EVALUATION OF WYNN CASSIA
(*Chamaecrista rotundifolia*)
AS A PASTURE AND HAY CROP FOR THE DOUGLAS DALY AREA OF THE NORTHERN TERRITORY

DOUGLAS DALY PRODUCER INITIATED RESEARCH AND DEVELOPMENT PROJECT (FINAL REPORT)

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Table Contents

Table of Figures

INTRODUCTION

Wynn Cassia (WC) (*Chamaecrista rotundifolia),* also referred to as round leaf cassia, is an early flowering, heavy seeding, short-lived perennial legume. The species is native to tropical and subtropical North and South America. WC was collected from Sao Paulo, Brazil in 1964 and was released as a cultivar in Queensland in 1983. WC grows on a range of soil types but prefers sandy surfaced soils of neutral to acid reaction (pH 5.0 to 7.0). It grows in areas with 500 mm or less rainfall/year where it acts as an annual, regenerating from seed. However, WC is better adapted to areas receiving 900 to 1,500 mm of annual average rainfall.

WC is easy to establish, is a prolific seeder and persists on low fertility soils. It responds strongly to applied phosphorus and sulphur. It tolerates heavy grazing and spreads readily. It is these attributes that encouraged scientists and pastoralists alike to trial and promote WC as a pasture for tropical Australia.

WC and other *Chamaecrista rotundifolia* accessions were first evaluated in the Northern Territory between 1971 an 1976. WC was sown at all research centres from Berrimah Research Farm (BRF) to the Victoria River Research Station (VRRS). It grew well and persisted at all sites except VRRS. WC and eight other legumes were evaluated and compared in grazing trials at Beatrice Hill Farm (BHF) from 1991 to 1997. Legumes were planted with Kazungula setaria (*Setaria sphacelata*) in four hectare paddocks and grazed at 0.75-1.0 beasts/hectare. Results indicated that pastures with adequate soil nutrients which contained WC and a grass provided moderate to good animal productivity of between 0.5 and 0.8 kg/head/day over the growing season.

WC has been sown into improved and semi improved pastures in the Douglas Daly and Katherine regions over the past 20 years. Producers were impressed by its ease of establishment, its growth and proliferation under varied management. Gradually pastoralists noticed its dominance in certain situations. Many began to question its merits and whether cattle ate it at all or just selected the companion grasses. In situations of intensive grazing and set stocking, WC became the dominant species in many paddocks on some Douglas Daly properties. At local field-days and producer meetings the merits of WC were debated with opinions often divided.

The major concerns of producers are the ability of WC to produce large amounts of seed, dominate pastures and its inherent low palatability. While there are still mixed opinions as to which soil type WC prefers, there is no doubt that it is adapted to a wide geographical area and a wide range of soil types. WC grows on most soil types in the Top End. In the northern region of the coastal plains it persists on yellow podzolic soils which are seasonally waterlogged. WC grows equally well on the sandy red earths of the Douglas Daly region and the heavier Tippera clay loams around Katherine.

WC is a prolific seeder and establishes readily on practically any soil type. Flowering and seed set can occur within 40 to 60 days after rain. Its seed is spread by any physical movement, including stock, slashing, grading and in hay. WC is now prevalent along most roadsides in the Top End. While producers acknowledge WC has some value as a pasture, soil stabiliser, competitor with weeds and nitrogen fixer, they are concerned about it continuing to invade and dominate productive pastures.

As a result of concerns over WC the community submitted a proposal to Meat and Livestock Australia (MLA) for a Producer Initiated Research and Development (PIRD) project. The objective was to learn more about WC, its management and determine its value as pasture and fodder crop under commercial conditions. The project ran from August 2001 to November 2003.

Two grazing trials were conducted where cattle live weight gain and pasture composition and quality was measured on pure swards of WC. Fertiliser response demonstrations, hay and feeding evaluations, nutrient and tissue analysis were conducted to ascertain the quality and productivity of WC over two seasons. Regular meetings and field walks were held to discuss, plan and review trials and activities. The community nominated and facilitated the project and were assisted by Departmental staff.

This report covers the findings of the trials and evaluations undertaken along with additional relevant material on WC in the NT and Queensland.

SUMMARY

The Douglas Daly PIRD project was concluded in November 2003 with a review meeting. At the meeting the group discussed the relevant data, information and experience of the past two and a half years. The information included results from two grazing trials, fertiliser response demonstrations, soil and plant analysis, WC hay and pellet feeding trials and general observations.

The group then focused on developing a statement to describe WC in the Douglas Daly area, based on prior experience and new knowledge gained from the project. The group listed a number of criteria by which they judge other pastures they intend sowing. They then chose four of the most popular pasture species presently grown in the district. A matrix (score chart) was drawn up using the criteria and the pastures nominated. WC was judged against these criteria and the four species chosen. This allowed the group to measure WC against a set of important criteria and rank it directly with other productive pastures.

This process highlighted both the positive and negative aspects of WC and showed where it ranked in relation to other important pasture species of the district. As a result of the process the group then described WC as ***"An easy to establish, highly persistent, dominating legume of low palatability and low grazing value on fertile soils [in the Douglas Daly area]. It may have a role in soil conservation and may also have potential for hay and pellet production."***

Before this project was conducted there were many reservations about WC as a pasture. The question of what people thought of WC was invariably answered with a combination of doubt about its usefulness yet hope that it may be better than it appeared. Many who had planted and promoted WC believed it was a productive legume but still had fears about its palatability. In many situations cattle have performed well on WC/grass pastures. For over 15 years people have had various opinions on WC and the question of its real benefit has remained unanswered.

This project has evaluated WC objectively. While the trials and demonstrations in this project were not strictly scientific, the information gathered is valuable in its own right. The project measured the performance of cattle on WC under commercial and research-farm conditions. As a result some previously held reservations were confirmed.

During this project, pure swards of WC have consistently provided less animal performance than alternative pastures. The data suggests that WC provided between 20 and 30% less liveweight gain than other improved pastures being evaluated under similar conditions. The potential loss could be over $200 per hectare depending on stocking rate and cattle prices. WC's prolific seeding habit and adaptation to a wide range of conditions almost guarantees its continued spread. The challenge for industry is to develop sustainable management strategies to insure improved pastures remain productive and profitable.

Producers of the Douglas Daly area have now formed a common opinion on the value and productivity of WC, particularly in a pure sward. With this information producers will now implement management practices to improve the productivity of pastures dominated by WC. One major outcome of the project is that few producers in the district will plant WC in the future.

There have been many other benefits from this project. It has given the community the confidence to conduct its own R&D and provide young people with the chance to become involved in applied research and to organise and address meetings. PIRD projects are valuable in that they allow communities to identify their problems and work towards solutions.

REVIEW OF GRAZING TRIALS

Midway Station Grazing Trial

Objective

To determine animal productivity from a pure sward of WC under commercial conditions by measuring monthly weight gains/loss over a six month period, from January to June.

Method

The grazing trial at Midway Station was a major part of the PIRD project in 2003. The site consisted of a 250 ha paddock of which approximately 190 ha was a pure sward of WC. The remainder was uncleared bush. The paddock was stocked with 245 mixed sexed weaners of varying weights. The objective was to assess the performance of cattle on a commercial stand of WC over the wet (January to June) and into the dry season. The stocking rate was approximately 0.98 head/ha over the entire area or 1.3 head over the cleared area.

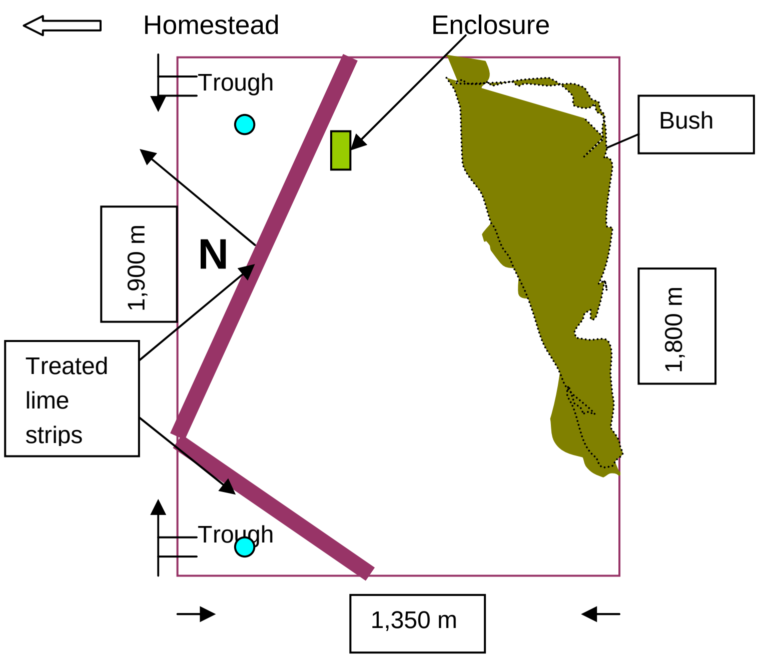

Figure 1. Midway site, showing lime-treated strips, enclosure and bush area

The cattle were weighed and introduced to the area on 3 January 2003. They were re-weighed at about 30-day intervals until mid June. The paddock had biomass levels of between 2.0 and 4.0 t/ha of WC in January. Levels increased to an average of 3.0 to 5.0 t/ha over the grazing period. The animals were supplemented with molasses and Phosrite® mineral supplement in the wet season and a urea (8%)-molasses supplement in the dry season.

Results

As in the previous season cattle spent a lot of time in the bush country and grazed that area heavily. The WC growing in the bush was also grazed harder and more consistently than in the open areas. This was also the case in 2002. Table 1 summarises the results.

Table 1. Live weight gain of weaner cattle on WC at Midway from January to June 2003

Period of measurement	Average gain/head (kg)	Days	Average gain per day (kg)
3 Jan to 5 Feb	18.3	33	0.55
5 Feb to 10 Mar	5.9	33	0.17
10 Mar to 3 April	17.7	24	0.73
3 April to 12 May	25.4	35	0.73
12 May to 16 June	- 4.7	35	-0.13
Total	62.6	160	0.39

Although animals gained weight through the grazing period, gains were relatively low, deteriorating rapidly from May onwards. February was a particularly bad month when cattle barely maintained weight. This could have been due to a very wet period. The cattle gained less than 0.4 kg/day over the entire period (0.6 to 0.8 kg/day is expected), which should normally be the most productive period on improved pasture. At the end of the trial in June 2003, there was still an average biomass of 2.0 to 5.0 t/ha of live plants and 1.0 to 3.0 t/ha of uneaten WC leaf material on the soil surface.

Figure 2. Weaners early in the Midway grazing trial 2003
Note: An almost complete sward of WC.

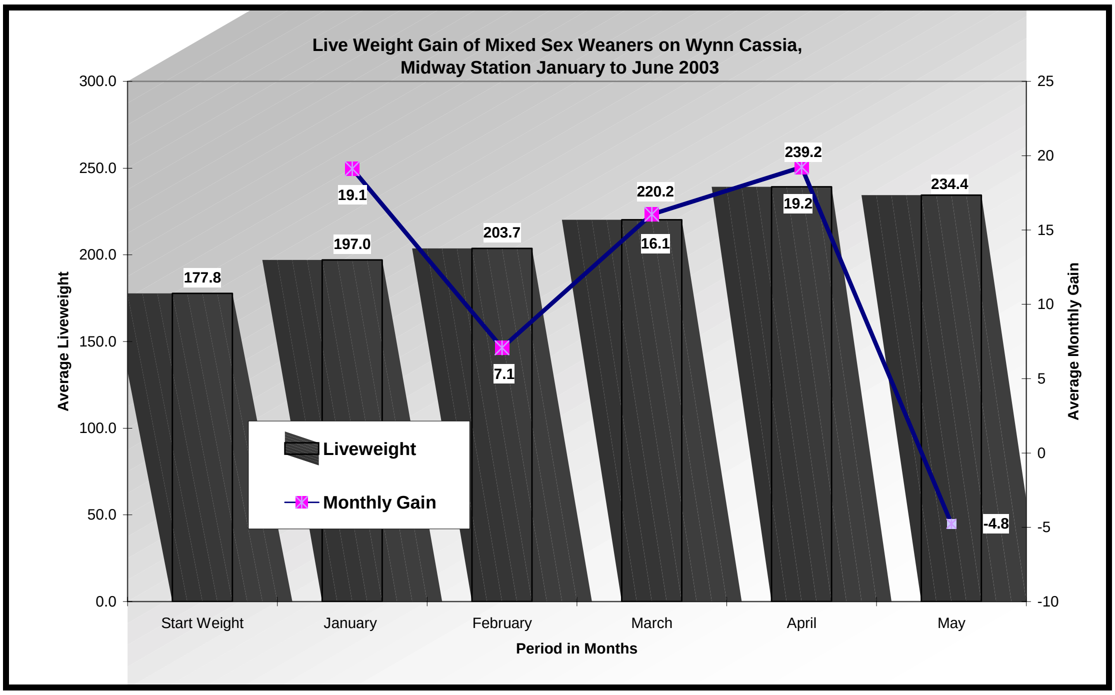

Figure 3. Seasonal changes in stock weights on WC on Midway Station January to June 2003
Note: Figures are not strictly monthly gains/losses, as recordings were not always taken at the start of every month.

Figure 4. Midway cattle ready for weighing

After the trial was completed the data was separately pooled for the three even groups of animals (i.e. light, medium and heavy) based on initial weight at the start of the trial.

This was done to determine if any groups (i.e. lighter or heavier animals) performed any better on a pure sward of WC in this instance (see Figure 5).

The results were surprising. The light group performed better than the medium group and significantly better than the heavy group. The lighter animals put on significantly more weight in total and put on more as a proportion of their starting body weight than the heavier animals. There was no conclusive explanation for this result. One theory is that if daily intake was reduced due to low digestibility or some other factor the lighter animals may perform better due to their lower total requirement.

When the three groups were separated a single-factor analysis of variance was conducted to determine any significant differences in the mean weight of the groups. The results are shown in Table 2.

Table 2. Analysis of liveweight gain from January to June 2003, expressed as a total and as a proportion of initial weight for three weight groups

Group	Mean weight January (kg)	Mean weight June (kg)	Total weight gained (kg)	Proportional increase
Light	145.9012	210.2763	64.42105[a]	0.4455[a]
Medium	173.1012	232.5125	59.47500[a]	0.3448[b]
Heavy	219.8933	264.6522	45.21014[b]	0.2139[c]

Note: Figures in columns with different superscripts are significantly different ($p<0.0001$)

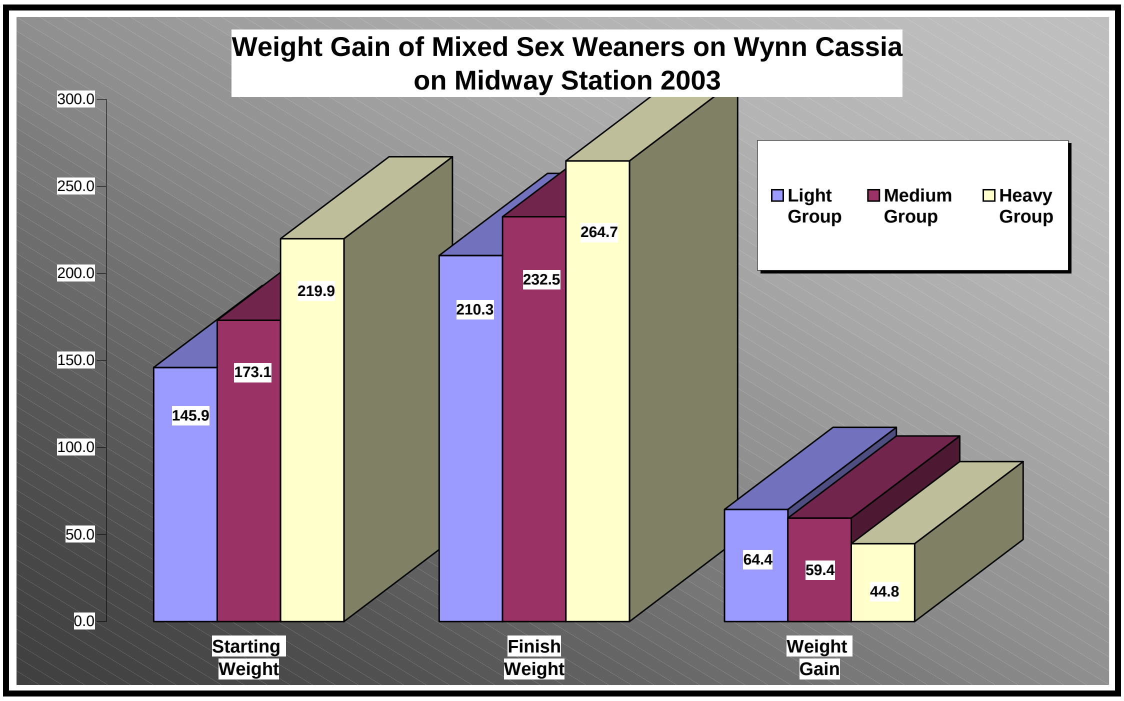

Figure 5. Start, finishing and total weight gain for different weight groups

Figure 6. WC, typical of the sward in the Midway grazing trial, early February 2003

Figure 7. Cattle at Midway concentrated in the bush, despite ample feed on offer in the cleared area

While the group with the heaviest initial weights still weighed more at the end of the trial, they put on significantly less weight than the lightest animals. The physiological reason for this is still not well understood.

Dr. Matt Bolam, a veterinary surgeon and animal nutrition specialist was asked to comment on the results of the trial at Midway. He provided some calculations to determine how well weaners should perform on pasture with similar nutritive value to that of WC. Details are in Appendix 1. He suggested that the lack of liveweight gain could be due to factors such as sward structure, palatability, anti-nutritive factors and low energy levels.

The suggestion is that WC as a pure sward lacked sufficient energy and digestible dry matter to sustain high liveweight gains. Despite sufficient protein for animal needs the limiting factor to performance may have been energy. This may explain why animals on mixed swards of grass and WC perform better. The higher energy in grass may compensate for low metabolisable energy and digestibility in WC. It would appear that lower than normal intake along with insufficient energy levels may have attributed to the poor performance. Measuring pasture intake would have been a useful indicator but beyond the scope of this project. Figure 10 shows the seasonal changes in nutritional quality of WC. Protein and digestibility dropped off considerably over the May-June period, which coincided with significant weight loss in the cattle.

Robert Bright (co-operator and owner of Midway Station) noted that a similar group of cattle grazing on native country over the same period did considerably better. He could not sell the cattle from this trial in 2003 but had to keep them for another season until they were acceptable for the live cattle trade. He said the lack of weight gain on the WC had cost him between $40,000 and $50,000.

Figure 8. Stock at the end of the Midway grazing trial
Note ample standing feed and poor condition of animals.

Figure 9. Leaf and stem material present at the end of the trial
Note: Up to 3.0 t/ha of dead material was measured each season

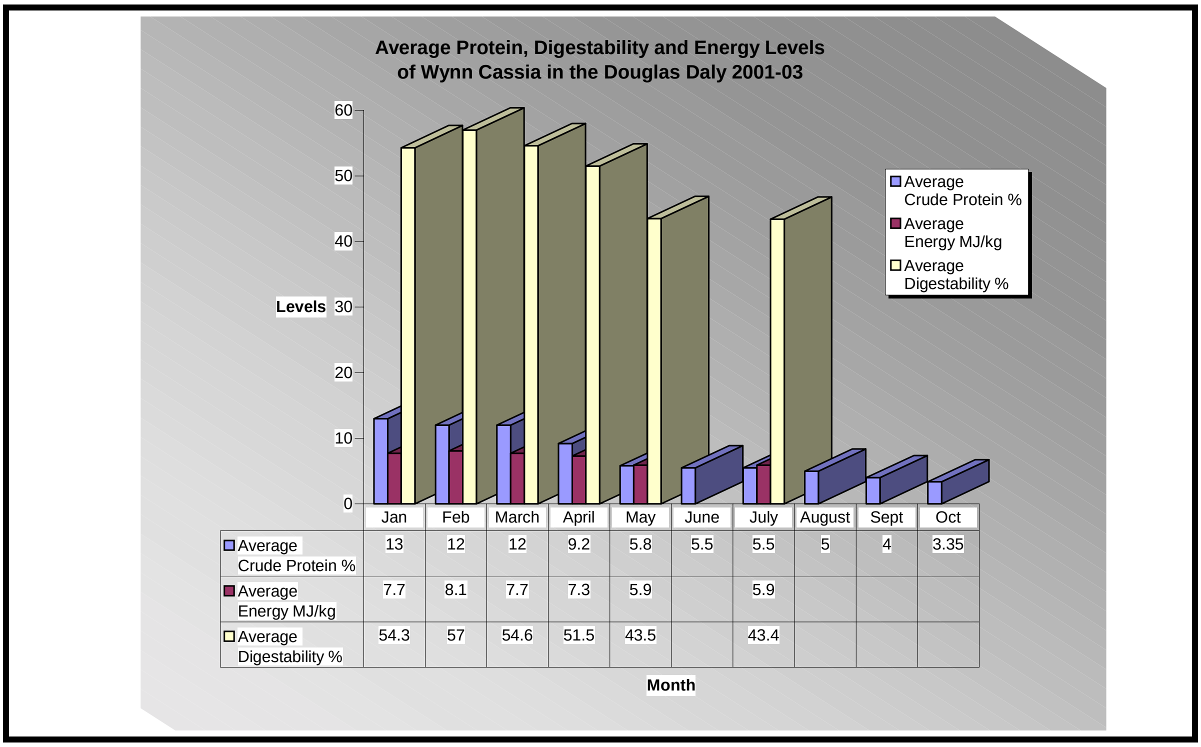

Figure 10. Seasonal changes in WC (whole-plant) protein, digestibility and energy from Douglas Daly sites

Douglas Daly Research Farm (DDRF) Grazing Trial, Paddock 42

Objective

To determine the animal productivity from a pure sward of WC under controlled conditions and compare the results with those achieved in a commercial situation.

Method

A smaller more controlled grazing trial was conducted in Paddock 42 (four hectares) at DDRF from March 2002 to June 2003. The paddock consisted of four hectares of pure WC. The paddock was initially fertilised with Goldphos 20® at 150 kg/ha and 50 kg/ha Muriate of Potash in late 2001. A further 50 kg/ha of Goldphos 20® with trace elements was applied in December 2002. Grass and other broadleaf weeds were controlled by selective herbicides to maintain the purity of the WC. Stock in this trial were supplemented with ad-lib Phosrite® in the wet season and Uramol® in the dry season.

In the first year of the trial (2002) five steers were put in the paddock on 7 March. They were weighed monthly until 28 June. In the first month the steers put on an average of 0.8 kg/head/day. However, in the last two months i.e. April and May, they achieved practically no liveweight gain. Four of the five animals lost between 5 to 15 kg in the last month alone, despite ample feed on offer. The loss in liveweight during May and June reflected a similar trend to that of the Midway trial in 2003. The first month of good weight gain may have resulted from grasses and other palatable species being present earlier in the season (B. Lemcke pers. com.).

On 28 June 2002 the five original steers were replaced by a new group of steers averaging 194 kg liveweight. This group remained in Paddock 42 until December 2002 when the paddock was de-stocked for grass and broadleaf weed control.

Results

The animals lost about 3 kg on average (three animals lost between 4 and 16 kg and two animals gained between 3 and 13 kg/head) during this period. From early February to 18 June 2003 (when this group was removed) the stock put on an average of 78 kg/head or a daily growth rate for the period of 0.6 kg/head. February was a particularly good month as most animals put on at least 30 kg or over 1.0 kg/head/day. However, subsequent weight gain was considerably less, i.e. about 0.5 kg/head/day. At the end of May the animals ceased to gain any weight despite ample feed in the paddock. Again, this trend reflected what happened in the previous year in Paddock 42 and in the Midway trial.

While the grazing periods were different, it is interesting to note that at both Midway and Paddock 42, DDRF, total liveweight gains were on average less than 0.4 kg/head/day. The gains from WC in Paddock 42 were the lowest of 15 other pure pasture and pasture combinations evaluated at DDRF under similar conditions in 2003 and 2004 (see Figures 11 and 12).

While it appears that liveweight gain on WC is relatively good in the early part of the wet season, performance drops off rapidly as the dry season progresses. On many pastures cattle continue to gain weight well into the dry season but this does not seem to be the case with WC. The poor performance may simply be due to a lower intake due to low palatability and reduced digestibility as the pasture ages. Intake of WC needs to be measured and compared with that of other pastures under similar conditions to test this assumption.

Although the project results indicated that the growth of cattle on pure swards of WC is relatively poor compared with other improved pastures, it has not explained why. Further studies are needed to determine how much WC is actually consumed, and what percentage of the animals' diet is composed of WC over the course of the season.

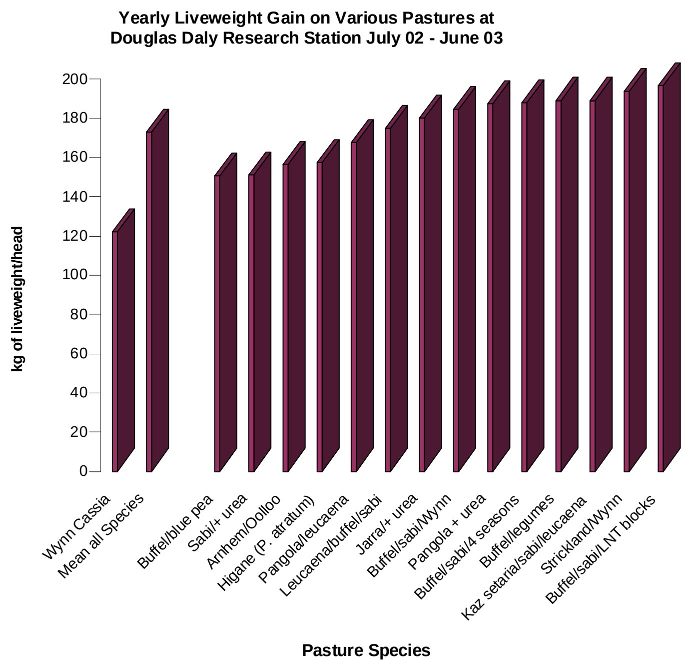

Figure 11. A comparison of yearly liveweight gain on different pasture/combinations at DDRF in 2003

Note: Trial animals were removed from Pad. 42 for December and January for herbicide application. Buffel/blue pea paddock was double stocked with 10 animals per 4 hectares. Unpublished data courtesy of P. Shotton and B. Lemcke from Species Evaluation Project at DDRF.

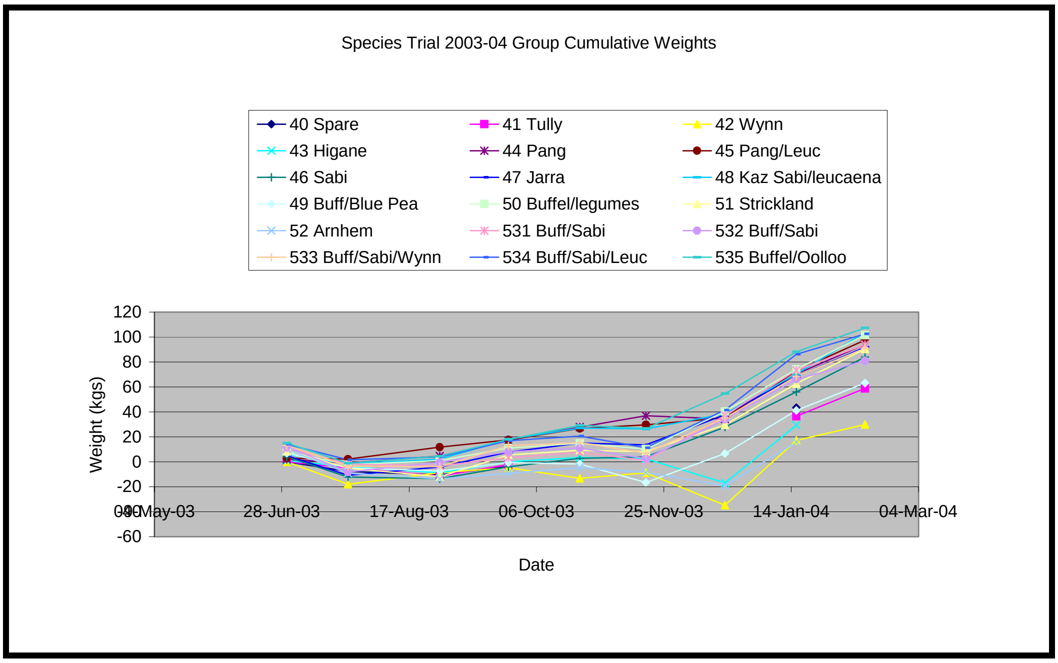

Figure 12. Cumulative liveweight gains from a range of pastures and combinations at DDRF from June 2003 to February 04

Note: The performance of WC (bottom yellow line). Unpublished data courtesy B. Lemcke and P. Shotton.

FORAGE QUALITY OF WYNN CASSIA

Objective

To determine the nutritional quality of WC throughout the season and ascertain whether it contains anti-nutritional compounds.

While WC appeared to be nutritious during the wet season, its protein, energy and digestibility levels were only moderate. Nutritional quality dropped off sharply in late April and May. While protein was sufficient for good animal performance throughout the wet season, energy levels were marginal and dropped below 6 MJ/kg (MegaJoules of energy per kilogram of feed) in May. Digestibility of WC was relatively low throughout the season and declined sharply in May (see Figure 10).

Neutral detergent fibre (NDF) which is the cell wall component of the feed i.e. the structural part of the plant and consists of lignin, cellulose and hemi-cellulose was analysed over the two seasons of the trial. NDF is insoluble in neutral detergent and can only be partially used by animals. Therefore, the higher the percentage of NDF the less the animal will consume and digest. It is interesting to note that during the early wet season the NDF for entire WC plants ranged from about 55 to 63%. However, in May the NDF fraction jumped to 74%. This was reflected in a substantial drop in digestibility and a subsequent reduction in animal productivity.

When animals browsed the WC, they selected the young top growth. Analyses revealed these parts were higher in protein with levels of up to 21% crude protein, energy levels of 10 MJ/kg and digestibility over 60%. From May onwards the lower feed value along with the unpalatable nature of WC was reflected in a steep decline in animal performance.

Palatability and Anti-Nutritional Factors in WC

There is no doubt that WC is a relatively unpalatable species compared with other useful forages and pastures. Both NSW and Qld Departments of Agriculture (see Appendices 2-3) describe it as relatively unpalatable. The group felt it may contain some anti-nutritional factors such as tannins, which may discourage stock from eating it. Tannins are compounds found in certain plants, which reduce feed intake by either slowing down the digestion in the rumen or by reducing the palatability of the pasture. A study of toxic properties of tropical legumes (*The Palatability, Feeding Value and Apparent Toxicity of 150 Legume Species Fed to Rats* by Strickland, Lambourne and Ratcliff, Genetic Resources Communication Number 10 1986 CSIRO Division of Tropical Crops and Pastures) concluded that WC was an acceptable and non-toxic feed.

Despite this evidence the group decided to determine whether WC grown in the NT (i.e. different climatic and soil conditions) contained detrimental substances. WC samples were taken at various times of the year over several sites and analysed at the University of Queensland Land and Food Sciences Laboratory. The results are shown in Table 4.

Table 4. Condensed tannin concentrations from various WC samples taken from three sites in the Douglas Daly region over two years

Paddock 42 DDRF		Paddock 10A DDRF		Midway Site	
Date	Conc. (mg/g)	Date	Conc. (mg/g)	Date	Conc. (mg/g)
Mar 02	9.71	July 02	4.90	Jan 02	4.11
Apr 02	6.76	Aug 02	5.70	Feb 02	3.36
May 02	5.07	Sep 02	6.03	Apr 02	3.44
June 02	4.29			July 02	5.15
July 02	4.94				
Aug 02	4.92				
Sep 02	4.90				
Oct 02	4.38				
Feb 03	10.04				
Mar 03	12.03				
Apr 03	12.85				
May 03	4.57				

Note: Results are equivalent to *Leucaena pallida* condensed tannin weights

The analysis used *Leucaena pallida* condensed tannin (CT) as the standard, because there was no standard available for WC. Therefore the CT found in the WC was measured against *L. pallida*. Although not precise, it provides a good indication of what level of tannins occur in WC in the NT (Poppy pers. com.). While the results do not indicate the exact astringency or protein binding capacity of the CT in WC, they are relative to the astringency of *L. pallida* CT.

Values of CT over 5 to 6% are considered high and would cause protein binding, possibly in an adverse manner (Poppy pers. com). The analysis results from WC from Paddock 42 in February, March and April 2002, while higher than in previous months, were only about 1 to 1.28%, suggesting a low presence of CT in the samples. The results indicate that the level of tannin detected should not interfere with, or affect animal nutrition.

Improving the Palatability of WC

In 2002, an observation site (enclosure) was erected in the Midway Station PIRD paddock. Two rates of super phosphate plus trace elements (i.e. 100 and 200 kg/ha) were applied as test strips. Half of the enclosure was also fertilised. The objective was to measure the response in WC to different rates of fertiliser and to compare pasture biomass in grazed and non-grazed areas with and without fertiliser.

Cattle were observed grazing the fertilised area more frequently than the non-fertilised areas. A comparison of both areas showed that the stock browsed the fertilised areas more frequently. While intake or consumption rates were not measured, the frequency of grazing was recorded. It was found that 88% of sites inspected in the fertilised areas had been grazed/browsed versus 32% of sites in the non-fertilised areas (see Figure 13). This trend was observed in both February and April 2002. Improving the palatability of other tropical legumes such as Stylos (*Stylosanthes* spp.) by adding fertiliser is well documented in the Northern Territory. WC appears to respond in a similar way.

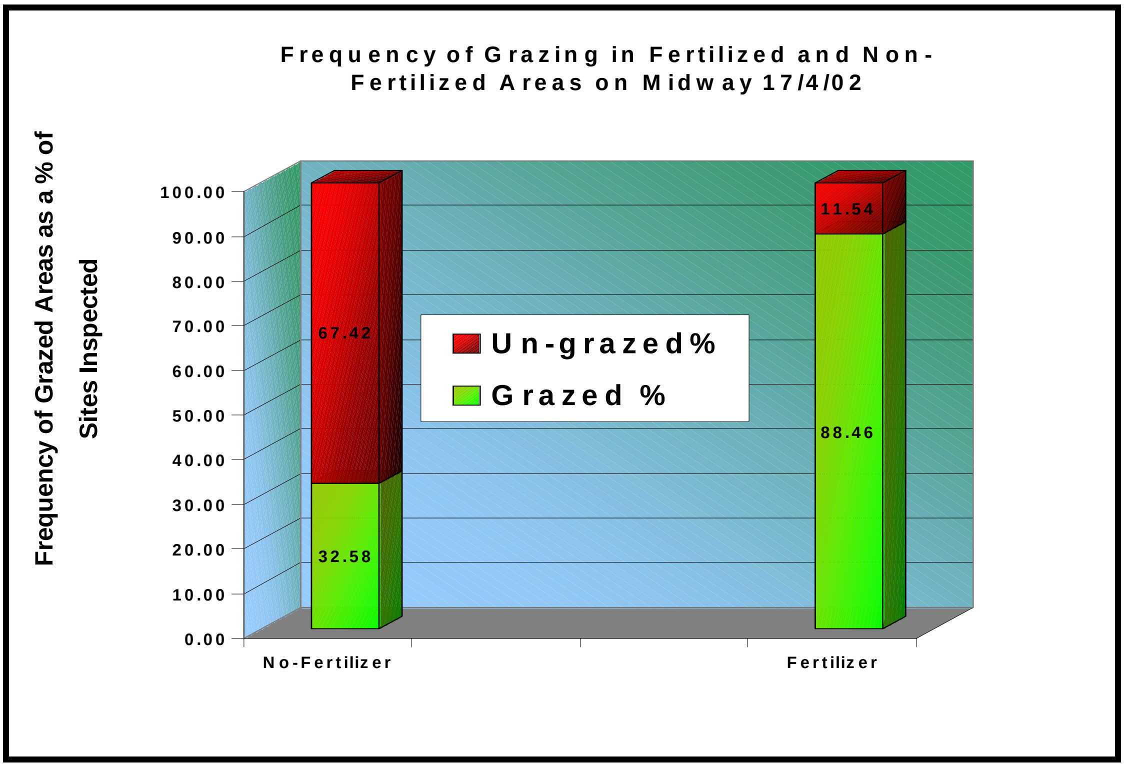

Figure 13. Differences in frequency of grazed patches between fertilised and non-fertilised WC on Midway Station

It was also noticed that on Midway certain patches of the general (unfertilised) WC were grazed more heavily than the rest of the pasture. These patches were several square meters in area. The animals had grazed these areas practically bare while the rest of the pasture had several tonnes of standing biomass.

Soil samples were taken from these grazed patches and compared with samples from the general pasture. It was found that the heavily grazed areas had elevated levels of calcium and phosphorus, higher cation exchange capacity and higher pH. The calcium levels in the heavily grazed areas were over six times higher than in the general paddock.

Table 5. Soil analysis: Midway PIRD site June 2002

	pH	K	Ca	Mg	Na	CEC	P	S	TK N	Cu	Mn	Zn	OC	Total P
	PH	mg/kg	mg/kg	mg/kg	mg/kg	CM(+)	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	%	%
	0.1	25	25	25	25	0.01	5	0.5	0.01	0.1	0.1	0.1	0.01	0.005
Sample														
Soil A	6.7	100	446	71	<25	3.06	<5	6.7	0.05	0.5	68	5.8	0.52	0.01
Soil B	6.6	97	432	68	<25	2.97	5	7.3	0.05	0.5	69	5.1	0.48	0.01
Soil C	6.2	78	360	47	<25	2.39	<5	3.3	0.04	0.5	78	0.4	0.42	0.01
Soil D	6.1	70	370	48	<25	2.42	<5	3.2	0.04	0.4	72	0.3	0.49	0.01
Heavily Grazed	8	48	2661	31	<25	13.7	12	2	0.04	0.4	36	0.2	0.5	0.01
Heavily Grazed	8.1	47	2271	29	<25	11.7	10	2	0.05	0.4	34	0.4	0.5	0.01

Note: Soil A to D was taken from the general lightly grazed areas of pasture at Midway.

The elevated levels of phosphorus and calcium may have contributed to the palatability of WC. To test this theory, a combination of agricultural lime and single superphosphate was applied in a strip over the length of the paddock (see Figure 1). The lime was applied at between 1 to 2 tonne/ha and the super at about 100 kg/ha. Cattle had to cross this treated strip to get to water each day. Cattle were observed to see if they found the treated WC more palatable and if grazing pressure increased. There was no observable difference in grazing behaviour or pasture depletion from the treated area prior to the end of the trial. Due to the relatively dry seasonal conditions in 2003 there may have been insufficient rain to allow the plants to take-up the added nutrients in sufficient quantities to create a difference in plant nutrient level or palatability.

Figure 14. Grazing patterns in WC. Left: patches of heavily grazed areas had elevated levels of calcium and phosphorus. Right: areas of browsing were more frequent in fertilised areas.

The observations over two years at Midway suggest that the palatability of WC may be increased with the use of a phosphorus fertiliser. It was also observed that cattle spent a lot of time in the bush country and grazed the WC there. This could be a direct result of stock preferring the shelter of the trees or preferring the WC and other species there. Soil analysis revealed higher levels of Ca in the bush area, primarily due to the limestone parent material.

FERTILISER RESPONSES IN WYNN CASSIA AND A COMPANION GRASS

Objective

To determine whether WC would respond to applied superphosphate and to measure changes in pasture quality, sward composition and grazing behaviour of animals as a result of fertiliser application.

Method

Single super-phosphate with trace elements, was applied at 100 and 200 kg/ha at PIRD sites at Midway and Stray Creek Stations in early 2002. WC responded well at both sites. Growth rates were considerably higher at Midway, which has a heavier loam soil compared with a sandier soil at Stray Creek. The maximum WC biomass recorded in the 100 kg/ha treatment was about 2.75 t/ha at Stray Creek. This was about 80% higher than the unfertilised area, which only produced about 1.5 t/ha. Fertiliser produced between 50% and 75% more biomass than unfertilised WC at the Midway site, with yields of up to 6.0/ha of standing dry matter (DM). While fertiliser treatments were not replicated there was little difference between 100 and 200 kg/ha of fertiliser at either site. The response to fertiliser was still apparent in the second year after application.

Re-establishment of Sabi Grass in a WC Sward Treated with Super-phosphate

At the Midway site, WC dominated the entire pasture, despite it being sown with a mix of sabi grass, Stylo and WC in 1998-99. Selective grazing by stock over the years had resulted in the loss of almost all the useful grass species. In the first year of fertiliser application (December 2001) the WC responded strongly, producing between 5.0 and 6.0 t/ha of DM, compared with about 3.0 t/ha in the un-fertilised area. sabi grass did not appear to respond to fertiliser in the initial year.

However, in early 2003 the sabi grass re-emerged vigorously in the fertilised section of the enclosure. While there were sabi plants present in the non-fertilised section of the enclosure, the plants were stunted and ill-thrifty. While it appeared that most of the sabi grass had been eliminated, there were sufficient plants remaining for re-establishment once grazing pressure was removed. The combination of applying super-phosphate and removing grazing pressure produced over twice the biomass (10.3 t/ha) of removing the grazing pressure alone (see Figure 15). The early season growth of sabi grass in the fertilised area of the enclosure was vigorous and helped to suppress the early growth of WC, which is a desirable situation. Outside the enclosure (with equal fertiliser and normal grazing pressure) there was practically no sabi in the pasture and the WC biomass was 5 to 6 t/ha.

This demonstration illustrated two points:

1. Restricting or reducing grazing pressure in the early wet season is likely to promote the re-establishment of grasses in WC pastures.
2. In the presence of adequate phosphorus and sulphur WC may supply sufficient nitrogen for a vigorous companion grass.

Figure 15. Effect of super-phosphate and removal of grazing pressure on sabi grass in a WC dominant pasture. Left: fertilised with 100-200 kg/ha super phosphate TE. Right: no fertiliser.

While these observations would need to be re-confirmed, the demonstration showed that some grasses have the ability to re-establish in WC dominant pastures provided there is adequate nutrition and grazing pressure is reduced at critical times. To allow grasses to effectively re-establish, paddocks would need to be spelled for a period (depending on seasonal conditions) after the first rains. WC is also likely to contribute a level of nitrogen to promote a healthy grass component, provided it has adequate phosphate. Heavy early season grazing will result in the loss of palatable grasses and a dominant WC sward. Maintaining the balance between grasses and WC should be the key to maintaining pasture productivity in the Top End.

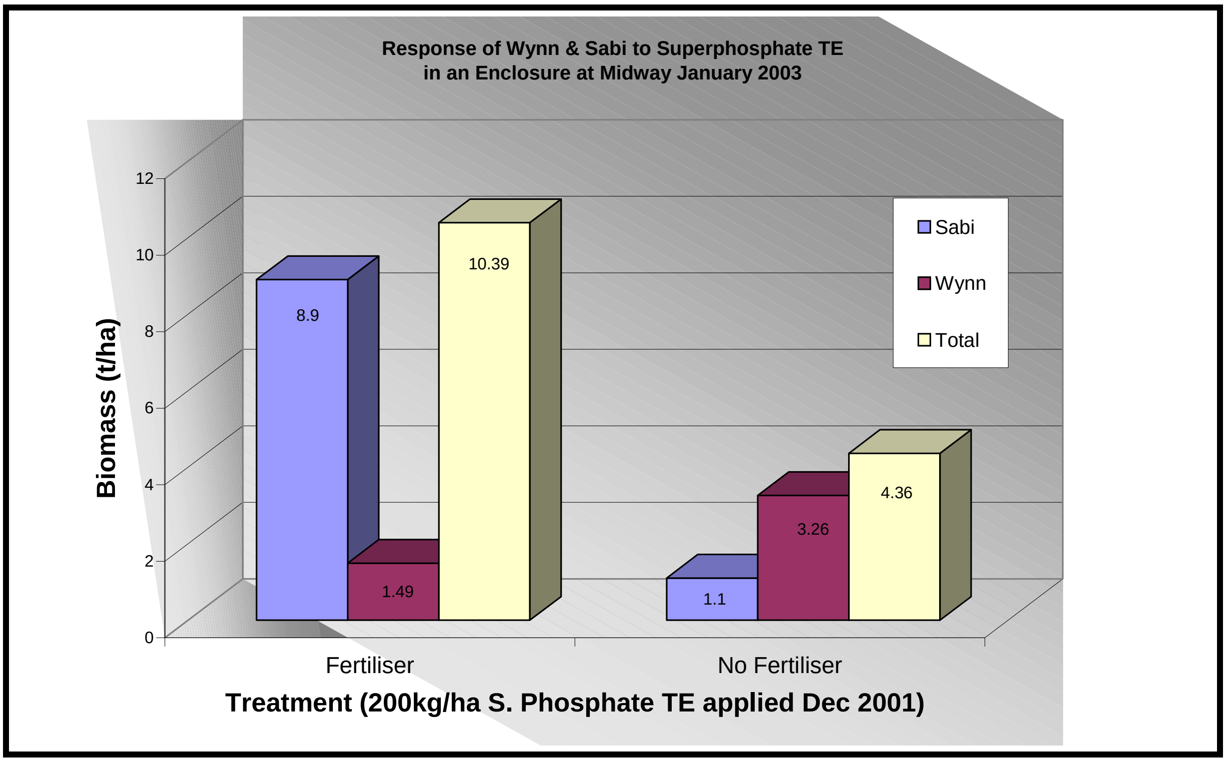

Figure 16. Effect of restricted grazing and fertiliser on a WC/sabi grass pasture at Midway Station, January 2003

Figure 17. Selective grazing of grasses in a WC paddock
Note: No grass outside the enclosure or where cattle can reach over the fence.

WYNN CASSIA AS A HAY AND PELLETING CROP

Objective

To determine if WC would be acceptable as hay or pellets for the live cattle trade. WC hay was also evaluated for its acceptability to horses. Details of the feeding trials conducted at Berrimah Research Farm (BRF) in Darwin appear in the appendices.

Method

The first study compared WC, pangola and Cavalcade hay with a commercially produced grass/cottonseed pellet in a feeding trial at BRF. The trial ran for 36 days. Cattle on the WC hay lost over 40 kg while the stock on the Cavalcade, pangola and pellet put on 7, 11 and 19 kg, respectively. The WC hay was less readily accepted and stock consumed about 30% less than stock on the other hays. Stock actively sought out the leaf of the WC hay in preference to the stem. As a result total WC intake may have been limiting weight gain in this trial.

The second trial at BRF compared a WC/sorghum pellet to pangola hay fed to light weaners (270 kg average weight). The pellets consisted of WC plus about 20% sorghum, 6% cooking oil as a binding agent and 3% molasses. The trial ran for 25 days. The stock on the WC pellets averaged 17 kg (0.68 kg/day) in weight gain over the period while the pangola hay group basically maintained their weight after an initial loss.

A third trial at BRF compared WC pellets containing 0, 10 and 20% grain sorghum to Calopo (a naturalised tropical legume) pellets. The WC with 0% sorghum was consumed in the highest quantity, gave the best weight gain and achieved an average of 30 kg over the trial. Intake of the pellets without the sorghum was higher than for the other pellets. Intake of sorghum based pellets gradually increased as the trial progressed. One would expect better performance in the long run from a grain based pellet. The WC pellets were only fed to steers for 34 days and averaged about 0.88 kg/head/day weight gain. It is hard to say why WC with grain sorghum was less attractive to stock in this instance (see Figure 18).

These trials indicate that WC may have potential as a source for making pellets. While WC hay is relatively unpalatable, when processed into a pellet, it appears to be well accepted and stock perform exceptionally well on it.

WC hay was also evaluated for its acceptance by horses. Small square bales were produced by the Howie family of Maneroo Station and distributed to horse enthusiasts in Darwin and at DDRF. The hay was good quality and looked and smelled fresh. While it had good leaf content, the stalks were coarse. From a small survey conducted in Darwin, four people stated that their horses ate the WC hay readily. Four other respondents said their horses rejected the hay and they would not buy it.

The hay used by most of the respondents at the time was of low quality and the WC hay was quite good in comparison. People did mention the stalkiness of the hay and stated that their horses left a large proportion of stalk behind. While the survey sample was too small to be conclusive, responses were split evenly between positive and negative impressions of WC hay.

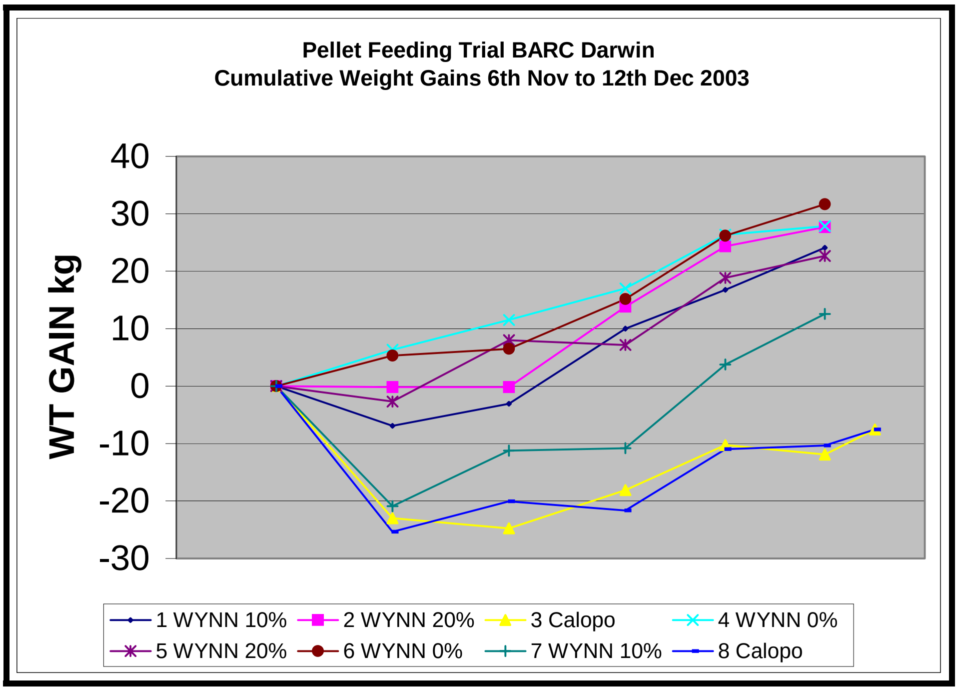

Figure 18. Results from a pellet feeding trial at BRF
Note: WC 0%, 10%, 20% refers to % grain sorghum in the pellet

At DDRF most of the horses given WC hay either ate it reluctantly or refused it outright. The horses preferred Cavalcade and Rhodes grass to WC. When they had access to WC only, they ate it but tended to pick out the leaf and leave the stem (Chris Hazel, Peter O'Brien pers. com.).

The general consensus is that WC hay is not palatable. One producer stated that hungry cows grazing in the same paddock (Bill Doyle pers. com.) avoided WC hay, which was stored in the paddock. Later on in the season the stock were reported to have eaten the hay. However, when WC is hammer-milled, it is readily eaten by stock. Most agreed that hammer-milling increases the acceptability of most feeds.

While further evaluation would need to be undertaken to definitely ascertain whether WC hay is acceptable to most horses, there is evidence to suggest that it will be accepted by at least some horses. Factors that will play a role in its palatability and acceptance will be the quality of the hay, the choice of hay available, how hungry the animals are and whether they have been exposed to WC in the past.

It would seem that if horses are well fed and are given a choice of other good quality hays such as Cavalcade or pangola, they are likely to reject WC. However, in cases where there is no other hay available, and the quality is good, then some horses may accept WC. When horses were offered WC pellets they readily accepted them (Lemcke pers. com.).

Figure 19. A horse eating WC in the dry season
Note: While WC is generally considered unpalatable, some livestock readily eat it.

Figure 20. WC pellets used in BRF feeding trials

CONTROLLING WYNN CASSIA WITH HERBICIDES

Objective

To determine whether WC could be controlled or managed with the use of selective herbicides in order to reduce its dominance and enhance pasture productivity.

Due to the spread and vigour of WC many producers expressed the need to develop strategies for containing and controlling it. Phil Howie from Maneroo tried the “spray-graze” technique, which is popular in southern states for the control of certain broad-leaf weeds. The technique involves spraying low rates of 2,4-D and letting stock graze it a week later. The herbicide mobilises the sugars in the plant, making it more palatable. The combination of herbicide and grazing reduces unwanted plants to a manageable level, gives desirable species an opportunity and allows some productivity to be achieved from relatively unpalatable plants.

Phil Howie from Maneroo Station ran a small observation using 2,4-D on WC. He observed cattle grazing the area more intensively than adjoining WC, which was not sprayed. To confirm the benefit of “spray grazing” a more detailed trial would need to be undertaken.

A herbicide demonstration was conducted at the Taminmin High School Farm at Humpty Doo near Darwin in 2003. The objective was to assess the effectiveness of a range of selective herbicides in controlling WC in a pangola grass pasture. The demonstration indicated that while there is a range of herbicides capable of suppressing WC, the species is particularly hard to kill. In many of the treatments WC did not die completely, but began to re-grow after a number of weeks. WC is tolerant to many selective herbicides that would provide control of other legumes and broad-leaf plants. More work is needed in this area to determine the most cost effective herbicide to control WC. The demonstration also showed that by reducing WC, grass productivity is likely to increase.

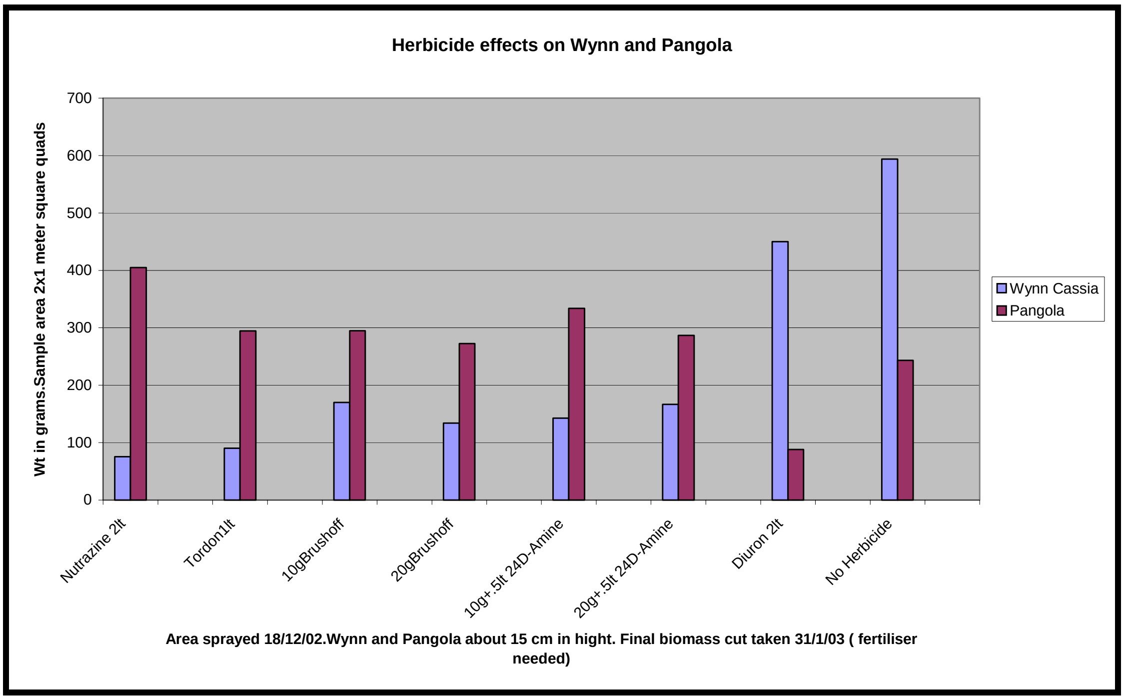

Figure 21. Comparison of selective herbicides in controlling WC in a pangola pasture
Data courtesy G. Schultz, N. Hartley and S. Denniss.

Figure 22. WC in a pangola paddock at Taminmin High School

The foreground has been sprayed with Brushoff® (20 g/ha) leaving an untreated strip of WC. Note the dominant and vigorous growth of the untreated WC.

Figure 23. Shows only the visible seed, which equates to over 60 kg/ha resulting in huge seed reserves building up over time.

WHAT ARE PRODUCERS DOING NOW TO MANAGE WYNN CASSIA

Most of the producers involved with this project have stated that they no longer intend to sow WC. They believe the objective from here on is to manage WC and try to prevent it from dominating the sward or invading new pastures.

Some producers are actively spraying WC with selective herbicides such as Brushoff® to suppress it and to give grasses an advantage. Some producers are happy to do this as the chemicals used also assist in the control of other important broad-leaf weeds such as *Hyptis* sp. *Sida* sp. and *Senna* sp.

The “spray-graze” technique is a possible option but needs to be evaluated further. However, WC is tolerant to many herbicides and one producer noted that where WC had been sprayed out a new generation of vigorous WC seedlings emerged to replace the parent plants.

In other instances producers have ploughed out paddocks of WC and over sown it with improved grasses in an attempt to restore the grass balance. As seen at Midway, grasses may return if paddocks are spelled and fertilised. Some options include *Bracharia humidcola* (cv. Tully), *Digitaria swynnertonii* (cv. Arnhem) and various cultivars of buffel grass. Producers are hoping that by planting a more vigorous grass, WC may be less dominant and a better grass/legume balance will be achieved.

Making hay from WC dominated pastures is another option. WC hay is less palatable than other hays, but is well accepted when hammer-milled or processed into pellets. Most producers in the Douglas Daly state that they will be monitoring WC and implementing different management strategies to control it. While most agree that WC has some grazing value they see the need to limit its spread and prevent it from dominating pastures. Producers know it will be an ongoing issue due to its adaptation to the region. With a combination of strategic herbicide use, grazing management and the use of competitive and resilient grasses, producers hope to be able to keep WC in check.

CONCLUSION

The PIRD project ran for just over two years, from late 2001 to the end of 2003. While the project was not intended to be a series of scientifically rigorous experiments, its aim was to investigate and evaluate many aspects of WC in an applied and practical manner. Aspects such as pasture quality and livestock performance, hay acceptability and processing, grazing selection, and chemical control were evaluated.

The group nominated 15 issues they wished to investigate about WC. The project addressed most of these to the satisfaction of the group. While many producers already had reservations about the productivity of WC, the two grazing trials confirmed that WC, in a pure sward gave relatively poor liveweight gains compared with other species. This information alone should convince producers that management is required to prevent WC from dominating pastures. The evaluation of WC for pelleting gives producers an option to sell WC hay to pelleting and cubing plants.

One of the first priorities is to develop practical grazing strategies to manage WC and keep the legume in balance. Current grazing practices place too much pressure on palatable grasses, leaving a dominant WC sward. Avenues for investigation include evaluating different companion grasses, altering grazing duration and timing and fertiliser and herbicide applications.

While there is empirical evidence to suggest WC fixes nitrogen, this project was unable to determine the level of nitrogen fixed or contributed to the sward. Given the amount of WC leaf litter returned to the soil each year, one would assume a reasonable amount of organic N is put back into the system. There is a need to determine how much is contributed under different circumstances and what can be done to enhance N fixation.

Another issue, which remains unanswered, is the contribution WC makes to total dietary intake. While the group wanted to know how much WC is actually eaten, this was beyond the capacity of this project. To address these questions, an analysis of feed and dietary composition using alkanes or near-infrared reflectance spectroscopy would be needed.

It is highly likely that WC will become a more important issue with time. With the intensification of pastoral enterprises in the Top End and the subsequent grazing pressure, unpalatable plants such as WC will become more dominant. While WC has the ability to compete with weeds, it may in the longer term promote the invasion of other weeds through the build up of soil N, unless more productive pasture grasses are maintained.

The cost of having WC dominant pastures may be significant. During this project WC paddocks have consistently provided a lower animal performance than alternative pastures. The data (while not conclusive) from Paddock 42 at DDRF suggests that WC provided between 20 and 30% less liveweight gain (refer to Figure 11) than other pastures being evaluated under similar conditions. If the potential liveweight gain from improved pastures in the Douglas Daly area is around 120 to 180 kg/head/year and WC provides only 120 to 140 kg/head/year, the annual potential loss could be over $200 per hectare depending on stocking rate and existing cattle prices.

The cost of having WC dominant pastures on half (8,400 hectares) of the fully improved grazing country of the Douglas Daly could conceivably cost local producers between $1m and $1.6m in lost production. While figures would need to be validated in an economic model using more detailed data, there is enough information to suggest that WC dominant pastures will have a considerable economic impact on cattle production in the Douglas Daly region.

Its prolific seeding habit and adaptation to a wide range of conditions almost guarantees the continued spread of WC. The challenge for industry is to develop sustainable management strategies to insure improved pastures remain productive and profitable.

Overall this was a successful collaborative community project which produced useful and practical information. As a result of the project many producers are no longer sowing WC and are now involved in some management strategy. The project has highlighted the need to monitor animal and pasture performance, because as seen in this case, productivity levels may be much lower than expected. The general recommendation arising from this project is not to sow WC if it already exists on farm. Alternative legumes should be sown and grazing pressure should be reduced to promote early season grass growth and prevent WC dominance.

ACKNOWLEDGMENTS

Meat and Livestock Australia is gratefully acknowledged for funding this project. The Douglas Daly community and pastoralists who have given generously of their time and ideas are acknowledged, especially Robert Bright and his team at Midway Station for providing the resources, time and labour for the commercial grazing trial. Staff of the Department of Business Industry and Resource Development at DDRF and Darwin are thanked for their contribution and input. I also thank Mark Hearnden for his assistance with the statistical analysis, Michael Nielsen and Dennis Poppy of the University of Queensland for advice and analysis of WC samples.

I thank the Tropical Grasslands Journal for permission to reproduce papers in Appendix 10, 11 and 12.

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APPENDICES

APPENDIX 1. AN EXPLANATION OF ANIMAL PERFORMANCE ON WYNN CASSIA

Expected animal performance and comment on the Midway grazing trial
Dr Matt Bolam: veterinary surgeon and animal nutrition specialist, Darwin NT

The declining weight gain of steers is not explained by estimates of performance based on the feeding standards. I would suggest a discussion of the previous treatment of the differing weight ranges of steers may explain some of this difference and an assessment of the age of the heavier steers may assist in shedding some light on the difference.

A dry matter digestibility (DMD) of 60% (ME of 8-8.5 MJ/kg DM) and a crude protein (CP) content of 140 g/kg DM is a reasonable estimate of feed quality available from a range of sampling techniques. Normally, where an excess of feed is on offer, sampling techniques under-estimate the actual quality of the diet selected by animals. So it is not unreasonable to suggest that the quality of the selected diet may be closer to 70% DMD (ME of 9-9.5 MJ/kg DM) and higher CP. I will therefore compare animal performance at ME content in the diet of 8 and 9 MJ/kg DM.

For example, using a diet quality of 8 MJ of ME/kg DM and 140 g CP/kg DM, the lightest steers (average 180 kg over the trial period) would be expected to eat about 2.4% of liveweight. This is 4.3 kg dry matter intake (DMI). Given an ME intake of 35 MJ and a CP intake of 602 g per day. This level of ME intake will result in about 250-300 g/day liveweight gain. This level of liveweight gain requires about 270-290 g CP per day, so there should be an excess of CP.

Estimated animal performance for the groups of steers at a DMD of 60% is presented in Table 1 and at 70% in Table 2. If the CP in the ration is all available to the animal, then there is excess CP and estimated liveweight gain is determined by ME intake.

Table 1. Estimated animal performance for steers grazing (DMD of 60%)

Liveweight (kg)	DMI (% liveweight)	DMI (kg/day)	MEI (MJ/day)	CPI (g/day)	Estimated LWG (g/day)
180	2.4	4.3	35	602	300
200	2.4	4.8	38	672	320
230	2.3	5.3	44	742	350
260	2.2	5.7	46	800	380

Unpublished data

Table 2. Estimated animal performance for steers grazing forage (DMD of 70%)

Liveweight (kg)	DMI (% liveweight)	DMI (kg/day)	MEI (MJ/day)	CPI (g/day)	Estimated LWG (g/day)
180	3.0	5.4	49	756	700
200	3.0	6.0	54	840	730
230	2.8	6.4	58	900	750
260	2.6	6.8	61	946	780

Unpublished data

Overall, the observed liveweight gains from the trial are not much better than the estimated liveweight gains based on a DMD of 60% (ME of 8 MJ/kg DM). Predictions of liveweight gain based on estimates of DM intake and the feeding standards must always be considered as ballpark figures. That said, on the basis of the estimates of feed quality that are available, it appears that ME intake is limiting animal performance. ME intake is a combination of ME in the feed and the amount of feed eaten.

Usually animals are able to select a diet that is higher in quality than the samples on which we base our estimates of quality. If that was the case, then the steers should have been performing better. Apparently there was a significant amount of feed on offer. The steers are not able to selectively graze to improve performance. This may be due to factors including the sward structure of the pasture, palatability of the forage or anti-nutritive factors such as tannins. In the above case I feel that both these factors are limiting the performance of steers grazing this pasture.

The declining level of weight gain performance of steers is not explained by estimates of performance based on the feeding standards. I would suggest a discussion of the previous treatment of the differing weight ranges of steers may explain some of this difference and an assessment of the age of the heavier steers may assist in shedding some light on the difference.

APPENDIX 2. NSW AGNOTE ON WYNN CASSIA

Round-leafed cassia
Chamaecrista rotundifolia
Agnote DPI-308, first edition, March 2000
Bede Clarke, District Agronomist, Casino
Revised August 2003

NOTE: The information in this Agnote **must** be read in conjunction with Agnote DPI-263 *Introduction to selecting and using pastures in NSW*, which covers information on areas of adaptation, sources of variability, species mixtures, and important issues related to animal health and the *Native Vegetation Conservation Act 1997*.

Pasture type and use	Short-lived perennial tropical legume, growing in the warm season. Main production is in summer. Grazing but has been used for hay and silage.	Round-leafed cassia
Area of adaptation	Far North Coast, North West Slopes.	
Min. average annual rainfall	Far North Coast: 800–1000 mm. North West Slopes: 650–700 mm.	
Advantages	• Good drought tolerance. • Tolerant of acid soils with high levels of exchangeable aluminium. • Can be established in frosty areas. • High seeder and rapid coloniser with seed spread by livestock.	
Disadvantages	• Unpalatable during good summer growth periods; readily grazed from late summer until winter. • Tendency for stock to overgraze companion grasses under long-duration grazing. • Intolerant of waterlogging. • Horses do not eat Wynn cassia. • Weaner cattle often reluctant to eat Wynn cassia. • Wynn cassia can be a major weed of peanut crops and a weed of some pulse crops.	
Soil requirements	Light-textured well-drained soils. Not suited to hard-setting soils.	
Varieties	Wynn	
Sowing rates:		
—as only species*	1–1.5 kg/ha	
—in mixtures	0.5–1.5 kg/ha	
Sowing time	A high level of hard seed allows sowing between September and early March.	
Companion species	Compatible in mixtures with adapted species.	
Inoculation	Group M	
Major nutrient deficiencies	Phosphorus, potassium, sulfur and molybdenum.	
Main insect pests	Relatively free from pests.	
Main diseases	Relatively free from disease.	

Management	In first season, allow seed-set for future plant recruitment, as plants die after about 16–18 months. Hard short-duration grazing suits Wynn. Do not allow selective continuous heavy grazing, which can lead to Wynn cassia dominance.
Livestock disorders of particular note	Some cassia spp. (e.g. *C. obtusifolia* and *C. occidentalis*) have been associated with poisoning in ruminants and horses — both leaves and seeds were toxic, and muscle damage was the main effect. So far there have been no problems reported for *C. rotundifolia*.
Additional tips	If stock water is low in sodium, a salt supplement can be beneficial to livestock grazing Wynn cassia. Phosphorus and sulfur maintenance requirement important for quality and animal intake.
Further information	Agnote 1/102 *Wynn round-leafed cassia*.

*The only grass or only legume sown.

Acknowledgment

Photo: Warren McDonald, NSW Agriculture, Tamworth

APPENDIX 3. QUEENSLAND DPI AGNOTE ON WYNN CASSIA

Wynn round-leaf cassia

Ian Partridge, DPI's Agency for Food and Fibre Sciences, Beef, Toowoomba

Wynn round-leafed cassia (*Chamaecrista rotundifolia* , formerly Cassia rotundifolia) is a vigorous, short-lived summer-growing legume that flowers throughout most of the growing season. Ungrazed plants may sprawl to 1 m across and 30 cm high while, under heavy grazing, plants become low rosettes 5–10 cm in diameter.

The legume will grow from far north Queensland to northern New South Wales and is perennial in coastal and sub-coastal areas where summer rainfall exceeds 700 mm. In colder, lower rainfall situations it is annual, regenerating rapidly after spring rain. Waterlogging will kill Wynn cassia which grows best on well drained sandy to light clay soils. Although tolerant of infertile conditions, it responds strongly to applied phosphorus and sulphur.

Wynn cassia is quite tolerant of drought when heavily grazed, but drops leaf prematurely when ungrazed and tall. Top growth is cut by light frost while heavy frosts can kill the plant. Surviving plants regrow rapidly from the crown, with massive regeneration from abundant seed reserves in the soil.

The best use for this legume is to augment native or sown pastures rather than in highly intensive systems because it is not particularly palatable. It has been sown successfully with Katambora rhodes grass in a legume mixture.

Sowing

When to sow

Seed can be sown any time between September and March, but planting before January improves the chances of achieving well-developed plants and a good seed drop before a frost.

Seedbed

All pastures establish better on a well-prepared seedbed, but Wynn cassia seed can be oversown into a burnt native pasture on loose surfaced soils. Hard setting soils need some mechanical disturbance.

Sowing rate

Sowing rates range from 0.5 kg/ha in legume mixtures to 1 kg/ha. Low seed rates are preferable as Wynn cassia seeds heavily and quickly.

Hardseed

Wynn cassia generally establishes rapidly without seed treatment. Seed with more than 70% hard seed can be scarified with dry heat treatment, but hot water should not be used because the seed becomes mucilaginous and glue together.

Inoculum

Wynn cassia usually nodulates well with native rhizobia present in the soil, but can be inoculated with Group I (CB756) rhizobium as insurance.

Sowing method

Prepared seedbed

Seed can be broadcast onto the prepared seedbed and covered lightly with harrows. Rolling on non-crusting soils can help to improve contact between the seed and moist soil.

Oversowing

Wynn cassia can be successfully established into native pastures with minimal land preparation. Seed can be broadcast after a burn on sandy-surfaced soils, but some light cultivation is needed on hard-setting soils. It may also be direct drilled into existing pasture using a suitable planter.

Sowing depth

No deeper than 10–20 mm.

Establishment

Germination relies on good rain after sowing. The seed must maintain close contact with wet soil for 3–4 days to produce a seedling. Subsoil moisture will sustain the seedling until follow-up rain occurs.

Fertiliser

Fertiliser is not essential for establishment, but will greatly improve growth on deficient soils. Applications of 100–200 kg/ha superphosphate every second year is may be economic on native pastures sown with Wynn cassia

Grazing management

Wynn cassia needs no special grazing management.

Although stock tend to avoid it when the grass is green and grazing pressure is low, they eat more legume as the grass matures.

Young plants of Wynn cassia start flowering about 6 weeks after germination, and continue to flower throughout the growing season as long as there is sufficient moisture. Ripe seed pods shatter in hot dry weather, and seed is also spread in dung.

Being a free-seeding legume that establishes easily, it spreads quickly under grazing. Dense stands of seedlings are seen after the first good rains, particularly following fire. Continuous heavy grazing may reduce black speargrass stands, leading to invasion by weeds or more grazing-tolerant grasses.

Wynn cassia has averaged 16% crude protein and 60% digestibility. It has increased the crude protein content of associated spear grass by 20%, or by 40% when fertilised with superphosphate.

In a trial in the coastal Burnett, steers increased weight gains by 40% when Wynn was sown into speargrass.

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APPENDIX 4. WHAT PEOPLE WANTED TO KNOW ABOUT WYNN CASSIA AND WHAT THEY OBSERVED

The following is a list of questions people wanted answered about WC when the project first commenced. Comments from the group are in Italics.

- Do cattle eat WC?

Most people observed that cattle do not accept WC readily. Most stated that WC is the last thing in the sward to be eaten. There are other instances where WC is eaten more readily. The general consensus is that it is eaten in the dry season when it is lower in quality. The protein and digestibility is highest from November to January. If WC is avoided in the wet season and predominantly eaten in the dry, then stock are missing out on the optimum feed quality. This would therefore have serious consequences on cattle productivity. Grazing depends on many factors, such as soil nutrition, time of year and whether cattle are used to WC. Most agree that WC is eaten under sufferance. In many cases animals browse rather than graze it. They browse the tops but estimating the actual intake is difficult. Many noticed that where WC was eaten well, so was Sida. This would suggest that WC is about as palatable as some of the important weeds in the district.

- How aggressive is WC i.e. will it out-compete other pastures?

It is aggressive and will take over pastures due to a combination of factors. The fact that cattle do not eat it early in the season allows it to out-compete other species and set seed every year. This contributes to its competitiveness. It was suggested that *WC has the ability to "choke" out buffel grass in certain situations where grazing pressure is high.*

- What soils does it grow on best i.e. does it grow better on clays or sands?

WC seems to grow on a wide range of soils including sands, sandy loams and white podzolic soils. It can handle a degree of water logging. Seems to grow better on the heavier sandy loams ie. Oolloo soils rather than the pure sands such as on Stray Creek .

- Do cattle gain weight on WC and if so when i.e. all season or part of the season?

People have stated that cattle have put on weight while grazing paddocks containing WC while others have said cattle have lost weight on WC dominant pastures. There is general agreement on the observation that cattle tend to avoid WC in the wet season when the plant's nutritional qualities are the highest. Observations tend to suggest that cattle graze WC in the dry season when there is little other pasture available and when WC has reduced nutritional qualities.

The two grazing trials confirmed that while cattle do put on weight when grazing WC, productivity is modest compared (especially in a pure sward) with other species. The trials indicated cattle seem to lose condition rapidly in the early to mid part of the dry season.

- Does WC put anything back into the soil i.e. nitrogen?

Peter Shotton (DBIRD) has found little evidence of WC contributing nitrogen to companion grasses from samples taken at DDRF. Bill Doyle's observation is that *in the laneway buffel grass is always greener and seeds earlier where it is growing in association with WC.* Phil Hausler thinks *WC may release nitrogen very slowly into the soil.* The demonstration plot at Midway showed that in the presence of adequate phosphorus there seemed to be enough nitrogen to promote vigorous sabi grass. However, analysis would need to confirm this. The deposition of over 3 t/ha of leaf and stem material would contribute nitrogen to the system.

- Will it form a good companion with Jarra and Tully grasses?

People believe *Tully is too aggressive for WC*. However that may be what WC needs to keep it in balance. Jarra grass as a companion is an unknown. People stated *that the performance of Jarra with WC would depend on how the pasture is managed*. Bill's North East paddock (a WC dominated pasture which was cultivated and sown with Jarra grass in 2001-02) would be a good test to see if WC eventually dominated the Jarra.

- How is WC controlled? Can it be controlled? Is there a biological control agent for it?

There is no biological control for it yet in Australia. Many herbicides will kill the parent plant such as glyphosate, Starane®, atrazine, metsulfuron methyl, etc depending on rate and time of application. Spinnaker® and 2,4-D will not kill WC. While the parent plant may be killed there is a lot of seed in the soil from which WC will re-emerge.

- What is the optimal stocking rate which will give the best weight gain and will benefit the pasture?

People suggested *it was difficult to use stocking rate as a management tool to achieve the best performance from WC. Light grazing will result in total avoidance of WC and probably low per hectare performance. Heavy grazing pressure will result in other species i.e. palatable grasses being grazed out earlier.* Bill Doyle stated that *WC responded well to fire and on Theyona WC re-emerged better and with more vigour after a fire.*

While the project did not arrive at a definitive stocking rate, there is enough evidence to suggest that set-stocking rates will lead to WC dominance. Observations from the project suggest strategic spelling of paddocks would assist grass growth and reduce WC dominance early in the season.

- Does WC produce acceptable and palatable hay?

The general consensus is that WC hay is not palatable. Bill Doyle's comments about cattle avoiding the hay in the paddock attests to that. Maybe stock have to get used to it before they accept it. When it is hammer milled it is accepted better, but most agreed that hammer-milling increases the acceptability of most feeds.

The project did limited evaluation of WC hay but the indications are that it is generally less well accepted compared to other hays available. In a feeding trial at BRF steers did not perform well on WC hay. 50% or more horses given WC hay either rejected it or ate it reluctantly. More evaluation is needed.

Palatability and acceptance by stock will depend on many factors. These include whether stock have previously been exposed to WC, how hungry they are, the quality of the hay and whether stock have an option of other types of hay.

- Is WC suitable for cubing?

The Tortilla pelleting plant has processed WC hay into pellets. The hay was combined with molasses, grain sorghum and cooking oil (as a binder). These products combined to make up about 21% of the pellet. The pellet was acceptable to stock and used in a feeding evaluation at BRF. WC can be processed into pellets or cubes, is well accepted by stock and they perform well on WC based pellets.

- What is the protein level of WC throughout the season?

In the early wet season the whole plant crude protein reached a high of 13 to 14 %, dropping to between 3 and 4% in the late dry season. Energy levels were relatively low which may have limited animal performance.

- What is the best method of seed harvesting?

Windrowing or direct heading would probably be suitable. However, a number of people stated they did not want to know because it is unlikely they will harvest or sow WC in the future.

- What is the effect of WC on weeds? Is it a better competitor than other legumes.

One comment was that *"WC is a weed".* It climbs over other species at the end of the season due to the fact that it is not grazed. Its competitive ability comes from the fact that it is a prolific seeder and it has a competitive advantage because of the lack of grazing pressure.

- Where does WC come from and how does it behave there?

A number of South American countries. A paper on its origin is attached.

- What other literature/information is available on WC?

There is research data available from other areas. Some of this has already been compiled and distributed. Sources include CSIRO and Qld Department of Primary Industries.

APPENDIX 5. EVALUATION OF WYNN CASSIA AS A FEED AND FODDER CROP

Project: Evaluate the benefit of WC as a pasture feed and fodder species in the Douglas Daly district

Project Officers: Douglas Daly PIRD Group, P. Shotton, F. O'Gara and B. Lemcke

Location: Paddock 42 and 10A - Douglas Daly Farm

Objective: To measure the performance of cattle on a pure stand of *Chamaechrista rotundifolia* (WC) in terms of weight gain, condition change and fatness.

Background

A Producer Initiated Research and Development (PIRD) project was started in the Douglas Daly area in 2002 to investigate the productivity of WC, its suitability as a hay and fodder crop and the performance of cattle grazing a pure sward of WC.

The objective of this trial was to measure the weight gain of steers on a pure stand of WC and compare the performance of animals on other pasture species.

Method

As part of the Species Evaluation Trial, a 4 ha paddock (paddock 42) was set up as a pure stand of WC to monitor the performance of Brahman weaner steers over a 12-month period. The area was sprayed with a knock down herbicide in November 2001 and planted to WC at 6 kg/ha early December using zero tillage. Goldphos 20 fertiliser was applied at 150 kg/ha pre planting and 50 kg/ha Muriate of Potash applied post planting. A further 50 kg/ha of Goldphos 20® with T/E was applied in December 2002.

Spinnaker® and Verdict® herbicides were used to control grasses and broadleaf weeds during the 2001-02 and 2002-03 wet seasons. Herbicide wiping and hand weeding were also used to control broad leaf weeds and to maintain WC purity.

Grazing

On 07/03/02 five steers, weighing between 284 to 336 kg, were introduced into the paddock. Animals were weighed each month along with the stock on the other pasture species being evaluated. Body condition was estimated and P8 fat was recorded. On 28/06/02 the original five steers were replaced with five weaner steers as part of the standard 12 month grazing change over. These new animals remained for 12 months until 18 June 2003.

Results

The establishment of the WC pasture was slow, eventually thickening up later in the wet season.

During the first month of the steers put on an average 0.8 kg/head/day. The following two months showed little or no weight gain and the last weighing found four of the five steers had lost 5 to 15 kg over the 28 days.

The 2002 steers on average remained at similar weight from June 02 to December 02. Between December 02 and the end of May 03 the mean per head weight gain over six months was 123 kg, the lowest of all the species grazed (see Table 1).

On 20 January 2003 approximately half the paddock was supplied with 900 kg of Katherine lime to see if the five steers would favour these areas. No differences in grazing patterns were noted between limed and non-limed areas.

Discussion

The palatability of WC appears to be low. During the 15 months of the trial weight gains, animal condition and fat measurements were low compared with animals on other pasture species at the same stocking rates. Pasture biomass has been adequate throughout the seasons but utilisation of available feed has obviously been low.

Table 1. Weights from steers grazing WC at DDRF March 02 - June 03

Paddock 42 monthly steer live weights in kg												
	Steer ID											
	First group weights						Second group weights					
	711	779	802	811	870	Mean	904	940	945	1023	1053	Mean
Mar 02	336	332	306	292	284	310						
Apr 02	353	356	332	314	306	332						
01 May 02	354	350	330	320	306	332						
29 May 02	358	359	335	323	310	337						
Jun 02							192	191	206	172	209	194.0
Jul 02							186	194	219	174	213	197.2
Aug 02							185	192	216	179	211	196.6
Sept 02							183	193	208	175	201	192.0
Oct 02							186	200	216	173	207	196.4
Nov 02							184	194	201	173	198	190.0
Dec 02							177	204	209	176	193	191.8
Jan 03							195	218	228	195	215	210.1
Feb 03							217	251	258	226	257	241.8
Mar 03							246	280	276	260	289	270.2
Apr 03							257	288	286	277	310	283.6
01 May 03							270	303	306	292	333	300.8
29 May 03							288	314	335	306	356	319.8
18 Jun 03							283	320	338	300	358	319.8

While it is unusual to have a pure sward of any one species in commercial situations, WC has the ability to dominate and become almost a monoculture under certain grazing practices. The objective of this trial was to see how stock would perform at a moderate stocking level on a pure sward of WC. While the steers did put on weight, gains were relatively low considering the quality of the pasture, its good nutritional status and the low grazing pressure. WC gave the lowest liveweight gain of 15 pasture species or combinations being assessed at DDRF. Steers on the WC also started to lose weight at a faster rate than stock on other pastures at the end of May despite ample feed being available in the paddock.

APPENDIX 6. EVALUATION OF WYNN CASSIA AS A FEED RATION FOR EXPORT STEERS

Project: Evaluate the use of WC as a feed source for Brahman export steer rations.

Location: Berrimah Farm

Objective: To determine the feeding value of WC hay and pellets as feed to penned steers compared with Cavalcade and pangola hay.

Background

As part of a Producer Initiated Research and Development (PIRD) project conducted by Douglas Daly producers, WC hay was evaluated as a feed source for export steers and compared to Cavalcade hay (*Centrosema pascuorum*), pangola hay (*Digitaria eriantha*) and Tully grass (*Brachiaria humidicola*)/cottonseed pellets. The different feeds were provided to pens of steers at Berrimah Research Farm (BRF).

Materials and Method

Trial 1

WC, pangola and Cavalcade hay was fed ad-lib to steers at BRF. Yearling Brahman-cross steers were sourced from DDRF. The hay treatments consisted of pens of three steers each and were replicated twice. Tully/cottonseed pellets were fed to a single pen of three steers. Each pen was supplied with a mineral block (Phosrite®). The animals were weighed on a weekly basis and fat measurements and *ad lib* feed intake were recorded daily. Round bales of WC were supplied by Theyona Station at Douglas Daly, Cavalcade by DDRF, pangola by BRF and the Tully/cottonseed pellets by Australasian Farms Pty Ltd. The pellets consisted of Tully, cotton seed, molasses and cooking oil as a binding agent. The cotton seed was not de-linted.

Table 1.

Trial 1. Average steer performance on WC, Cavalcade and pangola hays and a Tully/ cottonseed pellet							
Feed source	**Crude protein (%)**	**Weight (kg)**	**Weight (kg)**	**Weight (kg)**	**Fat depth change-P8**	**Phosrite®**	**Feed intake**
		Day 1	Day 9	Day 36	(mm)	(g/hd/day)	kg/day
WC	6.5	339	312	295	-2.5	66	3.08
Cavalcade	9.06	330	332	337	-1.1	75	4.23
Pangola	3.13	333	328	344	-1.5	61	4.99
Tully/cottonseed pellets	6.88	315	310	334*	0	90	7.96

* Weight after 32 days when supply ran out.

Discussion

All the animals except those on Cavalcade lost weight in the first week. By the end of the feeding period all animals had achieved a positive weight gain except those on WC. The animals on pellets performed better than all the hay fed animals giving an average gain of 0.6 kg/day over the entire period including the initial loss. Pangola provided better gains than Cavalcade hay, which is surprising, with 0.34 kg and 0.22 kg/day respectively over the entire feeding period. The WC hay did not provide any weight gain with animals losing 44 kg on average, almost 1.4 kg/day. During the last 23 days of the trial when the stock started to gain weight, the Cavalcade, pangola and pellet groups provided an average gain of 0.2, 0.69 and 1.04 kg/day, respectively. The WC hay resulted in an average daily loss of 0.73 kg/day

All hay treatments resulted in a reduction in fat depth over the trial while the pellet fed animals maintained their condition. Cattle on the WC hay actively ate the leaf and rejected much of the stem material.

Trial 2

WC pellets were compared to pangola hay in a feeding trial. Yearling Brahman-cross steers were fed WC pellets composed of 21% grain sorghum, 5.8% cooking oil and 3.1% molasses. Measurements were the same as in trial 1.

Table 2.

Average steer performance on WC pellets compared with pangola hay							
Feed source	**Crude protein (%)**	**Weight (kg)**	**Weight (kg)**	**Weight (kg)**	**Fat score**	**Phosrite®**	**Feed intake**
		Day 1	Day 9	Day 25	mm	g/day	kg/day
WC pellets	7.5	275	281	292	0.8	85	6.37
Pangola hay	4	276	268	277	-1	75	4.05

WC pellets provided a significantly better weight gain than pangola hay. In the 25 days animals on pangola recovered their body weight while the animals on WC gained an average of 17 kg. This is reflected in the higher intake of pellets (6.37 kg/head/day) compared with 4.05 kg/head/day of pangola hay. When compared to the results in trial 1, animals on both WC and Tully/cottonseed pellets gained more weight than those fed WC, Cavalcade and pangola hays. All of the hay in these trials was average commercial quality. Despite the low protein in the pangola hay, cattle did remarkably well on it in both trials.

These trials indicate that while WC hay is not well accepted and results in low daily intake, WC based pellets appear to be well accepted and have the potential to be utilised as feed for export steers.

APPENDIX 7. EVALUATION OF HERBICIDES FOR WYNN CASSIA CONTROL

PRELIMINARY EVALUATION OF SELECTIVE HERBICIDES FOR THE CONTROL WYNN CASSIA IN GRASS PASTURES

G. Schultz, N. Hartley and S. Dennis

Background

Interest has been expressed by landholders and pastoralists for cost effective chemical control of WC (*Chamaechrista rotundifolia*). A site was selected at Taminmin High School 45 km south-east of Darwin on 18 December 2002, to evaluate a range of herbicides to control WC.

Objective

To evaluate a range of selective herbicides to control or suppress the growth of WC in mixed pastures and other crops and formulate recommendations for land holders.

Method

Plots measuring 12 by 80 metres in a mixed pangola - WC pasture were sprayed using a quad mounted sprayer. The WC was 15 to 20 cm high and starting to flower. The following herbicides were applied in a spray solution of 100 L/ha plus 0.1% wetter.

1. Brush-off 10 g/ha + 0.1% wetter
2. Brush-off 20 g/ha + 0.1% wetter
3. Brush-off 10 g/ha + 0.1% wetter + 0.5 L/ha 2,4-D
4. Brush-off 20 g/ha + 0.1% wetter + 0.5 L/ha 2,4-D
5. Tordon 75D 1 L/ha+0.1% wetter
6. Atrazine 2 L/ha+0.1% wetter
7. Diuron 2 L/ha+0.1% wetter

Results

The following observations were made on 2 January 2003, 16 days post herbicide application.

Diuron 2 L/ha (1,000 g Diuron a.i./ha): Only had a slight effect on the WC by very slight discolouration, and had no effect on the pangola. WC continued to grow and out-compete the grass.

Atrazine 2 L/ha (1,000 g Atrazine a.i./ha): All the treated area showed moderate to severe chlorosis of the WC leaves. Growth was stunted with scattered dead patches. New growth tips were occurring on live WC plants. No visual effect was seen on the pangola.

Tordon 75 D 1 L/ha (75 g a.i./ha Picloram, 300 g a.i./ha 2,4-D amine): All the WC showed severe chlorosis but some unaffected new growth terminals started to appear.

Brush-off 20 g/ha + 0.5 L/ha 2,4-D (12 g Metsulfuron-methyl a.i. /ha + 312.5 g 2,4-D amine a.i./ha): This plot is showing the best uniform control, The WC was chlorotic and stunted, No new growth at WC terminals, grass was not effected.

Brush-off 10 g/ha+ 0.5 L/ha 2,4-D (6 g Metsulfuron-methyl a.i. /ha + 312.5 g 2,4-D amine a.i./ha): No visual difference between this plot and the 20 g application area.

Brush-off 20 g/ha (12 g Metsulfuron-methyl a.i. /ha): All areas were chlorotic and stunted, No difference to other Brush-off treatments.

Brush-off 10 g/ha (6 g Metsulfuron-methyl a.i. /ha): All areas were chlorotic and stunted. No difference to other Brush-off treatments.

APPENDIX 8. ORIGIN OF WYNN CASSIA

ID NO. 368

ORIGIN OF THE WORLD'S COLLECTION OF THE TROPICAL FORAGE LEGUME CHAMAECRISTA ROTUNDIFOLIA

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ABSTRACT
Round leaf cassia (*Chamaecrista rotundifolia*) cv. Wynn is an important legume in light textured soils in sub-tropical Queensland and forage evaluators in other regions of the tropics frequently wish to include in their evaluation trials this cultivar plus other accessions which represent the variation in the species. Provenance data of a world collection of 130 accessions of round leaf cassia were examined and a core set of 26 accessions selected.

KEYWORDS
Chamaecrista rotundifolia, germplasm, plant geography, core collection

INTRODUCTION

Round leaf cassia (*Chamaecrista rotundifolia*) cv. Wynn is an important forage legume for the light textured, acid soils of sub-tropical Queensland. This particular cultivar is an early flowering, heavy seeding short-lived perennial which is persistent under grazing and is most frequently used as a legume sown into native speargrass (*Heteropogon contortus*) pastures. The species is widespread throughout tropical America and is found in savannas, campos, llanos, openings in woodlands and is an abundant coloniser of disturbed areas (Irwin and Barneby, 1982). In a comparative study of 18 accessions of the species from which cv. Wynn was selected for commercial release (Strickland *et al.*, 1985), variation in morphological and agronomic attributes including yield, flowering time, seed weight and broad adaptation were clearly related to geographic origin. More recently, Whitty *et. al.*, (1994) were able to relate variation within the species to geographic origin using RAPD analysis. However relationships between phenotypes of *C. rotundifolia* and geographic origin have been difficult to establish in other studies (Irwin and Barneby 1982, Maass and Cárdenas (pers. com.). Wynn was collected from Sao Paulo, Brazil in 1964 and released in 1983. Since its release, the number of accessions held in the world's major tropical forage genebanks has increased to 130. This paper reports the geographic origin of those accessions and identifies a core collection of the species. Using that core collection in future evaluation studies should result inefficiencies in utilisation of the collection and, because of the reduced number of accessions for which large quantities of seed need to be available, improved efficiencies in seed multiplication and maintenance of the collection.

METHODS AND MATERIALS

Provenance data for *C. rotundifolia* accessions held at the two major tropical forage germplasm centres (CIAT and ATFGRC) were assembled. Data were examined to identify duplicate accessions, mapped and studied to identify the range of latitudes, mean annual rainfall, altitude, soil texture, soil pH and associated species at the site of collection. A core set of accessions was selected on the basis of provenance data. It includes accessions from the geographic range of the species as well as accessions from the extremes of rainfall, altitude and soil reaction (Table 1). CPI 34721, cv. Wynn, is included in the core set because of its cultivar status.

RESULTS AND DISCUSSION

Latitude. Site of collection is available for 117 of the 130 accessions. *C. rotundifolia* accessions have been collected from North, Central and South America with latitude ranging from 22°55' N in Jalisco, Mexico to 28°53' S in Corrientes, Argentina (Map 1). Some accessions have been collected from Ghana and Nigeria in West Africa. Hutchinson and Dalziel (1958) and Lock (1989), however, consider the species to have been introduced into Africa from the Americas. On the basis of seed size reported by Strickland *et al.*, (1985), it would appear that the origin of the west African material is possibly Brazilian. However Whitty *et. al.*, (1994) suggested differences between the African and American germplasm based on RAPD analysis.

Mean annual rainfall. *C. rotundifolia* has been collected from sites with mean annual rainfall ranging from 400mm to 3720mm. Most accessions were collected from sites with a mean annual rainfall of ca. 1000mm which is reflected in the adaptation of *C. rotundifolia* to the sub-humid and semi-arid areas of Africa (Tarawali 1994). The majority of accessions from dry sites (<1000mm) were collected from the states of Bahia, Rio Grande de Norte, Pernambuco in northern Brazil while the wetter sites were almost invariably located in Colombia.

Altitude. The majority of accessions were collected from below 0.9 m altitude although 6 accessions were collected from altitudes >1000m - from Jalisco in Mexico and from District Federal and the state of Goias in Brazil. The accessions from Jalisco, Mexico were collected from near the northern extremes of the species' distribution, at ca. 20°N and these accessions are likely to be the most cold tolerant accessions in the collection.

Soil texture and pH. Data for soil texture, fertility and pH at the site of collection are limited. In the 52 cases where soil texture data were available, 3 accessions were collected from stony soils, 28 were from sands, 13 from loams and 8 from clay loams or clay soils. These results confirm the observation of Irwin and Barneby (1982) that the species is largely confined to light-textured soils. While most accessions were collected from slightly acid soils (pH 5.0-7.0), six accessions were collected from soils with pH 5.0 and these could be of particular value for developing cultivars for acid soils in the tropics. No accessions were collected from alkaline soils.

Associated legumes. 59 accessions of *C. rotundifolia* were collected in association with various pioneer legumes adapted to open and disturbed environments, including *Stylosanthes guianensis, S. scabra, S. humilis, Desmodium barbatum, D. incanum* and *Centrosema brasilianum*. In 48 of these, the associated legume species included *Stylosanthes* spp. Also, most accessions of *C. rotundifolia* (ca. 70%) were collected from roadsides and together, these data indicate that the species is a strong coloniser.

CONCLUSION

Although there is conflicting evidence on the relationship between morphological variation and geographic origin, the results from Strickland *et. al.*, (1985) and Whitty *et. al.* (1994) justify the selection of a core set of accessions based on geographic origin and other provenance data. A core collection of 26 accessions of *C. rotundifolia*, which takes into account the geographic origin, soil, mean annual rainfall and altitude at the site of collection has been identified (Map 1, Table 1.). No representatives from Africa are included in the core set since most evidence points to the species being adventive in that continent. There are a number of regions of the Americas where *C.*

rotundifolia is reported and which are yet to be sampled. Important among these are Cuba, Honduras, coastal Ecuador and Bolivia.

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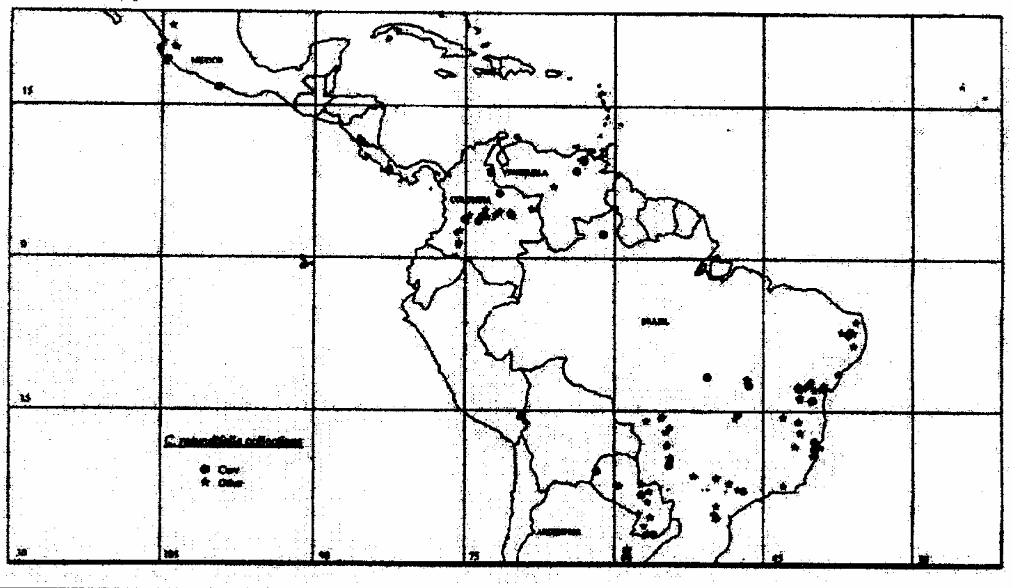
Table 1
Core accessions of *Chamaecrista rotundifolia* selected on the basis of geographic origin, rainfall, altitude and soil data.

Accession*	Country	State	Latitude	Longitude	Altitude (m)	Rainfall (mm)	pH
CPI 86162	Mexico	Jalisco	20.37N	105.15W	10	1500	6.5
CPI 86178	Mexico	Jalisco	19.35N	104.25W	1000	850	6.5
CPI 85836	Mexico	Guerrero	16.45N	99.30W	50	1400	6.5
CIAT7091	Panama	Chirique	8.43N	82.37W	770	2720	
CIAT7288	Venezuela	Anzoategui	8.37N	63.50W	130	1080	
CIAT18252	Venezuela	Zulia	8.29N	72.29W	10	2730	4.8
CIAT8158	Colombia	Arauca	6.23N	71.36W	280	2680	
CIAT21715	Colombia	Meta	4.03N	73.27W	340	3700	
CIAT20715	Colombia	Huila	3.50N	75.06W	550	1090	6.9
CIAT17958	Colombia	Meta	3.38N	73.44W	380	2850	4.6
CIAT17440	Brazil	Roraima	2.22N	61.10W	80	1930	
CIAT8389	Brazil	Paraiba	7.06S	36.17W	570	400	
Q10057	Brazil	Paraiba	7.22S	36.30W	580	420	
CIAT9847	Brazil	Mato Grosso do Sul	11.37S	50.40W	250	1580	
CIAT8556	Brazil	Goias	12.24S	46.27W	690	1510	5.0
CIAT8994	Brazil	Bahia	13.53S	40.01W	200	690	
CIAT8559	Brazil	Goias	15.23S	47.32W	1220	1600	
CIAT17002	Brazil	Bahia	18.01S	39.51W	90	1510	
CIAT17000	Brazil	Espirito Santo	18.46S	39.51W	70	1420	
CIAT9735	Brazil	Mato Grosso do Sul	20.23S	54.32W	580	1450	4.5
ATF2208	Paraguay	Nuevo Asuncion	20.57S	61.48W	300	500	6.0
CPI 34721	Brazil	Sao Paulo	22.54S	47.03W	800	1390	
ATF2222	Paraguay	Concepcion	23.17S	57.20W	250	1300	7.0
CPI 92985	Brazil	Parana	25.36S	49.48W	790	1260	
ATF2228	Paraguay	Itapua	27.14S	56.04W	260	1600	
CPI 78355	Argentina	Corrientes	28.53S	58.45W	80	1320	

CPI = Australian Commonwealth Plant Introdusction number
CIAT = Centro Internacional de Agricultura Tropical, Colombia
ATF = Australian Tropical Forages Genetic Resource Centre

Figure 1
Distribution of the world genertic resource collection of *Chamaecrista rotundifolia* together with those accessions selected on the basis of provenence data as being part of the core collection.

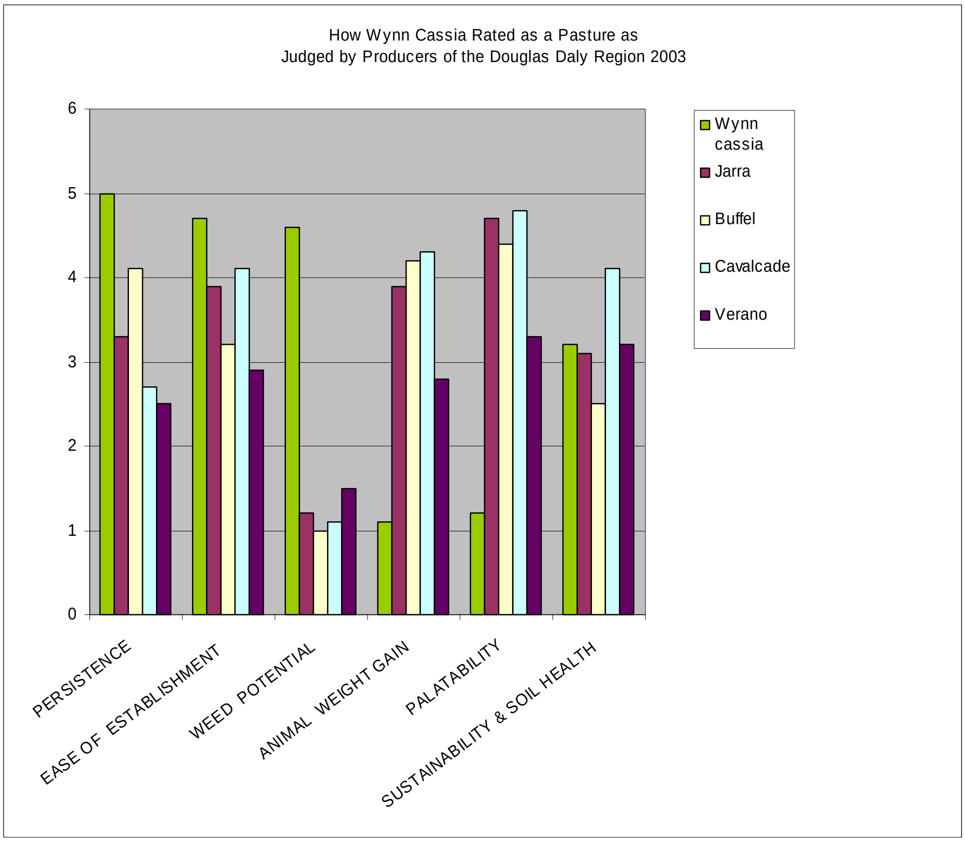


APPENDIX 9. HOW PRODUCERS RATED WYNN CASSIA AGAINST OTHER PASTURES IN THE DOUGLAS DALY REGION OF THE NT

Producers rated WC on a number of key criteria using a scale from 1-5 (1 = lowest rating, 5= highest). The criteria chosen by producers were those commonly used in assessing the usefulness and productivity of a pasture species. They also rated four other popular species as a comparison to WC. While WC was rated the highest in terms of persistence and ease of establishment, it was also rated as the biggest weed threat. WC was rated as the pasture with the lowest palatability and lowest potential for animal performance. WC rated moderately well for sustainability compared to other pastures, due to its potential nitrogen contribution and soil cover. The following table and graph show the results.

Table 1. Pasture ratings for key criteria

	Persistence	Ease of establishment	Weed potential	Animal weight gain	Palatability	Sustainability and soil health
WC	5	4.7	4.6	1.1	1.2	3.2
Jarra	3.3	3.9	1.2	3.9	4.7	3.1
Buffel	4.1	3.2	1	4.2	4.4	2.5
Cavalcade	2.7	4.1	1.1	4.3	4.8	4.1
Verano	2.5	2.9	1.5	2.8	3.3	3.2



APPENDIX 10. THE VALUE OF ROUND-LEAFED CASSIA IN SOUTH-EAST QUEENSLAND

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The value of round-leafed cassia (*Cassia rotundifolia* cv. Wynn) in a native pasture grazed with steers in south-east Queensland

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Abstract

Wynn cassia is a new forage legume which was untested with grazing animals prior to its release in 1984. Wynn cassia was sown into two 24 ha paddocks of black speargrass and, in an unreplicated trial lasting 5 years, steer growth was compared between Wynn cassia paddocks, with and without superphosphate (55 kg/ha/yr), and with a 75 ha native pasture paddock, all at a common stocking rate of 2.4 ha/steer.

Unfertilised Wynn cassia spread rapidly and, despite its reputation for low palatability, provided at least 16% of the steers' diet. Steers on Wynn cassia gained an average of 35 kg/hd/yr more (40%) than those on native pasture. Wynn cassia responded strongly to superphosphate but weight gains improved by only a further 10 kg/hd/yr.

Wynn cassia increased the N concentration of the associated spear grass by 20% when unfertilised, and by nearly 40% when fertilised. On the granodiorite soil at this site, P was generally adequate for plant and cattle but sulphur appeared deficient.

Resumen

La cassia Wynn es una leguminosa forrajera que no fue evaluada para pastoreo antes de ser liberada en 1984. Con el fin de evaluar su potencial en pastoreo, se sobre-sembró la cassia Wynn en potreros de speargrass de 24 ha y se comparó el crecimiento de novillos en estos potreros, con y sin superfosfato (55 kg/ha/a), con el crecimiento de novillos en potreros de 75 ha de pasturas nativas; el ensayo no tuvo repeticiones, duró 5 años y se utilizó una carga general de 2.4 ha/novillo.

La cassia Wynn sin fertilizar se estableció rápidamente y, a pesar de tener la reputación de baja aceptación animal, contribuyó con 16%, cuando menos, en la dieta de los novillos. Los novillos en cassia Wynn tuvieron una ganancia promedio de peso de 35 kg/novillo/a (40%) por arriba de aquellos en pasturas nativas. A pesar que cassia Wynn respondió fuertemente a la aplicación de superfosfato, los novillos únicamente tuvieron una ganancia adicional de 10 kg/a.

La cassia Wynn sin fertilizar incrementó 20% la concentración de nitrógeno de la gramínea asociada speargrass, y cerca de 40% cuando fue fertilizada. En los suelos granodiorite de esta localidad, el nivel de fósforo fue por lo general adecuado para el crecimiento de las plantas y los animales, pero parece haber deficiencias de azufre.

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Introduction

Round-leafed cassia (*Cassia rotundifolia*) is a native of savanna in tropical and subtropical South and North America, and of Africa. Dr D. Norris of CSIRO introduced a number of accessions to Australia in 1964 and one, CPI 34721 from Valinhos (23°S) in Brazil, was released in 1984 with the cultivar name Wynn (Anon 1984).

Because many species of *Cassia* are unpalatable or even toxic (Everist 1974), they are well known as weeds in many tropical countries. Selections of *Cassia* were tested in rat-feeding trials by Strickland *et al.* (1986) and round-leafed cassia was found to be palatable, of high quality, and free from deleterious compounds.

Round-leafed cassia had been planted in small evaluation plots at a number of sites before Wynn was released (Strickland 1985), but only by 1984 was sufficient seed available for a grazing trial. We report results of the first large-scale trial using pastures based on Wynn round-leafed cassia.

Materials and methods

Site

The trial site at Gaeta, near Gin Gin, in south-east Queensland (lat. 25°S, long. 154°E) was on undulating to slightly steep slopes supporting native pasture dominated by black speargrass (*Heteropogon contortus*). The original woodland community of narrowleaf ironbark (*Eucalyptus crebra*), spotted gum (*E. maculata*) and Moreton Bay ash (*E. tessellaris*) had been cleared with bulldozers, but the understorey shrubs, hickory wattle (*Acacia aulacocarpa*) and corkwood wattle (*A. bidwillii*) regrew during the trial. Mean annual rainfall at Gin Gin is 1070 mm of which 70% falls between October and March.

Soils

Soils on the site are texture-contrast, or duplex, non-calcareous browns or solodics (Dy 3.2.2 and Dr) (Northcote 1971) derived from granodiorite. They have 30–60 cm of hard-setting loam or sandy clay loam overlying yellow or red moderately heavy clay. Chemical analyses of the soils in the paddocks before fertilising are given in Table 1.

Treatments

The site had 2 main paddocks, a native pasture control of 75 ha and a Wynn cassia area of 48 ha which was divided into 2 equal paddocks. The treatments were:

i) native pasture,
ii) native pasture with Wynn cassia, and
iii) native pasture with Wynn cassia and fertiliser.

Wynn cassia seed was oversown, at 1.2 kg/ha, into the native pasture in the relevant paddocks after a single chisel ploughing in October 1984. The fertilised paddock received 110 kg/ha of single superphosphate (9% P) at establishment and every second year thereafter.

Weaner steers of mixed Brahman and Africander breed were introduced in December 1984 at a stocking rate of 1.6 ha per animal and stayed in the trial for 2 years. In subsequent years, yearling steers were grazed, at 2.4 ha per animal, and changed annually.

At the beginning of March 1988, following months of drought (see rainfall in Table 2), the water supply became unreliable and the trial steers were removed. The whole trial area was then grazed by commercial cattle with access to water elsewhere. Although good rain fell immediately after the steers were taken out and the subsequent growth of Wynn cassia was excellent, we were unable to alter our contingency plans. Trial steers were reintroduced in August 1988.

The native pasture treatment was stopped in December 1989, but trial steers remained on the 2 Wynn cassia paddocks until June 1990.

Measurements

Steers were weighed every 3 months, after an overnight fast. Because of the unreplicated design of the trial, the annual responses of the steers were compared using an analysis of variance, with protected l.s.d.; error was estimated from within-paddock variation.

Samples of green shoot of grass or tips (first 5 open leaves) of Wynn cassia were plucked every

Table 1. Chemical analyses of soils (to 10 cm depth) in the treatment paddocks.

Paddock	pH (1:5 H_2O)	Nitrate N	Extract. P (bicarbonate)	Extract. K	Extract. SO_4-S[1]
		(μg/g)	(μg/g)	(μg/g)	(μg/g)
Native pasture	5.9	1	4	160	3
NP + Wynn cassia	6.1	1	4	133	3
NP + Wynn cassia + fertiliser	6.1	1	4	94	2

[1] Method of Barrow (1967).

Table 2. Seasonal rainfalls recorded at trial site, and long-term averages for Gin Gin.

Season	1984	1985	1986	1987	1988	1989	1990'	Gin Gin average
				(mm)				
Summer (Dec-Feb)		152	503	169	83	165	111	469
Autumn (Mar-May)		130	74	138	254	420		263
Winter (Jun-Aug)		234	99	65	309	125		141
Spring (Sep-Nov)	177	214	239	166	39	92		192
Annual total	739	757	855	474	904	1041		1068

3 months and analysed for N, P, K and S. These herbage samples, and dung samples taken from the individual trial steers were bulked and analysed to determine faecal carbon isotope ratios ($\Delta\ ^{13}C:^{12}C$) (Jones *et al.* 1979) as a means of estimating the legume content of the diet.

The legume population was counted in spring of 1985 and 1986. Yield, botanical composition and species frequency were measured in 125–150 quadrats of 0.25 m^2 in each of the Wynn cassia paddocks in most years, and analysed using a modified Botanal technique (O'Rourke *et al.* 1984). The native pasture control was surveyed only in 1988.

Seed reserves of Wynn cassia were measured in the faeces (from rectal samples and dung pats), and in the soil in 7 quadrats of 300 cm^2 of soil to a depth of 2 cm. The soil was sieved with water, and the organic material floated off with perchlorethylene (Jones and Bunch 1977) before being separated in an ascending column of air.

Results

Liveweight gains

The yearling steers on the native pasture augmented with Wynn cassia gained, on average, an extra 34 kg/head (40% improvement), or an extra 45 kg/head with fertiliser, over those on native pasture alone (Table 3). These figures are the average over the last 4 years of the trial with all treatments at a stocking rate of 2.4 ha/steer. Only between September 1989 and June 1990 was there a significant advantage in liveweight gain from fertilising.

In the first year (1984–85) the weaner steers, at stocking rate of 1.6 ha/steer, grew poorly on all pastures, causing concern about the feeding value of Wynn cassia. These steers continued to grow poorly through autumn and winter of their second year but, in the last quarter of that year, the stocking rate was reduced to 2.4 ha/steer and the final gains for 1985–86 were good, probably due, in part, to some compensatory growth.

Botanical composition

The sown Wynn cassia seed germinated well in October 1984 but, as many seedlings failed to survive a subsequent heat wave in November, establishment was mediocre. After one year, there were less than 2 mature plants of Wynn cassia per square metre (Table 4). Steers from the other groups accidentally grazed the fertilised treatment for over a month in February and March 1985 and the higher grazing pressure reduced seed production. Hence, there were fewer seedlings in November 1985 and fewer mature plants in the next year. However Wynn cassia populations in both paddocks were sufficient to set large amounts of seed during 1985, resulting in about 165 seedlings per square metre by November 1986.

The population of black spear grass plants in the oversown paddocks remained high even though Wynn cassia spread throughout them; spear grass contribution declined from 65% in 1985 to 55% in 1989, but it still had a 90% frequency. Speargrass dominated the control paddock, contributing 73% of total herbage yield in 1988, although Wynn cassia started to invade from the fence line and access track to the weighing yards in later years.

Wynn cassia responded strongly to maintenance fertiliser in September 1986 and October 1988; uneven spread produced dark green strips of Wynn cassia-dominant pasture but the overall yield was not affected until 1989 (Table 4).

After four years, Wynn cassia provided over 30% of the overall herbage dry matter. Although it provided over 60% in the fertilised strips, the associated speargrass plants were vigorous. By the end of the trial period, the grass was recovering

Table 3. Liveweight gains of steers grazing native pasture with and without Wynn cassia.

Period	Initial steer weight	Stocking rate	Liveweight gain: Native pasture	Native pasture + cassia	Native pasture + cassia + super
	(kg)	(ha/steer)		(kg)	
Dec 84–Dec 85	200	1.6	24[a1]	46[b]	31[a]
Dec 85–Dec 86		1.6/2.4	106[a]	142[b]	153[b]
Mar 87–Mar 88	310	2.4	75[a]	93[a]	103[a]
Aug 88–Sep 89	290	2.4	81[a]	131[b]	141[b]
Sep 89–Jun 90		2.4		149[a]	160[b]
Av. lwg/yr (Dec 85–Sep 89)			87	121	132

[1] Values followed by the same letter are not significantly different ($P > 0.05$).

strongly, especially in spring after the Wynn cassia had been reduced by frost.

Herbage mineral concentrations

Potassium levels of around 1.2% in the grass and 1.2–1.9% in the legumes were well above published critical levels for legume growth, except in winter (0.6% K).

The overall mean concentrations of N, P and sulphur (S) in the grass and legume are given in Table 5. Average N concentrations in speargrass in the control paddock were low (1.14% N) but those in the unfertilised Wynn cassia paddock were raised by 20% (to 1.39% N) by the associated legume, and by nearly 40% (to 1.57% N) when the sward was fertilised with P and S. In general, P concentrations (over 0.12% P) appeared adequate for growth of plants (Andrew and Robins 1969) and for grazing steers, but they were increased by superphosphate. The S levels, on the other hand, were well below critical levels for other legumes (Andrew *et al.* 1974) and probably marginal for steers. Applying superphosphate raised the S levels of both grass and legume. N:S ratios were around 15 for grass, 22 for legume and 12 for faeces but, with fertilising, the ratios were reduced to 15, 13 and 9 respectively in later years. Dry frosted leaf taken in July from standing Wynn cassia plants, with and without fertiliser, showed concentrations of N at 1.74% and 1.36%, and of P at 0.09% and 0.07% respectively.

Dietary legume content

The steers never appeared to relish or select Wynn cassia — but would have had difficulty avoiding

Table 4. Attributes of Wynn cassia when grazed in fertilised and unfertilised paddocks.

Survey date	Populations: Mature	Populations: Seedling	Frequency	Presentation yield: Total	Presentation yield: Wynn
	(Plants/m²)		(%)	(t/ha)	(%)
November 85					
unfertilised	1.7	2.8	30	2.5	4
fertilised	1.6	0.6	25	1.7	3
November 86					
unfertilised	13.2	164		0.9	15
fertilised	7.4	174		1.0	13
March 88					
unfertilised			82	1.0	32
fertilised			83	1.1	33
April 89					
unfertilised			93	3.6	33
fertilised			95	5.9	39

Table 5. Concentrations of nitrogen, phosphorus and sulphur in grass and legume, averaged over all seasons and years.

Treatment	N		P		S	
	grass	legume	grass	legume	grass	legume
	(%)		(%)		(%)	
Native pasture	1.14		0.16		0.09	
Native pasture + Wynn cassia	1.39	2.26	0.16	0.17	0.08	0.11
Native pasture + Wynn cassia + superphosphate	1.57	2.71	0.19	0.22	0.11	0.14

it — and there was no difference in the proportion of C_3 plant material (legumes and other broad-leafed plants) in the diet between the fertilised and unfertilised Wynn cassia treatments (Figure 1).

There was, on average, an extra 16 percentage units of C_3 material in the diets of the steers grazing paddocks oversown with Wynn cassia than in the diets of those on native pasture alone. This can be assumed to be the minimum extra legume (Wynn cassia) in the diet. The difference was greatest in early winter (June) but the proportion of C_3 material in the diet of the native pasture steers was highest in early summer (December).

Wynn cassia seed reserves

The seed reserves in the soil under stands of vigorous fertilised Wynn cassia were 300 kg/ha. Germination of Wynn cassia seed was high after fires and rainfall, and bare ground was soon covered densely with seedlings.

Dung samples, taken from the rectum of steers after a 16-hour fast at the weighing in May 1989, showed little mature Wynn cassia seed, but fresh pats from the field at the same time of the year contained 800 mature seeds per kg of dry faeces.

Discussion

The value of Wynn cassia to augment native pasture is shown by the large increase in liveweight gain of the steers, even though this was an unreplicated trial. Good responses have also been shown in other recently conducted unreplicated grazing trials at Kabra near Gracemere (C. Middleton, personal communication) and at Gayndah (M. Quirk and R. Tyler, personal communication).

Wynn cassia showed nearly all the characteristics needed for a forage legume to naturalise — rapid germination and growth, early and extended flowering, high seed set, little or no disease, promiscuous rhizobial nodulation and only moderate palatability. Its population increased rapidly during the first 2 years because of these features, and this was aided by spread of seed through the dung. Cattle obviously eat large quantities of Wynn cassia seed pods, and a mature beast could spread more than 2500 seeds a day.

In the first year, the poor growth rates of the weaner steers and the poor acceptance of Wynn cassia raised concerns about the weed potential of this new legume. *Cassia rotundifolia* is from a family (Caesalpiniaceae) previously unused for commercial forage plants; many other *Cassia* species (*C. tora, C. occidentalis, C. barclayana*) can be serious pasture weeds in Queensland or throughout the tropics.

Despite its acceptance in the rat-feeding trials (Strickland *et al.* 1986), Wynn cassia was never relished by cattle in this trial and appeared to be less sought after than shrubby stylo, for example. Bitten-off stems could generally be found but rarely the rosette form of growth that indicates continuous grazing. Intake of Wynn cassia increased in autumn; in one year, cattle started to graze the dense patches of fertilised Wynn cassia only after mid-April.

The generally high content (around 25%) of C_3 plants in the diet of the steers grazing the Wynn paddocks could be due partly to other forbs (cf. the native pasture control), but the better weight gains suggested that Wynn cassia was a significant component of the diet.

Under the moderate grazing pressure in this trial, unfertilised Wynn cassia formed a good balance with the speargrass despite its rapid spread and low palatability. Uneven application of superphosphate did cause patchy Wynn dominance, but the extra N fixed should eventually boost grass growth. Experiences of Wynn

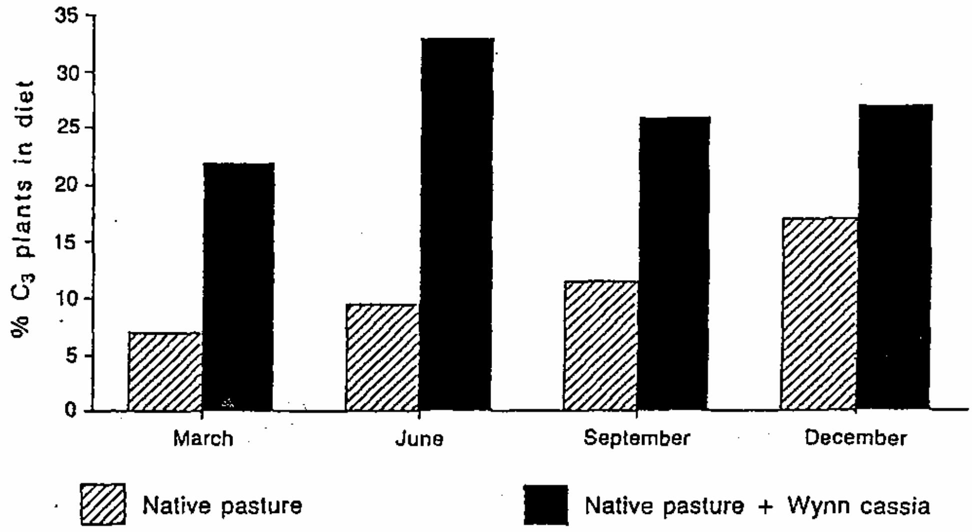

Figure 1. Proportion of C_3 plants (legume + forbs) in the diet of steers.

cassia dominance elsewhere (G. Elphinstone, personal communication) have resulted in a recommendation not to plant Wynn cassia on fertile soils in high rainfall areas.

Wynn cassia responded strongly to superphosphate on this site; the uneven spread of fertiliser produced vivid dark green strips dominated by legume. While the extra weight gain of steers on fertilised legume was not significant, except in the final year, presenting the improvement in weight gain by averaging the results from both Wynn treatments might exaggerate the value of Wynn cassia. However those in the fertilised paddocks were always in better condition than those without fertiliser. Higher stocking rates on fertilised paddocks would be needed to utilise the extra pasture growth and to show an economic response.

Fertilising Wynn cassia did not appear to increase the proportion of legume in the diet despite the higher mineral concentrations and lush growth. This response differs from the effect of superphosphate on stylos (McLean *et al.* 1981), but is similar to observations of steers on a fertilised bahia grass (*Paspalum notatum*)–Wynn cassia pasture at Samford where Wynn contributed only 3–4% of the diet (R. Clements, personal communication). These comparisons suggest that low palatability *per se* rather than low digestibility is the cause of the low proportion of legume in the diet. However Wynn cassia does not appear to contain any anti-nutritional factors (Ahn *et al.*, 1988; Quirk *et al.* 1991) and, to the human palate, *C. rotundifolia* is not bitter and has none of the obnoxious aromatic compounds found in some other *Cassia* species.

Phosphorus concentrations were generally adequate for plant and animal growth on this granodiorite soil, but S concentrations were low. In a P, S and molybdenum fertiliser plot trial later superimposed on the Wynn cassia paddock, S had the greatest effect on legume yield, while P increased yield only in the presence of S (I. Partridge, unpublished data).

If N:S ratios of around 17 indicate deficiency of S in plant material (Andrew *et al.* 1974), plant growth was often limited by low S. As the currently recommended dietary N:S ratio for cattle is 14:1 (ARC 1980), the trial cattle might also have been deficient in S, especially in the earlier period of the trial. The levels of S applied (5 kg/ha/yr) were insufficient to narrow N:S ratios quickly.

The large increases in the N concentration of the speargrass associated with Wynn cassia indicate that this legume can fix considerable amounts of N which are transferred to the grass.

Poor growth rates of animals in the first year were probably due to the use of weaners on such poor country and to the high stocking rates, but low sodium was also considered a possible cause. Very low sodium concentrations (0.03–0.05%) were recorded in our trial in herbage of both Wynn and speargrass on two occasions.

Since Wynn cassia was released, it has become well accepted by graziers who like its rapid germination and spread and its attractive appearance. It is now sown regularly in seed mixtures in many coastal districts of Queensland. Doubts about possible toxicity have been dispelled and, although it appears relatively unpalatable, this may aid persistence and spread and so contribute to sustainable weight gains.

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APPENDIX 11. QUALITY ASSESSMENT OF THE FODDER LEGUME

Tropical Grasslands Vol. 22, No. 2, June 1988 63

QUALITY ASSESSMENT OF THE FODDER LEGUME *CASSIA ROTUNDIFOLIA*

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ABSTRACT

The nutritive value of hays made from Cassia rotundifolia *cv. Wynn and* Medicago sativa *cv. Trifecta (lucerne) was compared in 2 experiments. In the first experiment, 16 adult wether sheep were fed (*ad libitum*) either cassia hay or lucerne for 35 days. Digestibilities of dry matter and nitrogen in the cassia were 55 and 66% respectively. Both values were significantly (P < 0.05) less than the corresponding values for lucerne hay (65 and 81% respectively). Sheep fed cassia hay exhibited significantly lower (P < 0.05) nitrogen retention than animals offered lucerne hay (5.4 versus 24.6 g N/d).*

In a second experiment, microbial protein production in the rumen was measured using abomasally fistulated sheep fed the 2 hays. The mean efficiencies of microbial protein production were 166 g and 223 g protein/kg organic matter fermented in the rumen for sheep fed cassia and lucerne hays respectively.

It is concluded that cassia hay cut at a mature stage of growth has the expected nutritive value and voluntary intake based on its chemical composition and appears to be free of noxious compounds.

RESUMEN

El valor nutritivo de los henos hechos de Cassia rotundifolia *cv. Wynn y* Medicago sativa *cv. Trifecta (lucerne) fué comparada en 2 experimentos. En el primer experimento 16 carneros adultos castrados fueron alimentados* (ad libitum) *por 35 dias con heno de cassia o de lucerne. Las digestabilidades de materia seca y nitrógeno en la cassia fue de 55 y 66% respectivamente. Ambos valores fueron significativamente (P < 0.05) menores que los valores correspondientes para el heno de lucerne (6.5 y 8.1% respectivamente). Los animales alimentados con heno de cassia mostraron significativamente (P < 0.05) menos retención de nitrógeno que los que recibieron heno de lucerne (5.4 versus 24.6g N/d).*

En un segundo experimento, la producción de paroteina microbial en el rumen se midió usando carneros fistulados alimentados con dos tipos de heno. Las eficiencias promedio de la producción microbial de proteina fueron de 166 g y 223 g proteina/kg de materia orgánica fermentada en el rumen de los animales alimentados con henos de cassia y de lucerne, respectivamente.

Se concluye que el heno de cassia cortado en una etapa madura de crecimiento tiene el valor nutritivo esperado y consumo voluntario de acuerdo con su composición química y parece estar libre de compuestos nocivos.

INTRODUCTION

Cassia rotundifolia cv. Wynn is a recently introduced pasture legume undergoing agronomic evaluation in Northern Australia (Oram 1984). It is a short-lived perennial whose growth habit varies with stand density and grazing pressure, but recent field observations (I. J. Partridge, pers. comm.) have indicated that the plant is not readily eaten by cattle in summer. No information appears to have been published on the chemical composition, intake and nutritive value of this forage plant although toxicity screening trials with rats have indicated that cv. Wynn produced greater liveweight gain than lucerne. (Strickland *et al.* 1986).

This paper describes 2 studies using cassia hay. In the first, feed intakes, digestibilities and nitrogen balance were measured in sheep. In a second experiment, rumen microbial protein production was determined. Lucerne (*Medicago sativa* cv. Trifecta) hay was fed as a control in both experiments.

MATERIALS AND METHODS

Feeds

Hay was made from a pure but mature stand of cassia grown at Woolooga near Gympie, Queensland, after the harvest of seed by header. Lucerne was grown at Lawes, Queensland and cut for hay at the half bud stage of growth. Both legume hays were chaffed to approximately 2-3 cm in length and a representative sample taken for chemical analysis.

Experiment 1

In this study the voluntary intake, digestibility of the dry matter (DM), organic matter (OM) and nitrogen (N) were determined together with the nitrogen retention. Sixteen wether sheep (Border Leicester cross) of 35 kg mean weight were treated with the anthelmintic Mebendazole (Merck Sharp and Dhome Pty. Ltd.) and held in individual metabolism cages. Eight animals were offered *ad libitum* the cassia hay and eight the lucerne hay for 35 days. At 9.00 a.m. each day the sheep were offered 20% more air dry forage than was eaten the previous day. During the final 7 days, intake was accurately measured and faecal and urinary output collected. Urine was collected in 20 ml of concentrated HCl. Each day a 10% aliquot of urine and faeces from each animal was stored at −10°C and these were bulked for each animal over the 7 days. Liveweights were measured at the beginning and end of the 5-week feeding period.

At the end of the trial, rumen liquor samples (10 ml) were withdrawn by stomach tube from each animal 3 hours after the morning feed, acidified with an equal volume of 0.3 m HCl and stored at 5°C prior to the determination of ammonia.

Experiment 2

The production of microbial protein in the rumen was determined for the 2 forages in a crossover design experiment. Four mature wether sheep (35 kg liveweight), cannulated in the rumen and abomasum were maintained in individual metabolism cages and fed *ad libitum* for 28 days on pangola (*Digitaria decumbens*) hay plus a daily supplement of 100 g of sunflower meal. The sheep were then offered the cassia and lucerne hay for a further 26 days at the rate of 1 kg/head/day. The forages were fed at hourly intervals, using overhead automatic feeders (Minson and Cowper 1966). During the last 5 days, each sheep was infused intraruminally with a solution containing Sodium ^{35}Sulphate (8.5 MBq) and ^{51}Chromium-EDTA (3.7 mBq) at a constant rate (250 ml/day) using a peristaltic pump. During the infusion periods, the intake of hay was recorded daily and any uneaten feed collected and bulked over the 5 days prior to analysis.

Abomasal digesta samples (approximately 200 ml) from each animal were collected 4 times daily on days 4 and 5 of the infusion. The 8 samples for each animal were divided into 3 equal portions. One portion was separated into filtrand and filtrate as described by Faichney (1980). Another portion was separated by centrifugation to produce a microbial fraction (Elliott and Armstrong 1982) which was frozen and subsequently freeze dried. The third portion was freeze dried without separation. The sheep were then offered the alternate legume hay and the infusion and sampling procedures repeated after 21 days.

Analysis

Samples of feeds, feed refusals and faeces were dried in a force draught oven at 60°C. Determination of nitrogen content was by the Kjeldahl procedure. Lignin and acid detergent fibre (ADF) content of the feed samples and abomasal digesta was determined by the technique of Goering and Van Soest (1970). Organic matter content of feed, feed refusals, faecal and abomasal digesta was determined by ashing at 550°C for 6 h.

^{51}Chromium-EDTA in the infusate and in samples of abomasal digesta was counted in a Hewlett Packard Gamma counter. Flow rates of abomasal digesta were calculated by the method of Faichney (1980) with the exception that lignin (quantitatively recovered in faeces) replaced Ruthenium as the solid phase marker. The proportion of cystine of microbial origin in abomasal digesta was estimated using the technique described by Elliott and Armstrong (1982).

Significant differences between feeds in Experiment 1 were determined by t test analysis and by analysis of variance in Experiment 2.

RESULTS

Chemical composition

Lucerne hay had a higher nitrogen and lower ADF and lignin content than the cassia hay which was harvested at a later stage of growth (Table 1).

TABLE 1

Composition, mean voluntary intakes and digestibility of 2 legume hays and nitrogen retention by sheep.

Parameter	Cassia hay	Lucerne hay	LSD ($P < 0.05$)
Feed composition (% DM)			
Acid detergent fibre	41.7	35.9	—
Lignin	10.9	8.4	—
Nitrogen	2.2	4.0	—
Voluntary intakes			
DM (kg/d)	1.09	1.40	0.16
N (g/d)	24.0	56.0	5.5
In vivo digestibility (%)			
DM	55.5	65.0	3.3
N	66.6	81.1	4.5
Predicted N digestibility[1]	66.4	79.0	—
Nitrogen retention (g/d)	5.4	24.6	3.0

[1]From regression equation of Milford and Minson (1965).

Voluntary intakes and digestibilities

Sheep readily accepted the cassia hay from the first day it was offered but dry matter intake was 22% lower than with lucerne hay. The digestibility of the dry matter in the cassia hay was 55%, which was 10 percentage units lower than for lucerne.

Nitrogen status

All sheep fed the cassia hay exhibited positive N balance. The mean retention of 5.4 g N/day was significantly less ($P < 0.01$) than that of sheep fed lucerne hay (24.6 g N/day) and this was reflected in superior liveweight gains by the lucerne-fed animals (165 g/head/day vs. 95 g/head/d for the sheep fed cassia hay). Nitrogen digestibility by the sheep fed cassia hay was significantly lower than for the lucerne. This difference appeared to be associated with the lower nitrogen content of the cassia. The N digestibilities of the 2 forages were close to those predicted from a published relationship (Table 1) between digestible crude protein and crude protein content of tropical feed (Milford and Minson 1965).

The rumen ammonia concentration in sheep fed cassia hay was 140 mg NH_3-N/L compared with 210 mg NH_3-N/L when sheep were fed lucerne. The proportions of microbial N in abomasal digesta of sheep fed cassia and lucerne hay (Table 2) were very similar and correspond to values previously reported by Mathers and Miller (1981) for lucerne hay. The efficiency of microbial protein synthesis in the rumen of sheep fed the cassia hay was significantly less than that of sheep fed lucerne (Table 2).

TABLE 2

Microbial protein production in the rumens of sheep fed the legume hays.

Parameter	Cassia hay	Lucerne hay	LSD ($P < 0.05$)
Intake of OM (g/24h)	726	725	NS
Flow of nutrients from stomach (g/24h):			
Organic matter	427	408	NS
Total nitrogen	18.6	30.7	9.4
Microbial Nitrogen	12.0	20.5	3.2
Proportion of nitrogen in abomasal contents of microbial origin	0.65	0.67	NS
Efficiency of microbial protein synthesis:			
g CP/kg organic matter apparently digested	250	407	103.1
g CP/kg organic matter actually digested	166	233	33.0

DISCUSSION

Many species of *Cassia* are toxic (Bailey 1985), but *Cassia rotundifolia* did not appear to contain any deleterious compounds. The sheep ate well throughout the study with voluntary intakes close to that predicted for material with a high fibre content and low digestibliity. This normal intake is in contrast to field observations of stock which avoided eating the cassia, a difference possibly associated with the loss during haymaking of volatile compounds disliked by the grazing cattle. Both the close agreement between measured and predicted N digestibilities and the high rumen ammonia concentration in the sheep fed cassia hay indicated that protein degradation in cassia was normal. This shows that polyphenolic tannins or similar compounds, which restrict degradation of proteins in other legumes (Barry and Blaney 1987) were absent from cassia. The yield of microbial protein from cassia (250 g CP/kg organic matter apparently digested in the rumen) is very similar to the value predicted for legume forages using the equation proposed by ARC (1984), but lower than was found in lucerne.

It is concluded that cassia hay cut at a mature stage of growth has the expected nutritive value and voluntary intake based on its chemical composition and appears to be free of noxious compounds.

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APPENDIX 12. SELECTION OF WYNN CASSIA BY CATTLE

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Selection of *Chamaecrista rotundifolia* by cattle

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Abstract

Hereford cattle fistulated at the oesophagus were used to study the proportion of roundleaf cassia (*Chamaecrista rotundifolia*) cv. Wynn in the diet when they were grazing a cassia-green panic (*Panicum maximum* var. *trichoglume*) cv. Petrie pasture during 2 years. The percentage of cassia in the diet was estimated from analysis of carbon isotope ratios of extrusa in both experiments and of faeces in Experiment 2 only.

In the first year, 1986–87, animals rotationally grazed the pasture for 7 months (early summer–early winter) and there was ample opportunity for selection. The cattle ate very little cassia in summer. Although the percentage of cassia in the extrusa increased in autumn to 22%, it failed to reach the percentage of cassia in the top "grazed layer" of the pasture (50–60%). In the second year, 1987–88, grazing was continuous from early autumn to early winter, and the grazing pressure was much higher. The percentage of cassia in the extrusa was again much lower than the percentage in the grazed layer until mid-autumn, but then increased to approximately equal the percentage in the pasture (10–20%). However, the estimate of percentage legume in the diet based on analysis of carbon isotope ratios of extrusa was consistently lower than the same estimate based on faeces. Possible reasons for this are discussed.

Cattle discriminated against cassia in summer and early autumn, especially when there was ample opportunity for selection. Cassia was eaten more readily in late autumn, particularly when grazing pressure was high. The role of plant P and S concentrations in affecting cassia acceptability warrants further study.

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Introduction

Roundleaf cassia (*Chamaecrista rotundifolia*) cv. Wynn was released in 1983 to the grazing industry in Queensland as a tropical pasture legume, after having been evaluated for many years in small plots (Strickland *et al.* 1985; Ahn *et al.* 1988). Special care was taken to ensure that the legume was not toxic (Strickland *et al.* 1987). The description of cv. Wynn in the Register of Australian Herbage Plant Cultivars (Anon. 1990) states that it "is readily eaten by cattle and sheep without any ill effects", but no data on its acceptability to livestock were given. Following reports by graziers of low acceptability on commercial properties, we examined the diet selected by cattle grazing a cassia-tropical grass pasture. Acceptability of some tropical legumes is known to change during the growing season (e.g. Stobbs 1977; Walker *et al.* 1983; Gardener 1984), so the cassia contents of the pasture and the diet were measured from early summer until early winter in the first year (Experiment 1) and from early autumn until early winter in the second year (Experiment 2).

Materials and methods

Experiment 1

The experiment was conducted at Samford Research Station (27°22′S, 152°53′E; mean annual rainfall 1100 mm), on a sandy red earth soil (Gn2.14, Northcote 1979). The pasture was established in 1984 and consisted of Wynn cassia, green panic (*Panicum maximum* var. *trichoglume*) cv. Petrie and, to a lesser extent, setaria (*Setaria sphacelata*) cv. Narok. The 0.5 ha site had been used for previous experiments, and superphosphate fertiliser had been applied on numerous occasions, most recently in the 1985 winter (125 kg/ha).

Two 700 kg Hereford steers, fistulated at the oesophagus, grazed the pasture rotationally (10 d on the experiment/18 d rest on an outside area) from December 1986–June 1987, at a stocking rate equivalent to 1.4 beasts/ha. The experimental pasture was subdivided with an electric fence into a 0.35 ha paddock and a 0.15 ha one. During each 10-d grazing period, the steers were placed in the larger paddock for 7 d (i.e. afternoon of Day 0 — morning of Day 7) in order to re-accustom them to the pasture, and then grazed the smaller paddock for 3 d (i.e. afternoon of Day 7 — afternoon of Day 10) while extrusa samples were taken.

The yield and botanical composition of the herbage on offer in each paddock were measured before and after grazing, from 10 randomly positioned 0.5 m^2 quadrats. On the smaller paddock, the material from sequential 10 cm strata on each sampling site was cut and sorted separately in order to determine the yield and composition of herbage at different heights in the sward. Material was separated into green and dead, as well as into species. Subsamples of cassia from each stratum were taken in April 1987 for chemical analysis (N, P, K and S).

Extrusa samples were collected from the steers on 4 consecutive days during each grazing period. The first sampling was taken when the steers were first placed on the small paddock (afternoon of Day 7), and the fourth sampling immediately before the animals were removed (afternoon of Day 10). The animals were fasted for 4h prior to sampling. One extrusa sample was collected from each steer after 20–60 min grazing on each occasion. Each sample was thoroughly mixed by hand, split into 2–4 subsamples, frozen and stored.

Sections of the frozen subsamples were later cut, thawed and oven dried. Equal weights of dry matter for each subsample for every day for each animal were bulked in Periods 1–4 and 7–8. For Periods 5 and 6, subsamples from each day were bulked, but samples from each day (1–4) were kept separate. The proportion of the C_{13}/C_{12} carbon isotopes (δ^{13} value) in each bulked sample was then measured to estimate the proportion of C_3 and C_4 plants in the diet (Jones *et al.* 1979).

The legume content of the diet was compared with that of the whole pasture (sum of all strata) and of a "grazed layer", defined in this experiment as the uppermost part of the sward that contained *c.* 700 kg herbage/ha. This was usually contained in the top two or three 10 cm strata. It represented the quantity of herbage expected to be eaten on the small paddock in 3 days by the steers at an average daily intake of 2.5% of body weight (2 steers × 3 days × 700 kg liveweight × 2.5% on 0.15 ha = 700 kg/ha).

Experiment 2

The 0.5 ha pasture used for the 1987 study was used again in 1988. The pasture was lightly grazed during the first half of the 1987–88 growing season and was slashed and fertilised with 120 kg/ha single superphosphate on January 20, 1988. There was no further grazing until March 28, when the 2 fistulated steers used in Experiment 1 were placed in the paddock, which was then continuously grazed at a stocking rate equivalent to 4 beasts/ha until the animals were withdrawn in mid-June. When grazing commenced, the pasture was sampled as described for Experiment 1, and this was repeated every 1 or 2 weeks. When the pasture was sampled, the animals were penned for 3h (1200–1500h) during the day for 2 consecutive days and an extrusa sample collected each day after they were released for subsequent afternoon grazing. Each sample was split into 3, so there were 12 subsamples (2 steers × 2 days × 3 samples) for each collection period. Each subsample was frozen. Sections were later cut, thawed, dried and ground. Subsamples from the 2-day grazing period for each animal were bulked and analysed as previously described.

After the extrusa samples were taken on the second day, samples of fresh faeces were collected from 3 dung pats, which had been recently dropped in the pasture, and then bulked. A subsample was dried and the proportion of carbon isotopes determined. Two other subsamples were taken from the bulked faecal sample. One was used to measure moisture content and the other was washed out to recover cassia seeds, using the technique of Jones and Bunch (1988). The objective was to determine if the presence of cassia seed in faeces gave an indication of its acceptability. The seeds were classed by observation into sound (normal) and unsound (abnormal, shrivelled) seed and seed of both types was germination tested.

As there was only a small proportion of C_3 plants in the pasture apart from cassia, usually <3% in 1987 and <1% in 1988, we have attributed the C_3 plants in extrusa or faeces to cassia.

Results

Rainfall and frosting

Rainfall during experimental grazing was above average in Experiment 1, but January–March rainfall in Experiment 2 (290 mm) was below the long-term average (461 mm). The site was lightly frosted in early June in both experiments.

Experiment 1

The green herbage on offer during each grazing period exceeded 3000 kg/ha DM for most of the experiment (Table 1), allowing considerable opportunity for selective grazing. At the February, March and April samplings, the cassia content was always above 40% in the whole pasture and above 50% in the grazed layer. Averaged over summer and autumn, 82% of the green grass was green panic, 10% was setaria and 8% other grass.

Averaging yield over all samplings from January–June, the cassia % in the pasture was higher in the post-grazing sampling (44%) than in the pre-grazing sample (38%), whereas the green panic % was higher in the pre-grazing sample (14%) than in the post-grazing sample (11%).

The percentage of cassia in the ingesta was always less than that in the whole pasture and the grazed layer (Table 1). During summer (December–February), cassia comprised <15% of the diet, compared with 20–50% of the grazed layer. It reached a peak of 22% in the extrusa in autumn (April–May). The 12% concentration of C_3 plants in the diet at the first sampling could reflect some selective grazing of the 1% "other dicot" component in the pasture as animals had been in the pasture for only 2 days prior to sampling. Cassia percentage in the diet was similar for both animals at 11.7 and 13.3%, averaged over all periods. The proportion of dead herbage in the diet, estimated from microscopic examination of extrusa, never exceeded 6% (authors, unpublished data), and was lower than that in the grazed layer in most measurement periods and much lower than that in the whole pasture.

The percentage of green cassia in the diet increased during each grazing period. The combined data for Periods 5 and 6, when cassia was most acceptable, were: Day 7, 5%; Day 8, 20%; Day 9, 24%; and Day 10, 34%. This trend reflected the increasing concentration of cassia at the top of the canopy as animals progressively

Table 1. Herbage yield on offer and the percentage of cassia in the whole pasture, in the grazed layer and in the extrusa samples of grazing cattle for 8 time periods in Experiment 1.

Period	Commencement date	Herbage on offer	Percentage composition[1]					
			Whole pasture[2]			Grazed layer[3]		Cassia in extrusa
			Green grasses	Dead herbage	Green cassia	Dead herbage	Green cassia	
		(kg/ha)	(%)					
1	15.12.86	3900	27	53	19	33	20	12
2	12.01.87	5000	31	39	27	7	39	4
3	09.02.87	6300	25	30	43	1	51	3
4	09.03.87	6900	23	26	48	2	61	9
5	06.04.87	9400	15	38	45	6	53	22
6	05.05.87	9400	17	44	36	12	54	19
7	01.06.87	8400	12	59	27	34	25	14
8	29.06.87	6500	17	59	23	38	22	15

[1]Data for the grazed layer are means of samples taken before and after grazing. Data for diet composition are means of 2 steers for 4 days.
[2]The remaining percentage (1–3%) consisted of other dicots. In Periods 7 and 8, 5% of the dead herbage was frosted cassia.
[3]Uppermost part of the canopy (see text). The remaining percentage consisted of green grass, except during Periods 7 and 8 when 19% and 10%, respectively, of frosted cassia was measured.

removed the grass and decreased the opportunity for further selective grazing. During the same 2 periods, the average cassia percentage in the top layers rose from 39% on Day 7 to 63% on Day 10.

The concentrations of both N and P in cassia were significantly ($P<0.01$) affected by position in the pasture profile — grazed layer (2.39 and 0.18%, respectively), intermediate layers (2.06 and 0.16%) and the lowest 2–10cm layer (1.54 and 0.12%), but K levels were similar throughout (mean 1.29%). Sulphur concentrations showed little variation — 0.10% in the grazed layer, 0.11% in the intermediate layers and 0.13% in the lowest layer.

Experiment 2

Total and green herbage yields were lower in Experiment 2 than in Experiment 1. This reduced the opportunity for selective grazing, particularly at the end of the grazing period, when there was only 710 kg/ha of green material (Table 2) compared with 2760 kg/ha in Experiment 1 (Table 1). The percentage of cassia in the pasture was again high in mid-autumn, but there was an increase in the percentage of dead material as the season progressed, with a corresponding decline in the percentages of green cassia and green grass. Averaged over all samplings, 83% of green grass was green panic, 11% was setaria and 6% other grass.

The percentage of cassia in the diet, whether estimated from extrusa or faecal samples, increased over the first 2 sampling periods, but was relatively constant thereafter. Cassia was discriminated against until the end of April, by which time the amount of green herbage on offer had fallen to approximately 2000 kg/ha. Averaged over the 9 grazing periods, the percentage of cassia in the diet of the 2 animals was similar (11.0% and 12.5%).

The cassia percentage in the diet, as estimated from faecal samples, was approximately twice that measured in extrusa samples. Both techniques showed that the cassia content of the diet was less than that of the pasture until the end of April. After that time, faecal analyses indicated that the cassia content of the diet exceeded that of the pasture, whereas analyses of extrusa indicated that it was similar.

The levels of sound cassia seed in the diet rose from 0.06 seeds/g OD faeces in the first sampling to about 3 seeds/g in mid-April, and remained at that level until the end of May, when they fell to 0.8 seeds/g (Table 2). The sound seed was 97% viable (60% hardseeded), whereas unsound seed had < 1% germination and no hard seed.

Table 2. Herbage yield on offer and the percentage of cassia in the whole pasture, in the grazed layer and in the diet (estimated from carbon isotope analysis of extrusa samples and faeces) and cassia seed levels in faeces, for 9 sampling dates in Experiment 2.

Period	Date	Herbage on offer	Percentage composition						
			Whole pasture[1]			Grazed layer	Cassia in diet estimated from		Cassia seeds per g OD faeces
			Green grasses	Dead herbage	Green cassia	Cassia	Extrusa samples[2]	Faecal samples	
		(kg/ha)				(%)			
1	28.03.88	5400	29	42	28	35	1	9	0.1
2	12.04.88	4400	20	40	40	41	6	13	0.1
3	19.04.88	5300	12	59	29	39	9	21	3.1
4	26.04.88	4310	17	53	28	na[3]	12	24	3.3
5	09.05.88	3900	22	61	16	na	14	21	3.2
6	23.05.88	3700	13	72	15	na	15	29	3.0
7	30.05.88	3000	16	65	18	na	21	29	2.3
8	07.06.88	3200	14	70	15	na	11	26	1.9
9	14.06.88	3400	11	79	10	na	16	26	0.8

[1]Other dicots never exceeded 1%.
[2]Data are means of 2 steers for 2 days.
[3]Not applicable as pasture was short.

Discussion

Cassia was less acceptable to animals than were the companion grasses throughout Experiment 1 where there was ample opportunity for the cattle to select. The difference between the percentage of cassia in the grazed layer and in the extrusa was greatest during summer and early autumn, but decreased thereafter. An enhanced acceptability of tropical legumes in autumn has also been observed for *Macroptilium atropurpureum* (Stobbs 1977; Walker *et al.* 1983) and *Stylosanthes* (Gardener 1984). However, with those legumes, the percentage legume in the extrusa samples during autumn was always greater than the percentage legume in the pasture. In contrast, while acceptance of cassia increased in late autumn in this experiment, the percentage in the extrusa samples was always less than the percentage in the pasture. Partridge and Wright (1992) also found a higher percentage of cassia in the diet of cattle in early winter than in summer or early autumn, although the differences were not as great as we recorded.

The same seasonal trends occurred in Experiment 2. Cassia was discriminated against until late autumn, but subsequently the percentage of green cassia in the extrusa was as high as, or greater than, that in the pasture. There was a much higher grazing pressure and much less opportunity for selection in this experiment than in Experiment 1.

The percentage of C_3 plants in the diet, as estimated from carbon isotope analysis of faeces, was consistently higher than that estimated from analysis of the extrusa (Table 2). Differences between the diet of resident steers estimated from carbon isotope assay of the faeces and diets of non-resident steers fistulated at the oesophagus have been reported in studies using several tropical legumes (Coates *et al.* 1987; Jones and Lascano 1991). In this study, there was a large difference in the estimates of diet legume using the 2 methods even though the fistulated steers in Experiment 2 were also the resident steers.

The different results from isotopic analyses of faeces and extrusa from the same animals have obvious implications for the use of fistulated animals to measure diet composition. One possible reason for the difference is that there is variation in selection throughout the day. Such variation would not be reflected in the faecal samples but would be reflected in the extrusa samples taken at one point in time. Such diurnal variation has been measured in animals grazing leucaena (R.J. Jones, personal communication). On the few occasions when extrusa samples were taken in the morning and afternoon in Experiment 1, there were no obvious differences (authors, unpublished data). However, these measurements were made only at the start of Experiment 1 when there was little cassia in the extrusa. Another possibility is that the fistulated steers had an atypical selection pattern when released to graze after fasting prior to sampling.

Levels of cassia seed in faeces in Experiment 2 reached a peak of 3 seeds/g oven dry dung during the main seeding period which occurred in late autumn. Other experiments confirm that these levels are reached only when cassia is seeding profusely and there is limited opportunity for selection (R.M. Jones, unpublished data). In pastures where there is more opportunity for selection, even in the presence of high cassia seed loads, levels of seed in faeces are closer to 1 seed/g oven dry faeces, similar to the 0.8 seeds/g measured by Partridge and Wright (1992). These low levels compare with seed levels of 10–100 white clover seeds per g of faeces from cattle grazing good white clover-based pastures in periods of heavy seeding (Jones 1982), even though the soil seed reserves, and presumably seed set, are similar for pastures of white clover and cassia (R.M. Jones, unpublished data). Thus, these data support the finding from extrusa and faecal analyses that, even in mid-to late autumn, cassia will still be avoided if grazing pressure is low.

The preference of cattle for grass rather than cassia in the growing season has important implications for the persistence of cassia in pastures. Clements (1989) showed that, over a wide range of grazing pressures, fewer growing points of cassia were grazed than those of Siratro (*Macroptilium atropurpureum*) and *Centrosema virginianum*. This was partly attributed to growth habit and partly to palatability. This is likely to give cassia a competitive advantage and will also aid seed set of cassia and hence long-term persistence (Jones *et al.* 1993).

Although cassia yielded up to 4 t/ha in Experiment 1, with no visual signs of S deficiency, the S concentration and N:S ratio could be indicative of S deficiency in the plant (Partridge and Wright 1993). In one instance, where cassia was extremely unpalatable in a pasture near Bundaberg, south-east Queensland, cassia plants contained only 0.13% P and 0.12% S and the soil had only 2 ppm bicarbonate extractable P (R. Cheffins, personal communication). The plant P% was lower than we measured, whereas the S levels were similar. This suggests that the different P levels at the 2 sites may have been responsible for the different acceptability of cassia. Low P levels in stylo are known to reduce its palatability (McLean *et al.* 1981). However, S application has also increased acceptability of *Desmodium ovalifolium* (Lascano and Salinas 1982). Thus, although it has been demonstrated that cassia is eaten by animals, and can increase liveweight gain (Partridge and Wright 1993), further study of the effect of P and S on cassia palatability is required.

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