardoo header estimated cost $200/hour, 28 hours estmated | | | | | |
| | | | | | |

**Comment:** Silage yield assumed reliable, aligned with contractor record and pit volume.

Corn grain yield queried, when considering the yield of the neighbouring silage crop (not necessarily the same crop yield). Yield of corn grain is typically around half that of whole crop silage, which would equate to a yield of 6 rather than 9 T/ha. This cannot be confirmed. As it is, the corn appeared to have a favourable cost of production (Table 25).

These yields were considerably below expectations. A review attempted to diagnose possible associated factors including time of planting, weed control, seed quality, degree of insect damage, timing and amount of fertiliser application, and water balance.

**June/July 2022 maize crop**

Pivots 2,3,4,20 (half) 140 ha maize silage, Pivot 19, 40 ha corn grain. Pivot 20, 2/3 Panic grass, 1/3 maize.

These yields were considerably below expectations (Table 26). Costs were not inordinately high, referring to prior crops; yield was the issue. Review identified quite a few possible associated factors including:

- time of planting (heat?)
- seed quality (demonstrated in one case).
- degree of insect damage (significant).
- Wallaby damage (in places severe).
- grass weed competition.
- water balance.
- timing of critical management activities and inputs.

**Table 26. Harvest records from the June 2022 Maize Crops**

| | | | | | |
|---|---|---|---|---|---|
| **Maize crops March - June 2022** | | | | | |
| Silage P2,3,4,20(half) | | | | | |
| Corn P19 | | | | | |
| | | **Costs** | **$** | | |
| | **Total** | | **silage** | **corn** | |
| | | per ha | per 140 ha | per 40 ha | |
| Fertiliser | 357411 | 1787 | 250188 | 71482 | |
| Seed | 76224 | 381 | 53357 | 15245 | |
| Herbicides and pesticides | 50600 | 253 | 35420 | 10120 | |
| Harvest | 97915 | 490 | 97915 | 5600 | |
| Labour and on costs | 52752 | 264 | 36926 | 10550 | |
| Operational incl pivots | 73228 | 366 | 51260 | 14646 | |
| Depreciation | 40000 | 200 | 28000 | 8000 | |
| TOTAL ($) | 748130 | 3741 | 553066 | 135643 | |
| TOTAL/ha ($) | 3741 | | 3950 | 3391 | |
| YIELD (tonnes) | | | 2020 | 300 | |
| Yield/ha as harvested | | | 14.4 | 7.5 | |
| DM % * | | | 38 | | *Maize silage 120 ha 38% DM |
| Yield/ha DM | | | 5.5 | 7.5 | (Panic/Maize silage 20 ha 28% DM |
| **Cost/tonne ($) as fed** | | | **$273.79** | **$452.14** | |
| | | | | | |
| **Notes** | | | | | |
| Corn harvest Pardoo header estimated cost $200/hour, 28 hours recorded | | | | | |
| Labour, operational and depreciation from actuals, 4 months assumed allocated to crops (actually 140 days) | | | | | |

**November 2022 Maize crop**

Many of the problems in the July crop were overcome for the November crop, but Fall armyworm (FAW) proved a major challenge. The intention to harvest the crops as grain was relinquished as the crop advanced and FAW damage to corn cobs reached alarming proportions. The decision to salvage the crop as silage was made and quickly organised; this proved to be a good decision (Table 27)

**Table 27. Harvest records November 2022 Maize crops**

| | | | | |
|---|---|---|---|---|
| **Maize crops July-November 2022** | | | | |
| Silage P3,4, | | | | |
| Corn P7 C1,2,3 | | | | |
| | | **Costs** | **$** | |
| | **Total** | | **silage** | **corn** |
| | | per ha | per 76 ha | per 29 ha |
| Fertiliser | 213780 | 2036 | 154736 | 59044 |
| Seed | 42000 | 400 | 30400 | 11600 |
| Herbicides and pesticide | 48817 | 465 | 35334 | 13483 |
| Harvest | 51637 | 492 | 37375 | 5600 |
| Labour and on costs | 28530 | 272 | 20650 | 7880 |
| Operational incl pivots | 41300 | 393 | 29893 | 11407 |
| Depreciation | 22750 | 217 | 16467 | 6283 |
| TOTAL ($) | 448814 | 4274 | 324856 | 115297 |
| TOTAL/ha ($) | 2244 | | 2320 | 2882 |
| YIELD (tonnes) | | | 1928 | 250 |
| Yield/ha as harvested | | | 25.4 | 8.6 |
| DM % | | | 36 | |
| Yield/ha DM | | | 9.1 | 8.6 |
| **Cost/tonne ($) as fed** | | | **$168.49** | **$461.19** |
| | | | | |
| **Notes** | | | | |
| Corn harvest Pardoo header estimated cost $200/hour, 28 hours recorded | | | | |
| Labour, operational and depreciation from actuals, 4 months assumed allocated to crops (actually 140 days) | | | | |
| Corn yield estimated, not confirmed | | | | |

### 4.5.3.2 Tropical grass silage

In the circumstance of repeated difficulties in management of maize crops, notably skilled staffing and seemingly an escalating challenge of insect control, a decision was made to utilise the summer growth potential of tropical grasses as a more reliable and economical source of silage for Pardoo. The advantages of this included the considerable summer growth potential of the subtropical grasses, not easily managed and not fully realised to date by grazing. It was recognised that the quality of the product would not be as good as that of maize, but the reality and comparable economics aligned.

Three harvests were completed between December 2022 and February 2023. Under forage production management, growth rates were high for each crop. Unfortunately, the budgeted program could not be managed with staff changes and harvest was delayed by an excessive amount for the first two crops in particular. The program correctly predicted growth rates of 150 kg/ha/day, to be harvested at a target of 3.5 t/ha DM in 24 days.

As expected, delay in harvesting resulted in excessive yields for all but pivot 13 for the first December harvest, for which regrowth time, growth rate and yield were close to ideal (Dry Matter (DM) target 3.5 T/ha 24 days growth, PGR 145 kg/ha/day).

Most of the first two crops was at a growth stage of high stem proportions and lower digestibility, which inevitably affected the ensiling process and lowered the feed value of the product. This was accepted and allowed for in ratio formulation. The last February cut was better but still of excessive yield. The operations as carried out by the contractors went extremely well in the circumstances. Mowing, wilting, and ensiling were impressively carried out (Table 19).

The physical performance of the three silage cuts was excellent(Table 29), as were the economics: $60 – $90/T as ensiled or $200 – $260/T dry matter (Table 30).

Feed analysis confirmed the lower quality (Table 28). This was factored into ration composition and advice is that it will still be a useful and cost-effective component of a TMR (Appendix 8.6).

For an economic analysis, an estimated residual amount of the grass mix and urea applied to the December crop was costed against the January crop, as neither of these was applied over the growth of the latter – it must have used some fertiliser!

Other than harvest (actual) and fertiliser costs, daily average costs were applied for the time of crop growth (45, 34 and 31 days respectively), using 2022 annual irrigation costs plus an allocated 0.6 of General & Workshop costs from the Monthly reports. Depreciation was estimated as previously.

**Table 28. Silage crops feed analyses**

| Date | Crop | DM | CP | NDF | ADF | WSC | Fat | Ash | DDM (%) | ME (MJ/kg) | NSC (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan 19 | Maize | 37.5 | 7.7 | 44.4 | 25.3 | 15.3 | | | 70.4 | 10.6 | |
| Jan 19 | Sorghum | 36.0 | 6.0 | 61.4 | 36.4 | 8.1 | | | 58.1 | 8.9 | |
| Nov 20 | Maize | 39.5 | 6.5 | 45.8 | 24.8 | 13.3 | | | 69.8 | 10.5 | |
| Jul 22 | Maize | 35.4 | 9.0 | 44.1 | 23.6 | 9.9 | | | 71.4 | 10.7 | |
| Jul 22 | Maize / Panic | 28.9 | 10.4 | 53.8 | 31.2 | 2.3 | | | 59.8 | 9.1 | |
| Nov 22 | Maize | 39.3 | 8.0 | 46.1 | 16.5 | | | | 67.2 | 10.0 | |
| Dec 22 | Panic | 27.4 | 9.6 | 67.4 | 35.1 | | 3.0 | 12.0 | 58.8 | 8.7 | 8.0 |
| Jan 23 | Panic | 30.9 | 8.0 | 72.4 | 39.2 | | 2.6 | 10.2 | 53.8 | 8.0 | 6.8 |
| Feb 23 | Panic | 33.0 | 12.1 | 65.3 | 34.4 | | 3.0 | 13.0 | 60.8 | 9.1 | 6.5 |

## Table 29. Grass silage harvest records

| Pivot | Area ha | Closed Date | Harvest Date | Days | As harvested T | T/ha | DM % | DM T/ha | PGR kg/ha.day |
|---|---|---|---|---|---|---|---|---|---|
| **Grass silage program summer** | | | | | | | | | |
| **December 2022 first harvest** | | | | | | | | | |
| 13 | 39 | 14/11/2022 | 10/12/2022 | 25 | 539 | 13.8 | 28.1 | 3.9 | 155 |
| 14 | 49 | 6/10/2022 | 7/12/2022 | 60 | 1294 | 26.4 | 28.1 | 7.4 | 124 |
| 15 | 49 | 21/10/2022 | 8/12/2022 | 47 | 1076 | 22.0 | 28.1 | 6.2 | 131 |
| 16 | 39 | 23/10/2022 | 9/12/2022 | 46 | 909 | 23.3 | 28.1 | 6.5 | 142 |
| 17 | | | | | | | | | |
| 18 | 40 | 18/10/2022 | 5/12/2022 | 49 | 1194 | 29.9 | 28.1 | 8.4 | 171 |
| **TOTAL** | **216** | | | **45** | **5057** | **23.4** | **28.1** | **6.6** | **145** |
| **January 2023 second harvest** | | | | | | | | | |
| **Pivot** | **Area ha** | **Closed Date** | **Harvest Date** | **Days** | **As harvested T** | **T/ha** | **DM %** | **DM T/ha** | **PGR kg/ha.day** |
| 13 | 39 | 10/12/2022 | 14/01/2023 | 34 | 848 | 21.7 | 25 | 5.4 | 160 |
| 14 | 49 | 7/12/2022 | 11/01/2023 | 34 | 1100 | 22.4 | 25 | 5.6 | 165 |
| 15 | 49 | 8/12/2022 | 12/01/2023 | 34 | 711 | 14.5 | 30 | 4.4 | 128 |
| 16 | 39 | 9/12/2022 | 13/01/2023 | 34 | 853 | 21.9 | 26 | 5.7 | 167 |
| 17 | | | | | | | | | |
| 18 | 40 | 5/12/2022 | 10/01/2023 | 35 | 860 | 21.5 | 25 | 5.4 | 154 |
| **TOTAL** | **216** | **7/12/2022** | **11/01/2023** | **34** | **4372** | **20.2** | **30.9** | **6.3** | **184** |
| **February 2023 third harvest** | | | | | | | | | |
| **Pivot** | **Area ha** | **Closed Date** | **Harvest Date** | **Days** | **As harvested T** | **T/ha** | **DM %** | **DM T/ha** | **PGR kg/ha.day** |
| 13 | 39 | 14/01/2023 | 13/02/2023 | 29 | 633 | 16.2 | 29.9 | 4.9 | 167 |
| 14 | 49 | 11/01/2023 | 12/02/2023 | 31 | 642 | 13.1 | 31.3 | 4.1 | 132 |
| 15 | 49 | 12/01/2023 | 13/02/2023 | 31 | 547 | 11.2 | 29.7 | 3.3 | 107 |
| 16 | 39 | 13/01/2023 | 14/02/2023 | 31 | 464 | 11.9 | 29.9 | 3.6 | 115 |
| 17 | | | | | | | | | |
| 18 | 40 | 10/01/2023 | 12/02/2023 | 32 | 521 | 13.025 | 33.6 | 4.4 | 137 |
| **TOTAL** | **216** | | | **31** | **2807** | **13.0** | **33.1** | **4.3** | **140** |

## Table 30. Grass silage costs of production

| | **Grass silage program summer** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Cost of Production** | | | | | | |
| | | **Dec-22** | | **Jan-23** | | **Feb-23** | |
| | Yield as harvested T/ha | | 23.4 | | 20.2 | | 13.0 |
| | DM T/ha | | 6.6 | | 6.3 | | 4.3 |
| | ME MJ/kg DM | 8.7 | | 8.0 | | 9.1 | |
| | **COSTS** | | **$/ha** | | **$/ha** | | **$/ha** |
| Fertiliser | Yara N | | 317 | | 120 | | 102 |
| Fertiliser | Grass mix | | 169 | | 128 | | 141 |
| Fertiliser | Urea | | 63 | | 63 | | 0 |
| | General overheads | | 25 | | 19 | | 17 |
| | R&M /variable | | 338 | | 255 | | 233 |
| | Labour | | 94 | | 71 | | 65 |
| | Depreciation | | 69 | | 52 | | 52 |
| | Harvest | 137235 | 624 | 118367 | 538 | 112810 | 522 |
| | | $ | 1699 | $ | 1246 | $ | 1132 |
| | **Cost/T ensiled** | **$** | **72.61** | **$** | **61.56** | **$** | **87.08** |
| | **Cost/T DM** | | **258.39** | **$** | **199.23** | **$** | **263.07** |
| | **ME Cents/MJ** | | **3.0** | | **2.5** | | **2.9** |

## 4.6 Gastrointestinal parasitism

### 4.6.1 Key messages

- The epidemiology and management of gastrointestinal parasitism remains to be resolved, including any association with diarrhoea and production loss in summer.
- KB cattle are more resistant to parasites than are PB.

### 4.6.2 Background

These observations and reflections are included to document an unexplained syndrome over summer circumstantially associated with gastrointestinal parasitism (worms). Further research would be required to explain this, including aspects of anthelmintic resistance.

Only towards the end of the first 3 years of the project did the number of Wagyu weaner cattle become significant to the extent that higher stocking rates were being maintained on pastures and worms potentially become a production-limiting issue.

Over this time smaller mobs of weaners had subjectively benefited from treatment in mid-winter (June), presumably when pastures were shorter and accessible worm larval numbers on pasture had increased. Clinical signs were not evident and growth rate reduction not measured but minor if parasitism was having an effect.

### 4.6.3 Early observations on parasite ecology

In June 2018 a worm egg count (WEC) was performed on a group of 400 young Wagyu purebred cattle weaned at approximately 6 months of age in January 2018. At weaning they had been treated with the anthelmintic doramectin pour-on. They appeared in good health and were gaining weight. They had been grazing irrigated Rhodes grass pastures in a rotational program over the period. The WEC average of 603 eggs per gram (epg) with a range of 0 – 1900 epg of 12 individual samples could be considered relatively high, but significance would depend on the species of worm involved.

Larval differentiation was obtained from DPIRD Parasitology laboratory, indicating the species present (Table 31).

**Table 31. Gastrointestinal parasite larval differentiation Pardoo June 2018**

| Species | Ostertagia | Trichostrongylus | Haemonchus | Oesophagostomum | Cooperia sp. |
|---|---|---|---|---|---|
| **Total : 100%** | 0% | 0% | 75% | 8% | 17% |

The WEC was not excessive considering the prolific egg-laying of Haemonchus, the predominant species at the time. However, the potential for sudden high levels of larval acquisition and acute parasitism was recognised. The decision was made to monitor WEC of the cattle monthly, whilst monitoring health and performance. Unless otherwise mentioned. WEC are an average of 12 individual samples. Additionally, the proportion of these positive is recorded (Table 32).

**Table 32. Sequential WEC for untreated weaner Wagyu cattle 12-24 months of age, grazing irrigated tropical pasture.**

| Date | WEC average | WEC range | WEC positive (number/12 samples) |
|---|---|---|---|
| **01.06.18** | 603 | 0 - 1900 | 11 |
| **12.07.18** | 693 | 150 - 1620 | 12 |
| **07.08.18** | 115 | 0 - 420 | 9 |
| **11.09.18** | 135 | 0 - 840 | 8 |
| **28.11.18** | 35 | 0 - 150 | 6 |
| **04.02.2019** | 40 | 0 - 240 | 5 |
| **28.03.2019** | 70 | 0 - 360 | 6 |
| **30.05.2019** | 233 | 0 - 660 | 11 |

The results (Table 32) were instructive in that within 2 months the WEC dropped abruptly and remained low through the following summer, until in May 2019 at about 24 months of age WEC increased significantly. Cattle were still gaining weight. At that time, possibly for the first time the available pasture had become lower in height (to 5 cm) and biomass and the opportunity for larval acquisition much greater. The increase in WEC was unusual in that the cattle should have attained their well-developed age-related immunity.

The cattle were treated again with the same anthelmintic, and the opportunity taken to gain some indication of possible parasite resistance to the active ingredient doramectin. This compound is widely used in the northwest cattle industry on account of its novelty and convenience of application, injectable or pour-on.

A field faecal egg count reduction test (FECRT) was conducted, the results (Table 33) indicating either developing resistance and/or careless application – the latter not unlikely. WEC reduction of 80% was recorded.

With a random 12 cattle sampled at each date, FECRT accuracy would be less, and approximate only; however, experience was that such a test remained a reliable indicator.

**Table 33. Field FECRT Doramectin pour-on efficacy June 2019 Pardoo**

| | **Worm Egg Count (WEC) eggs per gram** | |
|---|---|---|
| **Date :** | 31.05.19 | 25.06.19 |
| | Pre- treatment | Post-treatment |
| **AVERAGE** | 233 | 48 |
| **WEC positive** | 11/12 | 5/12 |
| **WEC % reduction** | | 80% |

At first consideration, the apparent minor impact of worms on young growing cattle in the seemingly dangerous environment was surprising, with a number of factors possibly ameliorating the availability of infective larvae:

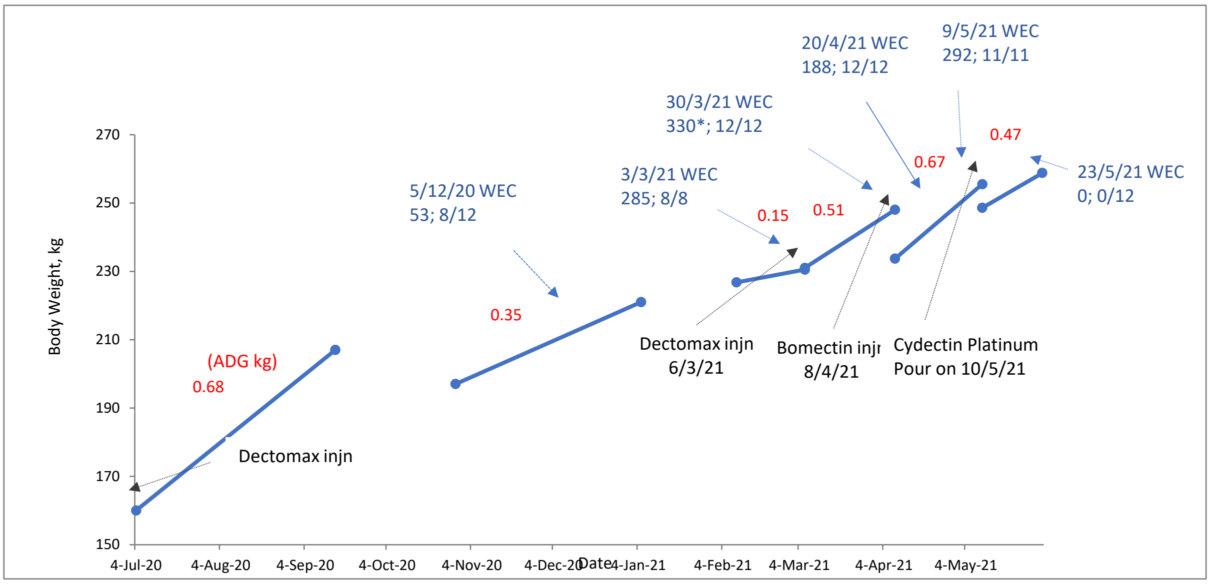
- Residual pasture height was often 15 cm and higher.
- Pasture bulk density was low.
- Utilisation (proportion of pasture on offer eaten) was routinely low, as is typically the case with tropical pastures. Although difficult to precisely quantify, utilisation was often estimated as below 40%.
- The avoidance of excreta-affected pasture areas was very strong and extended to more than twice the area of the faecal deposit.
- Cattle tended to camp on bare ground adjacent to the pasture, and a significant proportion of dung was deposited there rather than on the grazed pasture.
- High soil and ambient temperatures for much of the year might not favour larval survival.

Despite this, it was recognised that parasitism could well be a problem. Subsequently parasitism was associated with a syndrome including some production loss, not fully elucidated at the end of the project.

### 4.6.4 The emergence of apparent significant parasitism

By 2020, approximately 2000 Wagyu weaners were grazing in increasing numbers from June. They were treated with doramectin on entry to grazing. Growth rates were good till the following January and WEC low till December, although some diarrhoea was noticeable. During February the cattle appeared unhealthy, and the incidence of diarrhoea increased. At the same time Buffalo fly irritation was clearly increasing in severity and heat load effects would also have been having a deleterious impact. Weighing confirmed a February reduction in growth rates and WEC had increased, although not to a level considered high by parasitological standards (Fig. 19). WEC to December did not indicate an impending problem, and any signs perhaps obscured by unplanned and stressful cattle movements associated with protection from the effects of two separate cyclone threats.

**Figure 19 : Weaner PB steers weight, WEC and anthelmintic treatments July 2020-June 2021.**




Worm egg counting before and after two anthelmintic treatments in March provided strong circumstantial evidence that there was significant resistance in the parasite population to doramectin, the active compound in the drench used. For the steer weaners, WEC rose from 53 to 285 epg from December 2020 to March 2021. WEC 25 days after treatment with doramectin injection was 330 epg, raising some concern (Fig. 19).

It was so unusual that the possibility of long-term improper storage was considered – the drench had been in a metal container, subject to extreme heat for at least a year. Also, there was always the possibility of larval pick-up following treatment as could be the case with the 25-day interval from treatment to sampling. Injectable ivermectin was obtainable locally and the cattle treated again. Twelve days following that, the WEC was 188 epg and it was clear that the ML class of anthelmintics was inadequate. Two weeks later, a dual active compound (moxidectin and levamisole) was obtained, and the cattle treated; by this time WEC had risen to 293.

13 days later WEC was 0.

The measurements made to diagnose the existing worm resistance status are summarised in Fig 19. They point to what were seemingly highly resistant strains of both *Haemonchus contortus* and *Cooperia* spp., the latter not clearly defined as to species. This high level of resistance apparent in both species would be unique in the literature. Two post-drench larval differentiations of species reported *Haemonchus contortus* 86% and 80% and *Cooperia* spp. 14% and 20%, respectively.

These “field” egg reduction tests indicated a more serious case of drench failure than that measured two years earlier.

The prolonged pasture contamination because of inability to diagnose and treat the problem promptly may have been a factor responsible for ongoing cattle loss of production for the rest of the year. Infective larval numbers on pasture would have been accumulating over January and February with the high stocking rates. Pasture larval numbers would very likely have been high and infective larval intake overwhelmed cattle immunity. The effects could have been significant, with escalating pasture contamination caused by serious anthelmintic ineffectiveness not confirmed and rectified until May.

Awareness of possibly severe anthelmintic resistance resulted in less convenient and more expensive chemical control of worms for cattle on the irrigated pastures.

More importantly, it pointed to the impossibility of relying long term on chemical control of worms.

Methods attempted in the short term to manage the situation for grazing cattle included frequent (fortnightly) monitoring of WEC and treating with the drench combination when WEC demonstrated a rise. Efficacy of treatments was confirmed by WEC 12-14 days following with zero the consistent result. Spelling of pastures was not possible as frequent rotations were necessary on the irrigated tropical pastures. Where possible pastures likely to be less contaminated were selected, on the basis of the historical WEC of mobs, usually older or crossbred cattle.

Whereas much work has been done to inform such parasite management for intensively grazed sheep, by comparison little is documented in the case of cattle, particularly for intensive grazing on tropical irrigated pastures in the Pilbara. Pardoo will need to engage with this. There are large knowledge gaps, although principles are well known and encouraging information has been published relating to tropical environments. For example, the consistently hot and regularly moist pasture environment will be associated with much reduced infective larval life span, which may be able to guide cattle exposure (for example Lau *et al*, 1985, Fabiyi *et al* 1988, Waller, 1997).

As cropping increases in proportion of land use, strategic cropping and pasture rotations will certainly aid worm management.

It is a possibility that that the worm population resident on the pivot pastures arrived with the purchased heifers. One mob at least from the Northern Territory did have a low WEC. Reported long-term anthelmintic use for purchased cattle was like that in WA: Dectomax injectable or pour-on at a dry seasonal time. We now know this favours the development of resistance to any anthelmintic used. Alternatively, the worm population could be derived from the original Pardoo herd, or early cattle trading introductions. Worm genetics of unknown resistance status can arrive with any introductions.

The resistance status or degree of anthelmintic effectiveness for Pilbara and Kimberley worm populations was not known. To this end a brief survey of surrounding station cattle populations as well as Pardoo and sampling of available cattle before and after treating if practised was attempted.

Faecal samples from recently mustered cattle on 8 Kimberley or Pilbara Stations, representing 13 mobs, were tested for WEC. Eggs counts were relatively low (all positive, average 87, range 34-178 epg). The majority did not routinely drench weaners.  Of the 2 stations where drenching was practised, the degree of WEC reduction approximately 12-14 days after treatment indicated some degree of reduced anthelmintic effectiveness, typically around 80% reduction. It was recognised that this was not an accurate representation with low egg count and sample size rather than individual samples but pointed to the situation of consistently less than 95% WEC reduction for doramectin, the anthelmintic used in each case.

### 4.6.5 Worms – Breed differences

Over the course of managing parasitism, the opportunity arose in May 2021 to measure worm egg counts (WEC) from a mixed mob of PB and KB cattle The results of this are shown in Table 34, illuminating that the PB had significantly higher WEC than the KB grazing the same pastures. It can only be presumed that a lesser immunity in the breed was associated with more adult worm activity, as typically displayed by more numbers and/or greater egg-laying activity.

**Table 34. Field Worm Egg Counts (WEC) on mixed mobs May 2021**

| Date | 28/4/21 | 22/5/21 | 27/6/21 |
|---|---|---|---|
| WEC epg | (mob)<br>15 | (mob)<br>108 | PB 429<br>KB 240 |

Historically the Wagyu breed of cattle would not have experienced an environment conducive to the lifecycle of gastrointestinal parasites. The opportunity for stimulus to acquire some genetic immunity to gastrointestinal parasites would not have traditionally been available.

### 4.6.6 Additional comment on parasite response and anthelmintic resistance

1. The syndrome cannot be explained, despite the parasitological associations recorded. Observations did not fit the recognised hypersensitivity response of sheep to worm larvae, manifest as diarrhoea (Williams and Palmer 2012, Jacobson et al 2020). This has not been described in cattle as a syndrome. The cause of scouring remained a puzzle. The possibility that heavy larval intake was responsible for both production effects and scouring is a second-order possibility and would be considered only once other causes were eliminated (Appendix 8.5 Besier pers.comm).

2. It is likely that anthelmintic resistance was present to the ML types used, but the counts of pathogenic *Cooperia* worm species were very low (ie, when counts of *H.placei* were removed). The age of the cattle involved is also surprising for a worm effect, as many would be expected to have developed a good natural resistance to infection by this time (Appendix 8.5 Besier pers.comm).

3. It would not be surprising for resistance to be common in pastoral WA and across northern Australia. Resistance to the macrocyclic lactone group which includes doramectin has been detected in 66% of farms tested in south-west WA, to *Cooperia oncophera* (Cotter et al 2015). It is also common in north coastal NSW, New Zealand and globally. The resistance status of *Cooperia* populations in northern Australia is unknown, a concern as anecdotally doramectin is the most common drench used on account of its persistent activity and convenience of use (injectable). Extra exposure of worms to the compound in tick-prone areas of Australia would be a factor in hastening the development of resistance as doramectin is recommended as a component of tick management. As an additional consideration the treatment time at weaner muster typically coincides with the dry season. It is this practice of "summer drenching" which has led to rapid selection for anthelmintic resistance in south-west WA (Besier 2001).

4. Further opportunities to observe the syndrome did not eventuate as subsequently young cattle were retained in a feedlot for the following season mainly because the grazed tropical pastures failed to provide for a growth rate adequate for heifer joining at 15 months of age.

5. Plans to implement parasite management on grazed pastures were thwarted by the destruction of 19 of the 20 pivots in a severe cyclone in April 2023; restored pastures were of necessity prioritised for fodder production rather than grazing. The strategies were to include:
    - Retaining the small worm burden typical of weaners as long as possible before treating and moving to pasture. This may augment the development of immunity. The work of Barger (1988) showed that moderate burdens of *Haemonchus contortus* in young sheep stimulated the development of protective immunity, compared with suppressively drenched counterparts.
    - Delay grazing until cattle weighed 200 kg and were in condition score 3.
    - Utilise pastures from which silage or hay, or a crop had been harvested in the preceding summer.
    - Manage grazing to avoid grazing close to the ground – to avoid faeces from other infected livestock.
    - Confirm zero WEC before entry to minimise and delay increasing pasture contamination by infective worm larvae.
    - Monitor WEC fortnightly to forestall impending larval deposition. Treat and confirm with an effective drench if indicated.

The worm control program had the aim of minimising the pickup of infective larvae in order that immunity can develop without cattle being overwhelmed by excessive intake from pastures. In hindsight this was very likely the situation a year earlier when the weaners were noticed to be scouring excessively and weight gains dropped. Egg counts were not high at this stage, but it is likely that the scouring indicated very high infective larval intakes, with consequent severe gut wall inflammatory response. Reduced appetite and loss of protein as well as the very significant demands of the hyperimmune response result in the loss of production. This phenomenon is well recognised and researched in sheep.

### 4.6.7 Autopsy information

The opportunity arose in early February 2022 within one week to autopsy 3 steers from the problem group, with the possibility of elucidating any underlying pathogens. Results are briefly summarised:

Steer 1 (chronic ill-thrift):

- Chronic bronchopneumonia and pleurisy.
- Duodenal enteritis and associated lymphoid hyperplasia. Amongst other potential causes parasitic damage was identified as a possibility.

Steer 2 (found dead):

- Minor pathology.
- Mild duodenal enteritis as in steer 1.
- Cause of death unknown.

Steer 3 (recumbent, convulsive):

- Neurological signs relate to a small focus of acute polioencephalomalacia. Cause unknown.
- Intestinal enteritis, *not* typical of nematode enteric parasites.

Bacterial causes of diarrhoea were not found in any of the cases.

For all three trace element levels were satisfactory.

It was hoped that the opportunity to autopsy 3 steers from a class of cattle chronically underperforming would provide some useful information, particularly about enteric parasitism. For this, tests were not definitive. Some potential causes were ruled out, but the background to the abnormal diarrhoea was yet to be explained.

# 5 Conclusion

## 5.1 Key findings

- Identification of key inputs to irrigated tropical pastures, together with plant and soil responses, provided the basis for sustainable forage and crop production.
- The West Canning Basin aquifer has significant beneficial nutrients for agriculture, in association with sufficient neutralising carbonate to maintain favourable soil pH in association with high production.
- High annual levels of dry matter were produced over six years. Yield of forage was greater under conservation management, including better retention of nutrients.
- Under grazing management there is evidence that nitrogen loss through volatilisation was at the higher end of published estimates.
- Wagyu and Wagyu cross cattle growth rates grazing well managed tropical pastures were in line with nutritional expectations; however, this was insufficient to meet the requirements for heifers to be joined at 15 months of age.
- TMR rations based on forages or crops enabled adequate cattle growth rates at comparable cost.
- The significance of gastrointestinal parasitism for young cattle grazing irrigated tropical pastures was not adequately explained and remained a concern particularly for Wagyu cattle.

## 5.2 Benefits to industry

For the beef industry in northern Australia, significant practical information on forage production from irrigated tropical grasses in the Pilbara together with soil and fertiliser interactions was generated. Associated with this was the physical and economic performance of Wagyu and Wagyu cross cattle under grazing and feedlot management. This has relevance to beef production systems in related challenging northern Australian environments, particularly those seeking markets alternative to live export.

For the Pardoo Wagyu program, confidence to proceed with expansion and investment was enabled given the associated data and analyses produced.

# 6 Future research and recommendations

1. Other than maize primarily for silage, crops other than tropical grass were not evaluated. The opportunity exists for a variety of crop rotations over the summer/winter seasons to exploit the resources of water and temperature more fruitfully. For example, Garcia et al (2008) demonstrated conclusively that, for the same amounts of water and nitrogen, a three-crop rotation yielded more than double the DM and energy yield compared with kikuyu/ryegrass pastures. Potential crops as components of rotations might be winter cereals (barley, oats) and herbs (chicory, plantain) as well as tropical legumes such as Cavalcade (*Centrosema pascuorum*) and newer varieties of Sorghum.
2. Incorporating legumes into tropical grass pastures has been suggested as beneficial, but yet to be satisfactorily demonstrated in practice to be advantageous; this clearly would require research before investment in adoption.

3. Nitrogen loss particularly in grazed pastures is likely to be at the higher end of published estimates, the environment of climate and soils aligning to favour volatilisation. Identification of this is recommended if grazing of tropical pastures becomes more common.
4. The ecology of gastrointestinal parasites and any associations with diarrhoea and production loss for young cattle grazing at high stocking rates on irrigated tropical pastures were not explained. The attributes of Wagyu cattle compared with other breeds in this regard is of interest. Research on this would require resources not currently available in Australia.

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# 8 Appendices

## 8.1 Irrigation water nutrient and lime levels

| Nutrient | Average (range) mg/L Bores PB1 – PB11 | Average quantity applied kg/ha/year @ 17ML/ha | Satisfactory pasture level (%) | Annual requirement /ha (kg) @35T/ha DM grazed pasture | Current annual amount applied (kg/ha) | Potential value/year /ha ($) |
|---|---|---|---|---|---|---|
| Potassium (K) | 6.5 (5.9-7.7) | 110.5 | 1.75 | 400 | 400 | $330 |
| Sulphur (S) | 31 (21-47) | 527 | 0.20 | 70 | - | $54 |
| Magnesium (Mg) | 15.4 (9-28) | 262 | 0.15 | 52 | - | $112 |
| Boron (B) | 0.2 (0.17-0.22) | 3.4 | 5 (mg/kg) | 0.17 | - | $2.60 |
| Phosphorus (P) | <0.01 | n/a | | | | |
| Nitrogen (N) as $NO_3$ | <0.5 | n/a | | | | |
| Lime ($CaCO_3$) | 141 (95-240) | 2400 | n/a | 500? | - | $60 ? |

## 8.2 Cattle liveweight mineral and nitrogen content estimate

**Mineral and Nitrogen content estimates (modified from Grace 1983)**

| | | | | Element (g/kg) | | |
|---|---|---|---|---|---|---|
| Organ | fresh weight g | CP% | N g | P | K | Ca |
| Liver | 724 | 17 | 19.7 | | | |
| Heart | 214 | 26 | 8.9 | | | |
| Brain | 94 | 5 | 0.8 | | | |
| Spleen | 68 | 10 | 1.1 | | | |
| Pancreas | 60 | 10 | 1.0 | | | |
| Kidneys | 129 | 10 | 2.1 | | | |
| Digestive tract | 2842 | 15 | 68.2 | | | |
| Lungs | 537 | 10 | 8.6 | | | |
| Muscle | 21488 | 26 | 893.9 | | | |
| Bone | 4948 | 0 | 0.0 | | | |
| Skin | 2000 | 30 | 96.0 | | | |
| Fat | 1298 | 0 | 0.0 | | | |
| Blood | 3054 | 0 | 0.0 | | | |
| Gut contents | 3500 | 0 | 0.0 | | | |
| TOTAL | 40956 | | 1100.2 | | | |
| **N, P, K, Ca g/kg liveweight** | | | **27** | **5.2** | **2.1** | **10.5** |

## 8.3 Nitrogen pathways and utilisation in irrigated tropical pastures at Pardoo: a review

Summary

A review of nitrogen pathways and potential utilisation by cattle grazing irrigated tropical pastures in the Pilbara indicates that loss from the system is likely more than 70%.

The proportion of nitrogen captured in cattle liveweight is of the order of 5 to 7%.

An estimated nutrient budget for grazed pastures indicates potentially 25% of nitrogen is unaccounted for.

Harvesting and feeding forage in a balanced ration increases the efficiency of nitrogen use.

Background

Nitrogen (N) is a key driver in production in all grass and cereal production systems, particularly so in tropical climates where the response is potentially so much greater. As one of several necessary nutrients required, it is the most expensive fertiliser input – for Pardoo approximately 60% of fertiliser cost and 30% of total pasture production costs (Table).

Since inception of irrigated pasture production at Pardoo, N application rates have been informed by limited local trial data, industry recommendations based on a range of trials, and sometimes ill-informed advice. Currently application rates and method are relatively stable and reflect experience and relevant industry trial results.

It is recognised that N balance can be particularly inefficient in grazed pasture systems, more so in hot climates and particularly for pivot-irrigated tropical pastures. Whilst N balance has not been determined at Pardoo, some estimates can be inferred from a range of research work in variety of climates. Being aware of this should aid better use of fertiliser N.

Following fertiliser application, N losses from soil before plant assimilation are not accounted for; numerous studies have found that this can be considerable, more so with broadcast urea application. Currently at Pardoo with the use of ammonium nitrate N losses at this stage should be minimal.

A figure of approximately 35000 kg/ha/year of pasture is estimated to be grown under good grazing management. Healthy grass and legume pastures typically have crude protein levels of 15 to 25%. This applies to temperate and tropical pastures. Analysis of healthy Pardoo pastures confirms this; leaf most commonly has a N level of 3.0 to 3.2%, (19 to 20% crude protein).

Cattle intake and excretion of nitrogen – the reality.

Of this pasture, it is estimated that with good grazing management, of the order of 60% is eaten by cattle. Thus 1050 kg of N is captured by the grass, of which 630 kg is eaten by cattle. The remainder is trampled, fouled by dung and rejected, primarily the stem fraction. These adverse effects exceed the potential positive effect of nutrient return through excreta (Nevens and Rehoul 2003).

This uneaten grass becomes litter, itself a nitrogen sink as it decomposes (Robbins et al 1989), although returning a proportion of N to the nitrogen pathway.

It is estimated that cattle grazing pivot irrigated pastures locate to bare/bush areas off the pasture for most of the time they are not grazing; grazing time for cattle is a maximum of 12 hours/day, and probably less for most of the time (Chacon and Stobbs 1976; Chacon et al 1978). An estimate of 50% of time off pasture results in 50% of nutrients eaten, minus a small amount retained, being not returned to pasture and therefore lost to the pasture nutrient cycle.

Consider a 300 kg Wagyu steer gaining 0.2% bodyweight on a good Rhodes grass pasture of 3% N and 9 MJ ME. Daily intake is around 7.5 kg pasture DM to give 0.6 kg ADG. One kg of liveweight contains about 2.5% N, therefore of the 225 grams of N eaten per day 15 grams (6.7%) is retained. The remainder (93%) is excreted. The majority of this is in urine, in the form of urea – likely to be 90% of the urinary N. As explained N loss through volatilisation is relatively high from urine patches.

Even high producing dairy cattle on pastures of relatively high digestibility cannot retain N and most of that consumed in the diet is excreted.

**Pathways of nitrogen loss**

*Transfer to non-pasture areas*

- The major pathway of loss. It is estimated that possibly 50% of all nutrients are lost this way, with cattle electing to choose surrounding bare ground and bush when retiring from grazing to rest and ruminate – and excrete. A typical time grazing each day on tropical pastures might be up to 10 hours, increased time being in response to low pasture availability; 12 hours would be an absolute maximum.

*Volatilisation as ammonia gas*

- This would be significant, but possibly less so now with the use of ammonium nitrate as fertiliser. Although loss at application is eliminated (compared with urea), significant loss takes place from urine patches.
- Rates of ammonia loss are greatest whilst cattle are grazing, reflecting the rapidity of urea hydrolysis after urine deposition – greater than 80% within 2 hours and largely complete within 24 hours. Losses as ammonia volatilisation are also rapid, more than half of the process occurring within 2 days of urine deposition (Vallis et al. 1982). It has been estimated that 50% or more of urinary N can be lost in this manner.

*Leaching to a depth in soil beyond the root zone.*

- With good irrigation practice, leaching should not be significant over an annual period with low rainfall and few heavy rainfall events. Occasional only.
- Monitoring of irrigation and soil moisture aims that water and therefore soluble nutrients are confined to the top 1.5 metres of soil; Rhodes grass and other tropical pasture grass roots can be identified to access to a depth of 2 metres where moisture is available.

*Denitrification*

- Not likely in Pardoo soils – not waterlogged and presumed aerobic conditions would not favour denitrifying bacteria.

**Factors favouring volatilisation (all prominent at Pardoo):**

- high urinary N content
- alkaline soils
- high temperatures

- high wind speeds
- soils with low cation exchange capacity
- rotationally grazed pastures
- high pasture litter loads

It follows that the N volatilisation losses from Pardoo intensively grazed and managed pastures will be at the higher end or greater than established figures.

**Discussion and some relevant studies**

The N derived from fertiliser and recovered in intensively managed tropical pastures can be low in the short term. Martha et al (2004) from studies on pastures in Brazil concluded that more than 60% of fertiliser was found in the soil and non-harvestable portions of the plant (stubble, roots, and litter). Clearly this would in time eventually become available to pasture plants but could remain susceptible to losses such as leaching and denitrification. Tropical grass roots decompose very slowly.

The short regrowth time after the addition of fertiliser, less than one month (17 days summer, 20 days autumn) and the severity of defoliation for tall tussock grasses (250mm) would have limited N fertiliser response in these grazing trials.

With increased plant maturity there is a fall in the N concentration of the plant. Also, as the plant matures there is a decline in the minimum quantity of N required per unit of assimilated carbon to give the maximum growth rate. Thus, N productivity increases with plant growth. However, the amount of regrowth in a direct grazing system must be managed to an amount less than half typical conservation yields to avoid substantial physical losses and hence N utilisation under grazing is curtailed.

Prasertsak et al. (2001) studied the fate of urea applied to a Setaria pasture in the wet tropics of Queensland, in the absence of grazing animals. Pasture plants took up 42% of the applied N in the 98 days between fertiliser application and harvest. At harvest 18% of the applied N was found in the soil, and 40% was lost from the plant-soil system. A micrometeorological study showed that 20% of the unrecovered N was lost by ammonia volatilisation.  As there was no evidence of leaching or runoff losses it was concluded that the remaining 20% of applied N was lost by denitrification.

As denitrification takes place almost exclusively in anaerobic conditions, it is an unlikely pathway of N loss in the sandy Pilbara soils.

Laubach et al (2013) measured ammonia emissions from urine and dung excreted by cattle eating fresh ryegrass/clover pasture, during grazing and for 10 days afterwards. Total N volatilised as ammonia was 19.8% of N intake and 22.4% of N excreted. The cattle excreted 88.5% of N eaten.

Broadcasting urea onto grass pastures has been often reported to result in large losses of N by ammonia volatilisation, particularly associated with soil dampness without sufficient moisture to convey urea and nitrate into the soil. This occurs because the plants and surface litter have high urease activity.

Plant material has an effect on ammonia volatilisation from urine patches (Whitehead and Raistrick 1992). With reference to a 5 to 6 cm ryegrass pasture, the volatilisation of urinary ammonia was 39% from bare soil and 23% in the presence of ryegrass. Plant litter also had an effect, volatilisation being increased by dead litter on the soil surface. High litter loads, observed on Pardoo pastures, are common on tropical grass pastures particularly if grazing management is lax.

Relevant to the Pardoo discussion comparing grazing compared with cut and carry systems, Neven and Rehoul (2003) concluded that N use efficiency was considerably higher in cut grassland systems than in grazed pastures, even when the animal component of a cut and conservation system was included.

Total grass yields of energy and N were calculated by measuring heifer performance during grazing - production/head x stocking rate x days.

Heifer performance was measured by daily energy demands of growing and grazing heifers (Dutch system). The cutting performance was measured by reference to the net energy for lactation.

Compared with the cut plots, over 3 years the grazed plots yielded approximately 0.80 net energy for lactation. N yields as measured by liveweight gain were very small, 0.06 – 0.08 of those from the cut plots. eg 25 kg N/ha/year compared with 400 kg N/ha/year.

There were discrepancies between observed N yield and net energy yield due to heifer liveweights and liveweight gains. N yields only comprise the liveweight gain while energy yields comprise energy needed for both liveweight gain and maintenance. Heavier and/or slower-growing animals use relatively more energy for maintenance than for growing; hence they yield less N per unit of net energy.

The lower yields under grazing result from the higher frequency of defoliation and the adverse effects on the sward through treading, selective grazing and fouling of herbage by dung. These adverse effects exceed the potential positive effect of nutrient return through excreta.

Restricted to the grassland area only, overall N use efficiency (N-out:N-in) on cut plots was 10–12 times higher than on grazed plots. However, when feeding the cut grass to livestock was included in the calculation the ratio was only 2-4 times higher.

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## 8.4 Faecal Worm Egg Counting - Cattle

### Individual technique

1. Collect 12 individual samples from paddock or rectum.
2. From each sample weigh 4 grams at 0.1 g accuracy into 70 ml specimen containers.
3. Add about 5 ml of water to each sample to soak and aid mixing.
4. Complete mixing using the plunger of a 10- or 20-ml disposable syringe or similar. A small volume of saturated salt solution can be added at this stage to further aid stirring and mixing if required.
5. Top up four of the specimen containers to 60 ml with saturated salt solution. This is to enable counting the eggs within 45 minutes of adding the saturated salt solution.
6. Mix the contents further by stirring and inverting several times, not too vigorously so as not to create excessive air bubbles.
7. Immediately withdraw an aliquot of at least 0.5 ml and fill one chamber of the counting slide.
8. Repeat this procedure for the next 3 samples, filling the remaining 3 chambers of the slide.
9. Count the eggs at 40 x or 100 x magnification.
10. Repeat procedures 6. to 9. for the remaining two groups of 4 specimen containers.
11. In the case of the Universal counting slide, with 0.5ml chambers, each egg represents 30 eggs per gram (epg).

### Bulk Technique

Advantages

- Quicker in the laboratory, encourages more frequent sampling.
- An opportunity to sample more cattle, with an improvement in accuracy of whole herd egg output and pasture contamination rate.

Limitations

- Distribution of individual cattle worm egg production not measured.

Where monitoring of pasture contamination is a priority the bulk technique is preferred, combined with the standard measuring of individual samples at intervals to verify WEC distribution among individuals.

### Method

1. Collect 20 individual samples as normal from paddock or rectum.
2. From each sample weigh 4 grams and add to a jar or beaker about 600ml in volume. The vessel has a line marker indicating 200ml volume.

3. Make volume up to 200 ml with water.
4. Mix the contents of the jar with a hand-held kitchen mixer.
5. Take four subsamples of 10 ml of the mixture with a kitchen measuring spoon or modified syringe and add to each of four 70 ml specimen containers.
6. Top up each specimen container to 60 ml with saturated salt solution.
7. Mix the contents of each container as normal and add to each of the 4 counting chambers of a Universal counting slide. As for the individual technique each egg represents 30 epg.
8. Average the 4 counts to calculate the mob average WEC in epg.

In theory each chamber should yield a similar egg count and the 4 counts give a satisfactory level of accuracy.

## 8.5 Pardoo station – cattle worm problem?

**- Opinion, Brown Besier**

(Comments based on conversations and written advice from Dr K Bell.)

Background

Worm infections of some level would be expected in this situation, as:

- The cattle of this age (most now > 18 months) are towards the end of their juvenile worm susceptibility, as the relatively strong natural resistance typical of adult cattle would be expected to have developed at their present age.
- The environment is extremely favourable for worm development, due to the green pastures, relatively mild seasonal temperatures, and the very high stocking rates. The very high temperatures of mid-summer would reduce the rate of worm egg development to larvae, but for most of the year, it would be very suitable for tropically-adapted worms (*Cooperia* and *Haemonchus*).

Likely effects on cattle growth rates

No effect on production would be expected for *Haemonchus placei* (especially at the trivial counts here for this species), and although *Cooperia* is considered as lowly pathogenic (much less than *Ostertagia*), some reduced weight gains related to *C.oncophora* have been shown in trials in NZ, and the tropical species (*C.pectinata* and *C.punctata*) are considered to be more pathogenic again.

However, the larval differentiation result for *Cooperia* (14% for the first, not yet reported for the second samples) constitutes a low proportion of a low count, and even if most of the most recent counts were *Cooperia*, it would still be at the low end of likely pathogenicity. (I would expect a mean of >300 epg before significant production effects from *Cooperia* was likely.)

It is possible that the development of worm immunity may be delayed or impaired due to a heavy intake of worm larvae, and that high rates of larval intake (“larval challenge”) has a role in diverting nutrients from growth. However, this has not been confirmed or quantified as a syndrome, although if it is present, it would be expected to reduce as age-immunity develops.

It is relevant that some improvement in weight gains was seen after ivermectin treatment, which obviously suggests a worm-related cause.

Scouring

This remains a puzzle, as although typically associated with worm infections, the counts (with *H.placei* removed) are relatively low. Presuming that other disease agents can be ruled out, and in the absence of known pasture types associated with diarrhoea, it could be speculated that a “larval challenge" effect may be responsible, similar to the larval hypersensitivity in worm-immune sheep. However, to my knowledge this has never been shown (or even suggested) in cattle, and must be a low possibility, and not to be considered until all other causes are dismissed.

Anthelmintic resistance

Resistance to MLs is very common in *Cooperia*, reported in Australia mostly in *C.oncophora* (most surveys have been conducted in winter rainfall regions), but also seen overseas in tropical *Cooperia* species (likely to be the majority here, but some *oncophora* are also probably present). Resistance has also been reported to *H.placei* in South America (not surprising, as we know it is common in *Haemonchus* in sheep, although the general effectiveness of MLs against *Ostertagia* in cattle is surprising, given the severity of resistance to *Teladorsagia* in sheep and goats).

Taken together, resistance would have to be the most likely explanation of the poor egg count reduction after ivermectin treatment in April (post-treatment counts at 5 and 12 days after treatment in heifers and steers, respectively), and also for doramectin, given the persistent activity claim of 21 days.

A point of interest is the likelihood of anthelmintic resistance in this worm population, as there is typically little use of anthelmintics in range cattle in WA. It would be useful to consider whether this has been introduced in cattle from Queensland (ML resistance is common, especially due to frequent use of moxidectin against ticks), or use in previous years in the Pardoo irrigation operation.

The results from treatment with Cydectin Platinum will be pivotal, as if counts are very low, the value of this combination anthelmintic will be obvious – the "cross-over" effect of activity of levamisole against ML-resistant worms, and for an ML against others, has been clearly shown in product development trials.

Unravelling the puzzle

In summary, it is likely that anthelmintic resistance is present to the ML types used, but the counts of pathogenic worm species are very low (ie, when counts of *H.placei* are removed). The age of the cattle involved is also surprising for a worm effect, as many would be expected to have developed a good natural resistance to infection by this time.

In particular, the cause of scouring remains a puzzle. The possibility that heavy larval intake is responsible for both production effects and scouring is a second-order possibility and would be considered only once other causes were eliminated.

If the response to treatment with Cydectin Platinum does not confirm a worm effect, a treatment trial could be considered to relate the effect of anthelmintics to clinical signs. The large number of cattle available would allow for a good statistical sensitivity (25, even 50 per group?), and should include an equal number of scouring and non-scouring animals in each group (but otherwise randomly assigned, so that starting weights and worm egg counts are similar). However, this may be better conducted on a younger set of animals, to eliminate the age-immunity effect, which must be in place in most of these cattle by now.

The management of constant worm infections must be considered a routine requirement in this environment and management situation, and the preventative program must take account of the sustainability of frequent anthelmintic treatment. Monitoring of worm burdens will be essential, as the aim should be ensuring that counts do not reach pathogenic levels, rather than to maintain counts at very low levels. Critically, the relationship of worm burdens and treatment effects to scouring should be understood.

Brown Besier

Veterinary Parasitologist

13 May 2021

## 8.6 Feedlot rations

### Grass silage and corn ration

| **Feedlot rations Pardoo Steers** | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Grass silage and corn** | | | | | | | | | | | | | |
| | Cost of ration as fed | | | | | **% as fed** | **DM** | **DM** | **NDF** | | | | **Ration requ** |
| Feed ingredients | $/T | DM | ME/kg | CP % | NDF % | **kg** | | **%** | **%** | **ME MJ/kg** | **CP %** | **$/kg as fed** | **kg/hd/day** |
| Maize silage | 140.00 | 0.38 | 10.2 | 8.0 | 45 | 0 | 0 | 0.00 | | 0.0 | 0.0 | 0.00 | 0 |
| Grass silage | 90.00 | 0.30 | 8.7 | 11.0 | 65 | 48 | 14.4 | 0.24 | 15.5 | 2 | 2.6 | 0.04 | 3.48 |
| Corn | 458.00 | 0.88 | 13.0 | 8.8 | 12 | 38 | 33.44 | 0.55 | 6.6 | 7.2 | 4.9 | 0.17 | 2.76 |
| Lupin kernel meal | 710.00 | 0.90 | 14.5 | 42.5 | 20 | 12 | 10.8 | 0.18 | 3.6 | 2.6 | 7.6 | 0.09 | 0.87 |
| Premix | 1,050.00 | 0.90 | | | 90 | 2 | 1.8 | 0.03 | 2.7 | 0.0 | 0.9 | 0.02 | 0.15 |
| | | | | | **TOTAL** | **100** | **60.44** | **100** | **28.4** | **11.9** | **16.0** | **0.32** | 7.3 |

| | | | |
|---|---|---|---|
| Cattle class | PB steer | | |
| Cattle number | 2,500 | | |
| Weight (kg) | 140 | | 120-160 kg 60 days average |
| Days on feed | 40 | | |
| ADG (kg/day) | 0.85 | | |
| ME required (MJ) | 52.0 | FCR | |
| Daily intake est. (kg DM) | 4.4 | 5.2 | |
| Daily intake as fed (kg) | 7.3 | | |
| Feed Cost/day ($) | 2.35 | | |
| Feed Cost/kg ($) | 2.76 | | |
| L & M cost ($/day) | 0.45 | | |
| Total cost ($/kg) | **3.29** | | |