Stability and productivity of *Stylosanthes* pastures in Australia. II. Animal production from *Stylosanthes* pastures

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Abstract

Native pasture is the major forage resource grazed by beef cattle in northern Australia. Cattle growth rates and annual production levels from these pastures often fall well short of those needed to satisfy market demands for well grown young cattle or high quality carcasses. Various technologies have been and are being used to improve production and enhance the producer's ability to meet market requirements. In this paper, we review and discuss the use of technology based on pasture legumes from the genus *Stylosanthes*.

The annual liveweight gain advantage to cattle grazing stylo-grass pastures compared with grass pastures is usually in the range of 30–60 kg/head. This advantage has been recorded in central and northern regions and appears to be independent of the length of the growing season. Seasonal growth rate varies between years and is often similar to grass alone in the early wet season. In the late wet and dry seasons, the advantage due to incorporating stylo can average 250 and 150 g/hd/d, respectively. These increases are associated with increased stylo selection at these times, as well as higher nitrogen and digestible energy intake. In northern regions in particular, oversown pastures can be grazed at 2–3 times the rate for native grass pastures, whereas in the southern region, no increase in stocking rate is recommended. Although these oversown pastures are presently robust and productive, additional management inputs may be needed in future to maintain balanced stylo-grass pastures. The increased flexibility that stylo-grass pastures offer producers enables them to target herd and market requirements better.

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Introduction

A range of species and cultivars of *Stylosanthes* (stylos) have been used for grazing by domestic ruminants for improved production in many countries throughout the tropical and subtropical regions of the world. In this paper, we will restrict the review to cattle production from stylo pastures, citing appropriate historical and current experimental data from northern Australia.

Of the numerous introduced tropical legumes that have been evaluated and released for pasture improvement in northern Australia, the stylos have had the greatest impact in terms of their commercial application. At least 14 registered cultivars from 5 different species have been released for commercial use in Australia, and additional species have been evaluated in grazing experiments. Much of the earlier research and development focused on the annual Townsville stylo (*Stylosanthes humilis*), which was adapted to the seasonally dry tropics with an annual rainfall of at least 700 mm. More limited research and development concerned the perennials, *S. guianensis* var. *guianensis* for the wetter tropics and *S. guianensis* var. *intermedia* (fine-stem stylo) for the subtropics. Animal production experiments with pastures based on these species were reviewed by Gillard and Winter (1984), with most of the experimental data coming from Townsville stylo pastures. However, Townsville stylo was devastated by anthracnose during the early 1970s and is no longer of commercial importance.

The demise of Townsville stylo was followed closely by the release of 2 new cultivars, Verano (*S. hamata*), a short-lived perennial, and Seca (*S. scabra*), a perennial shrubby stylo. Both cultivars are adapted to the seasonally dry environments of northern Australia and both are tolerant of the current strains of anthracnose in Australia. Most animal production experiments with cattle on stylo pastures subsequent to those reviewed by Gillard and Winter (1984) relate to pastures incorporating Verano or Seca or a mixture of both. This review will be confined largely to the more recent information and will therefore be biased towards pastures with Verano and/or Seca. Two other cultivars, Amiga (*S. hamata*) and Siran (*S. scabra*), are the most recent releases within Australia but we are not aware of any available animal production data relating to these cultivars.

Liveweight gain

A number of long-term grazing trials were established at sites in the Northern Territory, north-east Queensland and central coastal Queensland during the 1970s and 1980s to measure cattle weight gains from Verano- and Seca-grass pastures. These trials yielded data from years of above- and below-average annual rainfall and from a range of stocking rates (Table 1). The treatments selected represent those where cattle weight gains were not (to the best of our knowledge) limited by specific mineral deficiencies, particularly phosphorus and sodium. These production data, therefore, provide a realistic evaluation of the potential of stylo-based pastures to grow and fatten cattle in different regions of northern Australia. Annual liveweight gains measured at the Queensland sites are similar to the better production levels for Townsville stylo pastures quoted by Gillard and Winter (1984). The poorer annual gains in the Katherine environment can be attributed largely to the long dry season at that location. Growth rates during the wet season at Katherine were actually higher than those at Springmount, near Mareeba, and Lansdown, near Townsville (Winter *et al.* 1990), but this may represent compensatory gain following the long dry season.

The increase in animal production attributable to stylo compared with native pasture is often difficult to determine precisely because of a confounding with other management strategies such

Table 1. Annual weight gains of steers or heifers grazing stylo-based pastures in experiments in northern Australia. Gains are from treatments where there was no known mineral deficiency.

Reference	Location and pasture	Duration	Treatment	Stocking rate	Annual gain
				(an/ha)	(kg/hd)
Winter *et al.* (1990)	Katherine (NP with Verano, woodland)	4 years (1982–85)	Superphosphate plus supplement	0.90	99
	Springmount (NP with Verano and Seca, woodland)	2 years (1985–87)	Superphosphate (high rate)	0.2–0.32	141
McCaskill and McIvor (1993)	Lansdown (NP with Verano, cleared)	12 years (1973–85)	± Superphosphate		
			Low stocking rate	0.63	155
			High stocking rate	1.25	126
Coates (1994)	Lansdown (*Urochloa mosambicensis* with Verano and Seca, cleared)	6 years (1984–89)	± Superphosphate, plus supplement	0.75	166
Jones (unpublished)	Lansdown (Verano with NP or sown grass, cleared and fertilised)[1]	11 years (1979–1990)	Low stocking rate	0.65	153
			Medium stocking rate	0.95	138
			High stocking rate	1.25	130
Miller and Hendricksen (unpublished)	Springmount (NP with Verano and Seca, woodland)	2 years (1988–90)	Superphosphate (high rate) ± supplement	0.24	176

[1]Paddocks were also sown with Siratro (*Macroptilium atropurpureum*) and *S. viscosa* in addition to these legumes.

as tree killing or clearing, fertiliser use and the inclusion of other species besides stylo in the mixture. Gillard and Winter (1984) cited annual weight gains for steers on native pasture without supplement ranging from 53 kg/hd (1 year only) in the Northern Territory to 112 kg/hd (4-year mean) in coastal, subtropical Queensland indicating an annual production advantage due to stylo of 40–50 kg/hd. In a comparison between cleared native pasture and oversown (Verano) native pasture where stocking rates (0.6 and 1.2 steers/ha) and superphosphate applications were the same for both pasture types (McCaskill and McIvor 1993), mean annual liveweight gains on the Verano pasture were 37 and 29 kg/hd higher than those on native pasture for the low and high stocking rates, respectively, over the 12 years of the experiment. The differences between the Verano and native pastures were greater in the second half of the experiment with mean annual gains of 172 and 142 kg/hd on the low and high stocked Verano pasture compared with 119 and 96 kg/hd on native pasture. The smaller difference during the first half of the experiment appeared to be due to a component of Townsville stylo in the native pasture and possible residual effects of nitrogen from previous Townsville stylo growth.

Results from formal experiments have been confirmed at Producer Demonstration Sites at various locations in central and northern Queensland. Middleton *et al.* (1993) reported on 2 such sites. At one site south of Rockhampton (Wycheproof, Mt Larcom), the mean annual liveweight gain over 4 years for steers grazing Seca plus native speargrass (*Heteropogon contortus*) pasture was 146 kg/hd compared with 106 kg/hd for native pasture without stylo. Annual gains were probably depressed by the relatively high stocking rate of 0.37 steers/ha on both pasture types. At another site north of Rockhampton (The Springs, Yaamba) on a low-phosphorus soil, the growth rate of steers grazing Seca oversown into native pasture and fertilised with superphosphate averaged 0.58 kg/d (213 kg/hd/yr) over 5 years. This compared with 0.40 kg/d (145 kg/hd/yr) for steers grazing fertilised native pasture. Stocking rate at this site, at 0.24 steers/ha, was lower than at Wycheproof. These experimental programs clearly show a 30–60 kg annual liveweight gain advantage in cattle grazing pastures which include the perennial stylos Verano and/or Seca.

Effect of climatic variability

The variation in liveweight gain between years under set-stocking in northern Australia is quite substantial due to variability in rainfall and its distribution. McCown *et al.* (1981) demonstrated a linear association between the annual liveweight gain of cattle grazing native pasture in north-east Queensland and the length of the growing season as determined by the number of "green weeks" in the year. The green weeks were calculated from the climatic variables of rainfall, evaporation and temperature. Jones *et al.* (1990) used the same procedure for stylo-grass pastures at Lansdown, and green weeks accounted for 75% of the variation in annual liveweight gain per head. The linear relationships for native pasture (McCown *et al.* 1981) and stylo-grass pasture (Jones *et al.* 1990) were almost parallel, but the stylo pasture had a higher intercept. According to the model, annual gains for stylo-grass pasture ranged from 73 kg/hd for a short growing season of 20 green weeks (drought year) to 190 kg/hd for an extended growing season of 43 green weeks, but the advantage over native pasture was relatively constant at 43 and 49 kg/hd, respectively. Similar results were reported by McCaskill and McIvor (1993), where the annual liveweight gain advantage of Verano-based pasture over native pasture was independent of the length of the growing season, with differences of 32 and 42 kg/hd at high and low stocking rates, respectively. Variation in annual weight gain has important economic implications due to the linkage between weight gain and meeting market requirements for liveweight or carcass weight and grade. Maintaining the liveweight gain advantage on stylo pastures in the poorer years, especially drought years, may be of special economic importance with respect to marketing opportunities. Greatly depressed prices result from an oversupply of unfinished cattle in drought years, whereas heavier and better finished cattle from improved stylo-grass pasture are likely to find a ready market and capture a disproportionately higher price.

Seasonal patterns of weight gain

Cattle grow faster on stylo-grass pasture than on native pasture for most of the year but the main advantage occurs during the late wet and dry

seasons. This is well illustrated below by the data of Gardener *et al.* (1993), where the growth rates of steers (g/hd/d) grazing native and Verano-native grass pasture during the early wet, late wet, dry season and transition season (the relatively short period at the end of the dry season and the beginning of the wet season which includes the period of rapid weight loss associated with body water changes and loss of gutfill after the first storm rains) were compared over 12 years.

	Growth rates (g/hd/d)	
	Native	Verano-native
Early wet	886	947
Late wet	321	572
Dry	−61	91
Transition	−171	−390

A similar pattern of liveweight gain was reported by Gillard and Winter (1984). These growth rate advantages are important not only because of the improvement in annual liveweight gain allowing younger turnoff, but also because of the greatly improved marketing opportunities where cattle grazing stylo-based pastures maintain a marketable condition for much longer than those on native pasture.

Nutritive value

The improved rates and pattern of growth are due to the stylo reducing the major limitations to cattle growth on native pasture, *viz.* low nitrogen and digestibility in all but the early wet season. Data from Lansdown showed that the average nitrogen concentration of stylo (Verano and Seca) plucked (to simulate material selected by grazing cattle) at regular intervals over 2 years was more than double that of the associated grass (2.23% and 0.99%, respectively) and that dietary nitrogen was likely to restrict intake (<1%) on grass-only pastures before the end of the wet season (Coates *et al.* 1993). Similarly, the digestibility of plucked stylo averaged 7 units higher than that of the associated grass. In an experiment north of Charters Towers, the digestibility of the diet was similar for native and stylo-grass pasture in the early wet but there was an average difference of 5 units in favour of the stylo-grass pasture from April–September, while the average increase in dry matter intake (DMI) from March to September was *ca.* 18% (Coates *et al.* 1993). These increases in the DMI and nutritive value of the diet resulted in a 27% increase in the intake of digestible dry matter by animals grazing stylo-grass pasture.

Diet selection

Diet selection studies with cattle grazing stylo-grass pastures have helped to explain seasonal patterns of liveweight gain. Earlier studies with oesophageal fistulated steers grazing native pasture oversown with Townsville stylo (Hunter *et al.* 1976) and Verano (Gardener 1980) showed that cattle have a marked preference for young green grass early in the wet season. As the season progresses, cattle select an increasing proportion of stylo with maximum proportions occurring in the late wet or early dry season. The higher quality of stylo compared with grass during this time maintains dietary nitrogen and digestibility at levels that allow cattle to continue growing much faster than on grass alone (Gardener 1980; Hendricksen and Punter 1988; Coates *et al.* 1993). Dietary stylo proportions generally decline as the dry season progresses and grass is again preferred to stylo late in the dry season. The basic seasonal pattern of dietary grass:stylo proportions has been confirmed and refined in more recent studies using the faecal carbon ratio technique (Jones 1981) with frequent, regular sampling from cattle grazing pastures containing Verano and Seca (Coates 1996). The dietary stylo proportion of heifers grazing mixed pastures of Verano and Seca with *Urochloa mosambicensis* (Urochloa) during a typical year at Lansdown is shown in Figure 1. The botanical composition and presentation yield of the pastures were such that cattle could select readily for either grass or legume throughout the year.

The basic seasonal pattern is modified by various factors such as the amount and distribution of rainfall, grass: legume proportions of the pasture and the associated grass species. Seasonal preference also varies among different stylo species. Selection against stylo in the early wet season seems to be prevalent in annuals like Townsville stylo (Hunter *et al.* 1976) or short-lived perennials like Verano (Gardener 1980; Coates 1996), whereas the perennial Seca appears to be more readily eaten at all times (Hendricksen *et al.* 1987; Coates 1996). The renewed preference for grass in the dry season once the stylo has

matured and dried off has been attributed to spoilage by mould which is encouraged by heavy dews, high humidity or periods of overcast and rainy weather (Gardener 1980; McCown and Wall 1981). Spoilage of this nature is likely to be less prominent in perennials like Seca which retain green leaf well into the dry season and which respond with new growth to out-of-season rainfall. Nevertheless, in studies at Lansdown, the preference for dry grass late in the dry season occurs where there is no visible evidence of mould (*e.g.* Figure 1).

The strong preference for green grass early in the wet season can have undesirable consequences if the grasses, such as the native tussock species, are not tolerant of heavy grazing pressure. This can lead to the rapid decline of the grass component and to strong legume dominance (Mott *et al.* 1985; Winter *et al.* 1989; Gardener and Ash 1994). Stylo dominance can have a detrimental effect on animal performance during the late dry and very early wet seasons, when liveweight losses on strongly stylo-dominant pasture are substantially greater than those where there is a satisfactory perennial grass component (Liang *et al.* 1985; Winter 1988). In such situations, Winter (1988) recommended cattle be given access to grass pastures during this period to avoid excessive weight loss. The detrimental effect of stylo dominance is likely to be less pronounced with the perennial shrubby stylos like Seca because of the better leaf retention into the dry season, the more rapid growth response to early wet season rains and the better acceptance by cattle of Seca as a component of the diet early in the season. In experiments at Lansdown, cattle grazing strongly stylo-dominant pastures (90% or more of stylo at the end of the wet) with a high Verano component, had better gains through most of the dry season than those on pasture with a significant perennial grass component, but performance was poorer during the transition and early wet seasons. On one experiment, there was usually no difference in annual gain between the pasture types (R.J. Jones, unpublished data), but on

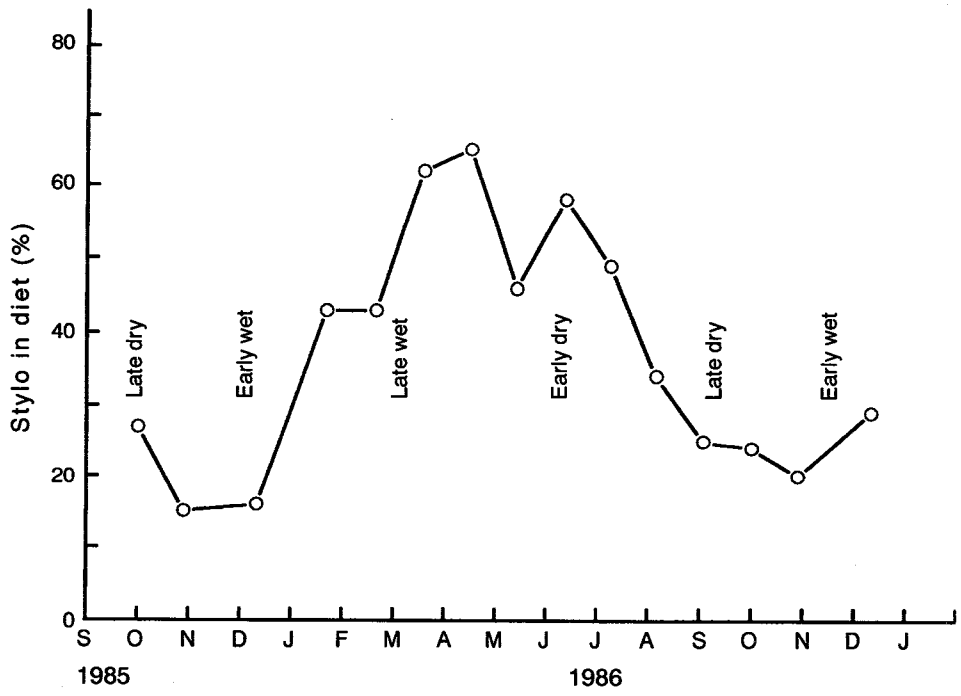

Figure 1. Seasonal changes in the level of stylo in the diet of heifers grazing pasture containing a mixture of Verano and Seca stylos with Urochloa grass at Lansdown, near Townsville. Grass and stylo proportions and pasture yield were such that cattle could select readily for either grass or stylo.

another experiment, annual gains on stylo-dominant pasture were often less than those on grass-stylo mixtures (D.B. Coates, unpublished data). Regardless of the effect on animal performance, stylo pastures with very little grass present risks with respect to soil loss and long-term stability and cannot be recommended.

Carrying capacity and stocking rate effects

Although Gillard and Winter (1984) reported that the stocking rate of native pasture oversown with stylo can generally be increased 2–3-fold over that of untreated native pasture, it is clear that the increase in carrying capacity is highly variable, being largely dependent on stocking rate existing on native pasture. In the extensively managed areas of the monsoonal tropics where stocking rates and animal productivity on native pasture are typically very low, published reports from experiments near Katherine in the Northern Territory (Winter 1989) and from a large commercial pasture improvement program at Wrotham Park, west-north-west of Cairns (Edye and Gillard 1985), indicated increases in carrying capacity up to 10-fold. Further south, where the native pastures can support higher stocking rates, the increases in carrying capacity associated with stylo pastures are much less substantial. Indeed, the current recommendation in central Queensland, where commercial stocking rates on native pasture are around 1 beast/4 ha, is for no increase in stocking rate after oversowing with stylo (C.H. Middleton, personal communication).

Unlike twining tropical legumes, which tend to decline under heavy grazing (Coates 1995), stylo, like *Lotononis*, can tolerate high grazing pressure. It can absorb occasional abuse brought about by drought or marketing delays and even persistent heavy grazing and this could encourage the use of higher than optimal stocking rates. Annual liveweight gain declines with increasing stocking rate and the choice of stocking rate will have a major influence on the financial returns to pasture improvement (*e.g.* McIvor and Monypenny 1995). If stocking rates are too low, costs per head are likely to be too high to maximise returns. Conversely, excessive stock will depress liveweight gain to the point where target market specifications cannot be achieved. Results from long-term grazing trials at Lansdown (R.J. Jones, unpublished data) and Galloway Plains, near Gladstone (W.H. Burrows, personal communication), indicate that the decline in annual liveweight gain on stylo pastures with increasing stocking rate is very sensitive to seasonal conditions, with the decline being much more pronounced in dry years. This indicates the need for flexibility in relation to stocking rate decisions, especially if target market weights are to be met consistently. Current market considerations and principles of sustainable production suggest a degree of conservatism is warranted in making stocking rate decisions.

Phosphorus status of soil

Nitrogen, available energy (digestibility) and phosphorus are the most important nutritional limitations to animal production in the northern beef cattle industry. Although the majority of north Australian soils are low in available phosphorus (*e.g.* Ahern *et al.* 1994), the tolerance by stylos in general, and Seca and Verano in particular, of low soil phosphorus status allows stylo-based pastures to be developed without phosphatic fertiliser except where the phosphorus deficiency is acute (*e.g.* <3 ppm bicarbonate extractable phosphorus). However, the full potential for increased animal production in response to the improved dietary nitrogen and digestibility of stylo-based pastures (Coates *et al.* 1993) will be met only if dietary phosphorus levels are sufficient to meet animal requirements (Winter *et al.* 1990). Kerridge *et al.* (1990) demonstrated a relationship between annual liveweight gain of cattle and the amount of bicarbonate extractable phosphorus (P_B) in the surface soil for legume-based (predominantly stylo-based) pastures in northern Australia (Figure 2). The important points arising from this model include:

(a) In the absence of phosphorus supplement, the response in liveweight gain to increasing soil P_B is due to improved legume productivity (through improved dietary N and digestibility) as well as improved dietary phosphorus.

(b) At soil P_B below 4–5 ppm, maximum annual liveweight gain cannot be achieved with supplement alone. This is due to limitations in stylo growth and productivity at very low soil phosphorus levels. At soil P_B above 4–5 ppm, stylo vigour is usually sufficient to achieve maximum animal production with supplement

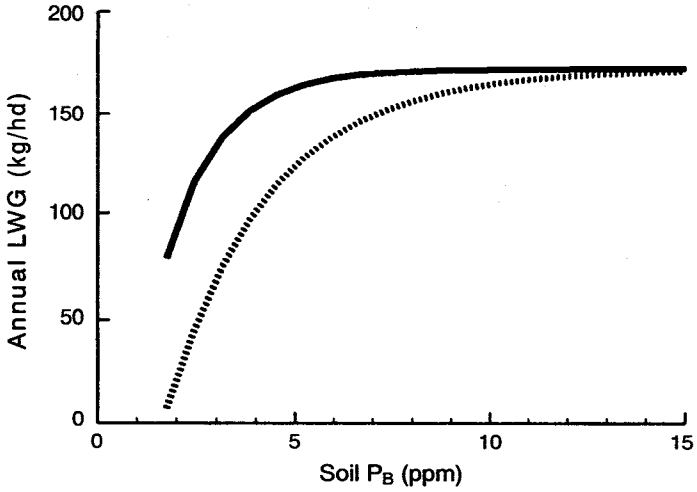

Figure 2. Relation between annual liveweight gain and soil P_B for phosphorus-supplemented (▬▬) and non-supplemented (▪▪▪▪▪▪▪▪) cattle grazing legume-based pastures in the semi-arid tropics of northern Australia. The relationship was developed with data from 4 locations, 3 with stylo-grass pastures and one with Siratro-grass pastures (After Kerridge *et al.* 1990).

alone. The actual soil P_B level, where maximum annual liveweight gain can be achieved with supplement alone, may vary from site to site depending on climatic factors and soil properties other than phosphorus status. At Lansdown, exceptionally good responses of around 100 kg annual liveweight gain/steer have been achieved by feeding phosphorus supplement at soil P_B levels of 3–4 ppm (D.B. Coates, unpublished data) and 5 ppm (Coates 1994). The stylos were productive on these low phosphorus soils (*e.g.* Coates 1994) and feeding supplement through the water ensured uniform, regular and adequate intakes of phosphorus.

(c) The difference between the 2 response curves (with and without supplement) is a measure of the dietary phosphorus limitation in unsupplemented cattle.

(d) There is no further response in liveweight gain to additional phosphorus (whether from fertiliser or supplement) above soil P_B of 8–10 ppm.

The routine use of fertiliser for increasing pasture and animal productivity in northern Australia is generally not economically viable except in the areas of higher rainfall where high stocking rates can be maintained. Therefore, pasture improvement is usually advocated only for those soils with 4–5 ppm P_B or more, where stylo pastures can be established and maintained without applying fertiliser, while phosphorus supplementation is recommended to obtain optimum liveweight gains where the soil P_B is less than 8–10 ppm (Miller *et al.* 1990). However, at low soil phosphorus levels, stylo development in oversown pasture is enhanced by fertiliser (Coates *et al.* 1990) and the application of fertiliser at or soon after sowing may be warranted to provide quicker returns on invested capital.

Introduced grasses such as buffel grass (*Cenchrus ciliaris*) and Urochloa are more responsive to high soil phosphorus than are the stylos. Severe competition from such grasses on high phosphorus soil may lead to a decline or loss of stylos from the pasture (Jones *et al.* 1997). This, in turn, could lead to a reduction in animal productivity, but we are unaware of any published evidence to this effect.

Potential production systems

Traditionally, producers have used sown pasture for the last stage of finishing cattle because it provides the quickest financial return to capital invested. Increasing diversification and specificity

of markets has increased the options for developing and using sown pasture.

The common requirement for all the better-priced markets, whether for slaughter or growing on, including live export cattle, is heavy weight for age. Average growth rates of about 400 g/d (146 kg/yr) are needed to meet the minimum weight-for-age specifications for such markets. Stylo pastures are able to meet these targets except when the growing season is short, whereas most native pastures, with the exception of those on the fertile clay soils, generally cannot support the required level of production. The results presented earlier in this paper indicate that annual liveweight gains of 140–160 kg/hd are attainable in most years on good stylo-based pastures in the coastal and subcoastal areas of eastern and northern Queensland, with gains exceeding 200 kg/hd in the better years. These gains are group averages and the performance of a proportion of the herd will be significantly above these levels. In practical terms, this means that a high proportion of steers grown out on stylo pastures from weaning will meet the demanding specifications for a grass-fed Japanese chiller market. The less demanding requirements for the Korean export carcass can be achieved easily by growing and finishing steers on stylo pastures. Similarly, growth rates on stylo-based pastures enable young cattle to meet the weight-for-age requirements of the live export trade.

These production requirements are dependent on healthy, well-grown weaner or yearling steers. Weaners, therefore, need to be protected from the dry season undernutrition which is common for weaners grazing native pasture in the seasonally dry northern environments. Stylo pastures have a place in ensuring good nutrition at that time, particularly for the increasing numbers of weaners less than 6-months-old and 150 kg liveweight. These weaners come from breeding systems in harsh environments where high reproductive rates are maintained only by removing lactation stress early. Regardless of the target market, early weaning of calves on to stylo pasture should be an economically attractive alternative to supplementary feeding.

As high reproductive rates become economically essential, sown pastures may also be needed to ensure heifers are well grown and capable of conception at 2 years old. First-calf heifers have notoriously variable conception rates, depending on seasons, and better forage in the form of stylo-based pastures would produce higher and more consistent pregnancy rates in herds where breeder groups can be segregated. Since stylos spread naturally, they may make a significant contribution to the diet of the general breeder population on some properties in future years. It has been suggested that the spread could be encouraged at relatively little cost by establishing "seeder plots" in extensive paddocks and protecting these from grazing until the stylo sets seed. When the plots are opened for grazing, distribution of stylo into the rest of the paddock is encouraged by seed dispersal in the dung. Provided any dietary mineral deficiencies are remedied, stylo in the pasture would bring positive responses by way of improved weaning rates, weaning weights, breeder survival and breeder condition.

Given stable herd numbers, use of stylo-grass pasture at higher stocking rates than those usually applied on native pasture, will reduce the grazing pressure on native pasture, contributing to both ecological stability and higher levels of animal performance in the cattle remaining on the native pasture. This outcome might be contrasted with supplementation where grazing pressure is normally increased and only supplemented cattle benefit from the improved nutrition. Nevertheless, there is growing concern that, in some areas, greater management inputs may be necessary to maintain legume-grass balance in pastures oversown with stylo.

Conclusions

Stylo pastures are widely adapted and productive and, compared with other tropical pasture legumes, are easy to manage. They can increase cattle growth rates to an annual average of 0.45 kg/d and extend cattle growth for several months beyond that produced by many native pastures. Stylo pastures have the potential to produce cattle which will meet the specifications of most markets for feeder or slaughter cattle, including the better-priced export markets for grass-fed carcasses. They also have the potential to improve breeder performance markedly. Along with other improved pasture components, their use will increase as the beef industry looks to supply increasingly specific and demanding markets.

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