Chapter 4

Cattle production from *Stylosanthes* pastures

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Summary

Introducing legumes to improve soil fertility and animal production from grass-dominant pastures on low fertility soils of the tropics has been a long-proven successful management system. The *Stylosanthes* genus (stylo) is being grown on all continents with varying levels of success and it has provided some of the most successful species for light-textured tropical soils, in both the high rainfall and the seasonally dry tropics. Although stylos will grow well at low fertility, the addition of nutrients, particularly phosphorus, have been required for grazing animals to capitalise on the higher protein and digestible energy intake available from a mixed grass–*Stylosanthes* pasture.

The annual increase in beef production from adding stylos to a pasture, providing phosphorus is not severely limiting, is around 30–60 kg/head, with over 100 kg/head achievable in some environments by also supplementing animals directly with nutrients. An increase of 2 litres of milk per day can be obtained from lactating cows on stylo-based pastures. Increases in stocking rates of over two-fold are normal in well-established *Stylosanthes* pastures.

The increasing market demand for younger and better-conditioned animals has provided the impetus for improving cattle nutrition by sowing *Stylosanthes* species in tropical and coastal subtropical areas around the world. The improved animal production from *Stylosanthes* pasture technology has increased the financial viability of cattle grazing in the tropics and provided greater management options to meet consumer demands for higher quality products. Cattle, sheep, goats, pigs and poultry are being fed from stylo pastures. Future roles for *Stylosanthes* species will expand into mixed grazing and farming systems of tropical countries.

This chapter outlines the adaptation of *Stylosanthes* species in grazing systems and reviews the latest research on cattle grazing performance from stylo pastures.

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Introduction

The *Stylosanthes* genus is a diverse group of species with a wide distribution throughout tropical Central and South America (Williams et al 1984). The genus has become well known in tropical agriculture over the last four decades. The natural distribution, taxonomy and environmental adaptation of pan American, South and North American, African and Asian species of *Stylosanthes*, the diseases and pests, genetic resources, cultivar development, utilisation, potential and limitations for animal production were reviewed by Edye (1987).

Species of *Stylosanthes* have proved to be widely adapted to low fertility, light textured, acid soils of the tropics. Stylos have been introduced to countries around the world with tropical and subtropical pasture grazing systems since the 1960s, to compliment native grasses and improve sown pasture quality. At least two reviews have appeared on animal production from *Stylosanthes* species (Coates et al 1997; Gillard & Winter 1984), comparing animal production from sown stylo pastures with native grass pastures. The Australian trials were conducted in central and northern Queensland and in the northern half of the Northern Territory from the early 1960s, and some have included the effects of adding fertilisers and direct nutrient supplements to the cattle.

The annual extra liveweight gain by adding a stylo into grass pasture has varied markedly, from no benefit in drought years to over 100 kg/head in long growing seasons. The common range is 30–60 kg/head extra liveweight per year from the legume. Animal performance cannot always be improved simply by introducing a stylo if soil fertility is poor, which in turn grows a nutrient deficient pasture. The addition of fertiliser, usually superphosphate, and direct mineral supplements, such as phosphorus, during the pasture growing season will increase cattle growth rates on stylo pastures on these low fertility soils.

New cultivars have been developed from a range of *Stylosanthes* species suited to both high and low rainfall environments. These cultivars include a range from proven species, such as *S. guianensis* in China (Changjun et al this volume), *S. capitata* and *S. macrocephala* (Grof et al 2001), and a more recently identified species, *S. seabrana* (Edye et al 1998), which has been evaluated for animal production (Hall 2000a). The release of the *S. capitata-S. macrocephala* cultivar Campo Grande in Brazil has reignited interest in the commercial development of stylos (Valle et al 2001). In northern Australia the current area of over 600,000 ha of commercial *Stylosanthes* pastures, predominantly *S. scabra* and *S. hamata,* is expanding annually (Miller et al 1997). This chapter serves as a timely review of recent research on cattle production from stylo pastures.

Stylosanthes Species in Production Systems

Stylosanthes species are among the most important forage legumes across northern Australia (Gillard & Winter 1984) and South America (Miles & Lascano 1997; Thomas 1984), and they are playing an increasingly important role in Asia and India (Ramesh et al 1997), China (Guodao et al 1997) and more recently in Africa (Peters et al 1994). Stylos are now being used to feed many forms of livestock, including cattle, goats, sheep, pigs and poultry.

Across the tropics in Australia there are extensive areas of low fertility soils with a light textured surface, which are suitable for introducing *Stylosanthes* species. *Stylosanthes guianensis* is the most suited species to the wet tropics; *S. hippocampoides* (cv. Oxley) does well in the subcoastal subtropics; and *S. scabra* and *S. hamata* have been successful species across the seasonally dry tropics (Miller et al 1997). Recently, *S. seabrana* has proved adapted to heavy clay soils of the inland subtropics (Edye et al 1998).

Stylosanthes capitata and *S. guianensis* were considered by Mannetje and Jones (1992) to be the best species for tropical and wetter areas of South-East Asia, and *S. hamata* and *S. scabra* were adapted to semi-arid areas. These species are all suitable for the cut-and-carry forage systems in this region (Phaikaew et al, this volume). Peters and colleagues (2001) reviewed the role of improved forages in enhancing smallholder productivity and maintaining ecosystem health in the tropics and presented studies of forage adoption of *S. guianensis* in China. The high-yielding, cut-and-carry forage systems using *Stylosanthes* enhanced year-round animal productivity, as well as improving land-use efficiency and reducing labour requirements.

In West Africa Muhr and colleagues (2001) reported that cropping and dry season feeding strategies were increasingly being limited by land availability, so the agronomic performance of legume species, in particular *S. guianensis*, promised substantial productivity gains once they could be integrated into the traditional fallow systems. Little and Agyemang (1992) have reviewed the role of *Stylosanthes* species in the African context and reported on its evaluation, population dynamics, animal production, agronomy, seed production and integration into cropping systems. Pengelly et al (this volume) have summarised the success of stylo in cropping systems of Africa and Australia.

Stylosanthes Species Research in Animal Production

The morphological and environmental adaptation variation within the *Stylosanthes* genus has provided commercial cultivars from species suited to a wide range of animal production systems in wet and dry tropical and subtropical environments around the world. Some of the successful species are:

S. capitata

Stylosanthes capitata has shown promise for low pH soils, with high aluminium and manganese saturation in South America (Grof et al 1979), and it has produced a positive effect on animal production (Thomas et al 1987). Cv. Capica, a blend of five similar ecotypes, was released in Colombia but has not been widely adopted (Miles & Lascano 1997). There is excellent performance and animal production from cv. Campo Grande, the multiline composite developed from selected lines of *S. capitata* and *S. macrocephala* (Valle et al 2001). At Fazenda Ribeirão in Mato Grosso do Sul, 11,000 ha are under cv. Campo Grande pastures in association with *Brachiaria decumbens* or *Andropogon gayanus* (B. Grof, pers. comm. 2003). There have been no trials on animal production from *S. capitata* in Australia, although high yields have been produced in small plot evaluation trials (T. Hall, unpublished data). Rhizobium specificity was seen as a limitation to its commercial application in the Australian tropics.

Nelore cattle on cv. Campo Grande stylo (*Stylosanthes capitata* and *S. macrocephala*) pasture in Brazil (photo: B. Grof).

S. guianensis

The first cultivars released in Australia were varieties of *S. guianensis* for the wet tropics and coastal Queensland, eg cvv. Schofield, Cook and Endeavour. These cultivars were exported to Asia and South America in the 1970s, where they succumbed to anthracnose disease or did not tolerate grass competition from well-adapted grasses such as *Brachiaria* species or *Pangola*. Endeavour has produced 138 kg/head/year on infertile sands when it was sown with improved grasses and well fertilised (Winter et al 1977).

Stylosanthes guianensis cultivars adapted to South America have been developed, eg cv. Mineirão (var. *vulgaris*), which was released in 1993 (Anon. 1993) and is well adapted to the Cerrados region of Brazil. It has thick stems, may grow to a height of 2.5 m with good soil fertility in the second season, is highly anthracnose resistant, and retains green leaf during the dry season. However, it has not been well accepted by farmers or seed producers because of its poor seed yields.

New *Stylosanthes guianensis* hybrid pasture in northern Queensland (photo: B. Grof).

Cv. Pucallpa (CIAT 184) was released in Peru for the humid tropics and low pH soils. This accession has been used in southern China as cv. Reyen II – Zhuhuacao, and is the second most used stylo after cv. Graham, originally an Australian cultivar (Devendra & Sere 1992). Reyan 5 is another cultivar to have originated from CIAT 184 in China, and two others, Reyan 7 from CIAT 136 and Reyan 10 from CIAT 1283, have been recently released in China (Guodao et al, this volume). Leaf meal concentrate is produced for poultry and pigs from these stylos.

In the Chaco in Paraguay, *S. guianensis* cv. Cook grows vigorously in the first year, but does not set seed before frosts in an average year, and even light frosts kill well-established plants.

Although *S. guianensis* cultivars have not been widely sown in Australia in recent years, there are new cultivars being promoted. A new generation of improved, hybrid-derived lines of *S. guianensis* has been developed. This material may have application in coastal and subcoastal regions of the tropics in areas with higher than 1500 mm annual rainfall. Two new lines, Nina and Temprano, were initially selected from South American material (B. Grof, pers. comm. 2003).

In trials of relative palatability of tropical legumes, Peters and colleagues (2000) reported only *S. guianensis* accessions were positively selected by cattle throughout the year.

S. hamata

A grazing trial comparing the established annual *S. humilis* with the new species *S. hamata* (Caribbean stylo) in northern Queensland demonstrated the benefit of the higher yielding and often biennial species. Selection within *S. hamata* accessions led to the release of cv. Verano in 1973. Subsequent field adaptation trials under grazing led to the release of *S. hamata* cv. Amiga in 1988, because of its superior adaptation to a range of more harsh environments than where Verano was suited (Edye et al 1991).

Native perennial grasses in tropical Australia are notoriously poor competitors at high grazing pressure. This has been observed extensively in commercial pastures, eg at 'Wrotham Park', and it has been widely reported. The poor competitive ability of native perennial grasses was measured in a *S. hamata* grazing trial in northern Queensland, where the native grasses decreased with increasing grazing pressure (by increasing the stocking rate) and they were virtually eliminated at high stocking rates (Jones 2003).

In coastal northern Queensland, Verano is a more successful grazing legume than the trailing *Macroptilium atropurpureum* (Siratro). It was becoming the dominant species at high and medium grazing pressure until *Bothriochloa pertusa* (Indian couch), an introduced grass, invaded and reduced the legume's contribution (Jones 2003). Indian couch was less invasive in the Verano pasture at low grazing pressure.

Over a four-year period, liveweight gains of steers grazing Verano-dominant pastures during the wet season were similar in northern Queensland (Lansdown) and in the Northern Territory (Katherine). However, losses in the dry season at Katherine were far greater than at Lansdown (Jones 2004). Mean annual liveweight gain at Katherine was 99 kg/head compared with 155 kg/head at Lansdown. The soils in the Northern Territory were of lower fertility than the Queensland site. Jones (2004) speculated that on infertile soils in the seasonally dry tropics, where stylo leaf can have low plant nitrogen (eg <1% N in Verano leaf) in the dry winter season, this may be insufficient to sustain steer liveweight, even on stylo-dominant pastures. Under these conditions, Verano pastures may require protein supplementation to prevent animal weight loss in the dry season.

Verano Caribbean stylo (*Stylosanthes hamata*) pasture in coastal northern Queensland (photo: D. Coates).

The first experiences with Verano and Amiga in the Chaco of South America in the early 1990s looked very promising. When sown at high seeding rates in low fertility regosol soils, where grasses requiring high fertility would not readily grow, these Caribbean stylos became the dominant pasture component by the second or third year. Thereafter, however, their populations declined, as shown in Figure 4.1. Being a biennial species, the stylos need to regenerate every second year from soil seed reserves, and the seedlings could not compete with the established perennial grasses. Re-establishment of Caribbean stylo seedlings was slow and inconsistent with the increasing sward density of invading perennial grasses. However, Caribbean stylos, along with *Alysicapus vaginalis*, have been successful in a ley farming system in the Chaco, where they regenerate from soil seed reserves following an intermediate crop of silage sorghum (Glatzle & Ramirez 1993).

S. hippocampoides

In Central Queensland the mean annual liveweight gain on *S. hippocampoides* (formerly *S. guianensis*) finestem stylo (cv. Oxley) was 167 kg/head at a stocking rate of 1.47 head/ha. Over the same period unsown native grass pasture, cleared of timber, gave a gain of 62 kg/head at 0.62 head/ha (Bowen & Rickert 1979). These relative differences in sown stylo pastures compared with native grass pastures have been reported with other stylo species across northern Australia, although total liveweight gains are usually less on the poorer tropical soils than on subtropical soils of Central Queensland.

In the Paraguayan Chaco, Oxley is the only species that persists and increases its proportion in permanent pastures over the years, given appropriate soil conditions (Figure 4.1). Finestem stylo prefers a coarse-textured soil with a sand fraction above 50% and a clay fraction below 5%. As it is frost tolerant, finestem stylo remains green the entire winter, being far less conspicuous during summer and autumn. It has shown high grazing tolerance, persisting even after being grazed close to the ground (1 cm) for months. Best regeneration from seed occurs when the grass component is kept short and the soil is disturbed by animal traffic. Anthracnose incidence, which was observed during prolonged wet periods, does not appear to be a threat to persistence.

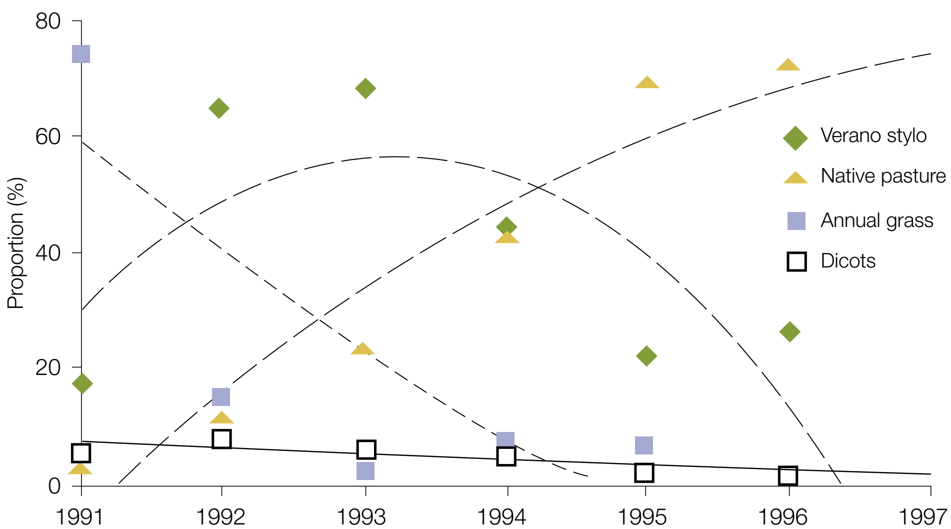


Figure 4.1 **Development of pasture composition on a sandy soil (72% sand and 7% clay) in the Chaco of Paraguay. *Stylosanthes hamata* cv. Verano was sown as a sole species in October 1990. Annual grasses were *Digitaria sanguinalis* and *Cenchrus echinatus*, and perennial grasses *Panicum maximum* cv. Gatton and *Cenchrus ciliaris* invaded the pasture.**

In South Africa, Kelly and Tiffin (1983) found that Oxley was difficult to establish on veld, and steer liveweight gains in the first year were not improved compared with grass-only pasture. In the second year Oxley reduced steer weight losses during the dry season and increased wet season weight gains. At peak weight, steers grazing Oxley were 13% heavier than those on unimproved veld.

In Zimbabwe the cattle liveweight gain on veld oversown with Oxley was curvilinearly related to stocking rate and was higher under continuous than rotational grazing systems (Lungu et al 1995).

S. humilis

In the late 1950s *S. humilis* was the first species evaluated for animal production from the *Stylosanthes* genus in Australia. It was called Townsville lucerne or Townsville stylo and was naturalised across extensive patches of the dry tropics and subcoastal Queensland. Examples of animal production include the following: Shaw (1961) reported an extra 48 kg/head from superphosphate-fertilised stylo compared with unfertilised native grass pasture at about one-third the stocking rate of the stylo in Queensland; and Norman and Stewart (1964) reported gains of 36 kg/head- from *S. humilis* compared with native grass pastures in the Northern Territory. Shaw (1978) suggested this increased animal production from the stylo was mainly due to increased legume production from adding fertiliser, and that there was an increase in stylo yield in fertilised pastures at high stocking rates. Grass competition declined at high grazing pressure and these stylo pastures often became legume dominant, while still maintaining good ground cover for most of the year.

Bothriochloa pertusa has invaded extensive areas of native pasture across the dry tropics of Queensland, replacing *S. humilis* and *Heteropogon contortus* (black spear grass) pastures on texture contrast (duplex) soils, as the *S. humilis* disappeared with the rapid spread of anthracnose disease (*Colletotrichum gloeosporioides*) in the early 1970s (McCaskill 1992).
This disease eliminated *S. humilis* from commercial pastures across northern Australia within several years. *Stylosanthes hamata* cv. Verano became its replacement. Liveweight gains were greater on *S. hamata* than on *S. humilis* pastures at low legume yields, although there were no differences in liveweight gain when the legume yield of both stylos exceeded 600 kg/ha (Gillard et al 1980).

S. macrocephala

The commercial material in Brazil, eg cv. Pioneiro, has not received widespread adoption by farmers, even though it is well adapted to western and central Brazil but not to higher rainfall areas (Miles & Lascano 1997). It is a component of the newly released cultivar Campo Grande in Brazil which has provided encouraging results in animal production from stylo–grass pastures (Valle et al 2001). However, it is too early to realistically assess its commercial success. An analysis of the nutritive characteristics of *S. macrocephala* suggest it has a higher fibre content (>68.8%), which produces a lower dry matter digestibility (37.4% in vitro), than that of *S. guianensis* (Villaquiran & Lascano 1986).

Adapted genotypes of *S. macrocephala* with its specific rhizobium have not been introduced successfully to Australia. In field evaluation of limited genetic material, there was good establishment on a sandy acid (pH 5.5) soil but it was not as productive as *S. scabra* and *S. hamata* accessions, so research never progressed to the animal production stage (T. Hall, unpublished data).

S. scabra

S. scabra cv. Seca (shrubby stylo) has been the most commercially successful tropical legume for the dry tropics of Australia. Cattle producers are convinced of the improved liveweight, increased stocking rates and better husbandry and management options provided by pastures of this species.

On an infertile, sandy-surfaced, duplex soil with P of <5 ppm (acid extractable) in northwestern Queensland, cattle performance on *S. scabra* pastures has continued to improve as the legume content in the pasture has increased over time. On a mixed pasture of Seca and Verano, with native *Sorghum plumosum* (perennial sorghum), *Chrysopogon fallax* (golden beard grass) and *Aristida* spp. (wire grasses), steer liveweight gains of 0.76 kg/head/day were produced on a nine-year-old stylo pasture, compared with 0.43 kg/head/day on native grass pasture, during the dry season from May to September.

Brahman steer grazing Seca stylo-dominant (*Stylosanthes scabra*) pasture in summer in northern Queensland (photo: K.A. Shaw).

The steers on the stylo pasture were in finished condition for market, while the native pasture fed steers required an additional year to achieve the same liveweight and they were still not in a finished condition for marketing. There were no consistent animal production benefits in the early establishment years on this pasture (Hall et al 1996). Much higher production, averaging 213 kg/head/year over five years (0.58 kg/day), has been produced from fertilised Seca pastures in more favourable coastal environments of central Queensland (Middleton et al 1993).

In southern South America, as in the Chaco, *S. scabra* cvv. Seca and Siran set seed before frost in an average year. Foliage death due to mild frosts is common, although in the following spring regrowth occurs from the crown. Severe frosts (close to –5°C at ground level, once every five to ten years) kill established *S. scabra* plants. Regeneration from seed is both poor and slow. Ten years after sowing, shrubby stylo populations decline to below 1%, even in grass pastures where stylo proportions in the second or third year were above 10%.

S. seabrana

Edye et al (1998) identified and commercialised two accessions of *S. seabrana*, cvv. Primar and Unica (Caatinga stylo), which performed well on fertile, heavy clay soils in the frost-prone inland subtropics, extending the contribution that *Stylosanthes* species can make to beef production in northern Australia. Of the *S. seabrana* accessions evaluated, the two cultivars were the best adapted and amongst the most anthracnose resistant (Trevorrow et al 1998), but they have since suffered anthracnose damage in the high rainfall, commercial seed production areas of northern Queensland (Chakraborty, this volume).

Increased steer growth rates on Caatinga stylo pastures have been measured in a frost-prone environment of southern inland Queensland on a grey-brown cracking clay soil previously supporting brigalow (*Acacia harpophylla*) and wilga (*Geijera parviflora*) forest. Good quality native pastures or sown buffel grass (*Cenchrus ciliaris*) on these soils is used for cattle breeding and fattening (Hall 2000b). Here Primar and Unica with sown Bambatsi (*Panicum coloratum*) and native Queensland bluegrass (*Dichanthium sericeum*) produced over 100 kg/ha liveweight gain each year for three consecutive years. Steer daily growth rates were 0.62 kg/head for ten months of the year, from August to June, at continuous stocking. The native pastures produced 0.35–0.5 kg/head at near half the stocking rate for the same periods (Figure 4.2). The steers on the Caatinga stylo were fat and ready for sale after ten months. Under this heavy and continuous grazing management, the stylo population increased annually and reached dominance in patches, while two other legumes adapted to clay soils, *Clitoria ternatea* (Milgarra butterfly pea) (Hall 1985) and *Desmanthus* spp. (Jaribu desmanthus, a mix of three cultivars) (Cook, Graham et al 1993), declined in population and could not seed (Hall 2000a; Hall & Douglas 2000).

On fertile, medium to heavy basaltic clay soils, pH neutral to alkaline, in subcoastal Queensland, Caatinga stylo produced liveweight gains of 140–200 kg/head/year, equivalent to 160 kg/ha/year. This production was 18% higher than from sown grass pastures. The density and yield of Caatinga stylo increased over time at these production levels (R. Clem, pers. comm. 2003).

Caatinga stylo has the potential, as a ley pasture on clay soils sown for cropping, to increase soil fertility, break disease cycles and be used for animal production to improve the economics of crop and pasture rotation systems.

In the Paraguayan Chaco, Unica is showing promise by being more frost tolerant than *S. scabra* and better adapted to fine-textured soils. Conclusive results on persistence or animal production are not yet available.

Steers grazing Caatinga stylo (*Stylosanthes seabrana*) pastures in winter in the subtropics of southern inland Queensland (photo: T.J. Hall).

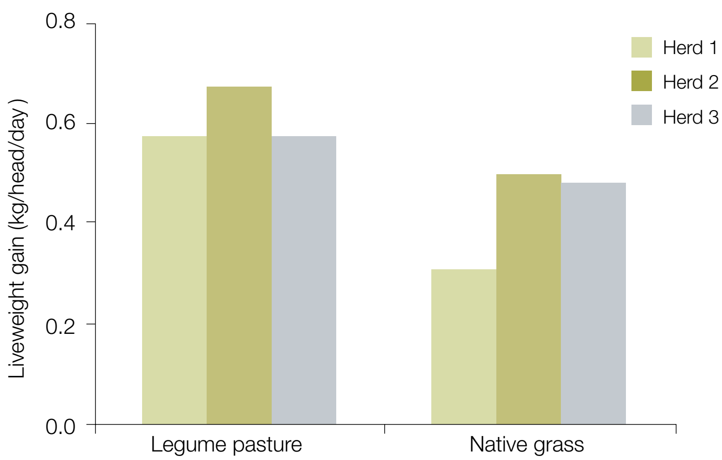


Figure 4.2 **Annual liveweight gain (kg/head/day) of three herds of steers grazing *Stylosanthes seabrana*-based pasture (Caatinga stylo cvv. Unica and Primar) with Bambatsi panic (*Panicum coloratum*) compared with native grass pasture (*Dichanthium* and *Chloris* species) in the subtropics of Queensland.**

Animal Production – Australian Experience

Production on native pastures

Native grass pastures on soils suited to stylos in the Australian tropics are most deficient for animal production due to low phosphorus concentration during the wet season, when plants are green and growing, and low nitrogen (protein) when plants are maturing during the dry season. Energy levels can be limiting, especially during the drier months (Miller & Webb 1990). They are also intolerant of heavy grazing pressure (Jones 2003).

The length of the growing season affects pasture yield, the green leaf period and nutrient dilution, particularly the limiting of soil nitrogen. A range of annual animal production has been reported from tropical grass pastures, varying from low levels of 53 kg/head in the Northern Territory (Norman & Stewart 1964) to 145 kg/head in central Queensland (Middleton et al 1993).

Production on stylos

In northern Australia the annual cattle liveweight produced from stylo pastures is normally in the range 89 kg/head (Norman & Stewart 1964) to 176 kg/head (Coates et al 1997). Up to 200 kg/head has been recorded on stylo–grass pastures on higher quality soils in central Queensland (R. Clem, pers. comm. 2003).

The annual liveweight gain advantage to cattle grazing stylo–grass pastures, compared with grass-only pastures, is usually 30–60 kg/head (Coates et al 1997), with an additional benefit of increased stocking rates possible. Adding a stylo legume to grass pastures increases cattle intake and reduces nutritional limitations of low nitrogen, which leads to poor digestibility. Coates et al (1993) reported an increase of 18% in dry matter intake during the dry season, and an increase of 27% in the intake of digestible dry matter, on stylo–grass pasture compared with a grass only pasture.

In the late wet and dry seasons of northern Australia the advantage due to incorporating stylo into a pasture can average 0.25 and 0.15 kg/head/day respectively. These increases are associated with increased stylo selection at these times as well as higher nitrogen and digestible energy intake (Coates et al 1997).

It is the green component of a pasture which has the higher nutritional value and the most effect on animal production. In a grass–stylo pasture in northern Queensland there was a close linear relationship between cattle annual liveweight gain and a pasture growth index of number of weeks of green pasture available (Jones et al 1990).

By 1996 *Stylosanthes* pastures contributed some $20 million annually to beef production in Australia, through higher turn-off weights, improved weaner and heifer nutrition, reduced death rates and reduced drought risk (Miller et al 1997).

Animal Production – Chaco Experience, Paraguay

There is little information available on animal production from legumes in the Paraguayan Chaco that has been documented with scientific rigour. However, it is commonly accepted that pastures improved with persistent legumes produce more dry matter and tolerate a higher stocking rate than grass-only pastures. In the early 1990s, Oxley, Verano, Amiga, Seca, Siran and Cook stylos were introduced to the Chaco from Australia. These cultivars were widely sown into the regosol soils, partly by seed broadcasting or drilling following thorough soil tillage, and partly by sod seeding into established *Pangola* pastures using a band seeder of Australian origin (Cook, Clem et al 1993).

In the seventh to ninth years after legume establishment, pasture with a legume composition as shown in Figure 4.3 was cut twice per year for hay. It consistently yielded 10–11 large bales/ha (400 kg each) compared to 5 –7 bales/ha harvested from an adjacent plot of *Pangola* alone. In addition, when leguminous pastures were rotated to a cropping phase,

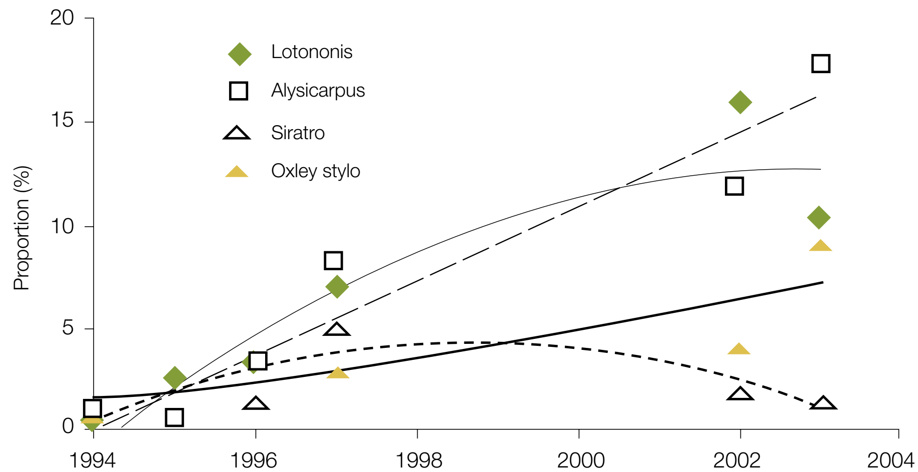


Figure 4.3 **Establishment and persistence of legumes in a continuously grazed *Pangola* grass pasture in the Chaco of Paraguay. Finestem stylo cv. Oxley was the only *Stylosanthes* that increased in proportion during the 10-year period. Other legumes, sown[1] but not shown, either did not persist or remained at proportions below 1%.**

[1] Legumes sown in December 1992, in rows 8 m apart with four rows of each species or cultivar, across a 3 ha plot of established *Pangola* pasture on sandy soil (58% sand and 4% clay): *Stylosanthes hippocampoides* cv, Oxley, *Stylosanthes hamata* cvv. Verano and Amiga, *Stylosanthes scabra* cvv. Seca and Siran, *Stylosanthes guianensis* cv. Cook, *Lotononis bainesii* cv. Miles, *Alysicarpus vaginalis* (CIAT 17360), *Macroptilium atropurpureum* cv. Siratro, *Centrosema pubescens* cv. Belalto, *Chamaecrista rotundifolia* cv. Wynn and *Desmanthus virgatus* (locally collected accession). No fertiliser was applied. Proportions of pasture components were determined by a point intercept method in autumn of every year.

Table 4.1 Pasture composition, stocking rate and annual steer performance (kg/ha) on a *Pangola* pasture, with and without legumes in Paraguay (see footnote of Figure 4.1).

Years after legume establishment	1	2	4	6	10
Legume proportion (%)	4	8	29	49	36
Stocking rate (steers/ha) with legumes	1.3	1.0	1.0	2.4	2.5
Stocking rate (steers/ha) without legumes	1.3	1.0	1.0	1.5	-
Live weight gain (kg/ha/year)					
In *Pangola* grass with legumes	292	270	284	464	401[1]
In *Pangola* grass without legumes	284	231	227	283	-
Liveweight gain in favour of legumes	8	39	57	181	-

[1] Liveweight gain in 7 months (January to August, 2003

yields of silage and grain sorghum increased up to 150% and 30% respectively, compared to preceding weedy fallow or non-leguminous crops (Glatzle 1999).

Dairy farmers report that lactating cows produce about 2 litres more milk per day when shifted from a grass-only pasture to a pasture with legumes, particularly Oxley. Grazing typically accounts for 25–50% of the dry-matter ration, with the rest consisting of sorghum silage and concentrates.

On *Pangola* pasture with an annual legume development as shown in Figure 4.3, growing steers were used to compare stocking rates and liveweight gains. Finestem stylo was one of three dominant and persistent legumes. Between the first and sixth years, and again starting with the tenth year, the pasture was continuously grazed at the stocking rates shown in Table 4.1. *Pangola* with legumes produced consistently higher liveweight gains than *Pangola* without legumes. For example, in the sixth year the legume advantage was 181 kg/ha. Furthermore, live weight gain per ha increased over the years in the pasture with legumes, as the legume proportion increased and contributed more nitrogen to the system. Legume proportion in the sward stabilised at about 35%. Despite below-average rainfall in the tenth year, steers gained 400 kg/ha of live weight in only seven months at a stocking rate of 2.5 head/ha. This performance, on a previously rundown sandy soil, compares favourably with production from grass pastures on recently cleared virgin soil.

One conclusion is that adapted and persistent legumes, eg from finestem stylo, can contribute considerably to soil rehabilitation and reconstitution of animal production on rundown arable lands in the Chaco.

Stylosanthes recta is a small native species on the Chaco (Hacker et al 1996) but it never attains a sufficiently high proportion within pastures to significantly improve animal production.

Animal Production – Cerrados Experience, Brazil

A cattle grazing trial at Fazenda Ribeirão, Chapadão do Sul-MS, on a typical oxisol soil in the Brazilian Cerrados compared cv. Campo Grande stylo and *Brachiaria decumbens* (signal grass) with *B. decumbens* alone. Liveweight gains on the legume-based pasture at stocking rates of 0.6 AU/ha, 1 AU/ha and 1.4 AU/ha were 7%, 18% and 20% respectively, above those of the grass-only pasture (B. Grof, pers. comm. 2003).

Mineirão is recommended for use as a protein bank to supplement native grass pastures in Brazil and it can be grazed at 0.3 ha/head. The crude protein content during the season ranges 12–18% and in vitro dry matter digestibility (IVDMD) ranges 52–60%. It has better persistence under rotational grazing with rest periods of 21 and 28 days than under continuous grazing. Mineirão in association with *Andropogon gayanus* has produced liveweight gains of 0.8 kg/head/day in the wet season and 0.15 kg/head/day during the dry season, at stocking rates of 1.8 AU/ha and 1.3 AU/ha respectively. In the Campo Grande region a liveweight gain of 0.5 kg/head/day has been recorded on Mineirão (B. Grof, pers. comm. 2003).

Management of *Stylosanthes* Pastures for Animal Production

The use of stylo legumes have been relatively low cost and easy to manage in combination with native and sown grasses in Australia. In the early years of stylo introduction, adaptation to low fertility soils and response to low rates of superphosphate increased the rate of commercial adoption. The ability of stylos to increase in population under continuous grazing was seen initially as a benefit; however, as pastures became more widespread and in use for many years, the steady increase of stylos at the expense of the grass component has become a management problem. With extensive property sizes, livestock management on native pastures is minimal, and continuous grazing or periodic spelling systems are practised.

Stylosanthes dominance

Stylo pastures can withstand constant stocking because there is greater grazing pressure on young green grass leaf in the early wet season, allowing the legume to become better established, grow and seed. A grass–stylo pasture in northern areas of Australia, in particular, can also support two to four times higher stocking rates than native pastures alone, and this causes excessive pressure on the less grazing-tolerant grass component, eventually creating a stylo-dominant pasture. This change in botanical composition in native pastures after the introduction of stylos has been reviewed by Jones et al (1997). The opposite problem, grass dominance over stylos, has been a limitation to sown pasture performance in South America.

Initially, stylo pastures are easy to manage; however, maintaining a balanced grass–legume pasture under grazing requires strategic spelling in early summer to promote grass to compete with the legume, and management can require occasional burning to reduce the legume (Cooksley et al 2003). There may be long-term detrimental effects on the pasture and soil condition by this grazing-induced stylo dominance if left unchecked. Jones (2003) reported that native perennial grasses declined with increasing stocking rates and that they were virtually eliminated at high stocking rates, while sown sabi grass (*Urochloa mosambicensis*) persisted. It may be important therefore to include a grazing-tolerant grass when introducing these perennial stylos into native pasture to prevent subsequent stylo dominance.

Spelling alone can restore the native grass component when mixed grass–stylo pastures are grazed at low stocking rates, while at medium stocking rates burning is necessary and there is a further significant response to spelling. At high stocking rates spelling is ineffective in restoring desirable native perennial grasses (Cooksley et al 2003). These authors concluded that a 30–50% grass component could only be achieved with a burning program to reduce stylo competition, regardless of stocking rate.

The increase in populations of *S. seabrana* under continuous grazing on clay soils in subtropical Queensland (Hall 2000a) suggests this species may perform similarly to the more tropical stylos under Australian conditions.

Townsville stylo dominance over native grasses occurred naturally across northern Australia in the 1960s until anthracnose disease destroyed the populations. This sudden disappearance of stylo has created landscape degradation problems due to the very slow or negligible reintroduction of perennial grasses on some soil types. The granitic soils of inland Queensland are one example where perennial grasses have not recovered in over 25 years, and the annual grasses only provide limited soil surface erosion protection from early summer storms.

Soil acidification

The strong adaptation of stylos under higher grazing pressure in Australian conditions has potential impacts on future landscape stability and productivity. Detrimental effects include: loss of soil surface stability, increased erosion, nutrient depletion, profile acidification and vegetation changes including weed invasion. Noble et al (2000) reported on strategies to reduce the negative impacts of stylo dominance and on sustaining productive legume pastures. The extent of acidification in northern Queensland has been assessed (Noble et al 2002), and soil buffering capacity was shown to affect the rate of acidification under a stylo pasture.

Cattle Producer Experience with Stylo Pastures

Naturalised *S. humilis* across the dry tropics demonstrated the animal production benefits of a legume in tropical grazing systems. Prime condition bullocks could be produced at high stocking rates on this stylo on country that otherwise was suitable only for breeding store animals (Barrett 1997). With the disappearance of this species in the early 1970s, Seca and Verano became the most widely planted pasture legumes in the Australian tropics. In coastal Queensland these commercial stylo pastures have produced steer liveweight gains of 0.73 kg/head for 200 days through the dry season and periods of gain to 1.6 kg/head for short periods during the wet season (Barrett 1997).

The first commercial grazing trials with Verano and added superphosphate demonstrated improved animal production and increased stocking rates at ‘Wrotham Park’, northern Queensland. Periodic aerial applications of superphosphate, to 100 kg/ha, maintained the stylo pastures and up to a 10-fold increase in animal production, compared with native grass pastures (Arnold 1997). These pastures fluctuated from Verano dominant to annual grass dominant, eg *Digitaria ciliaris* (annual summer grass) and *Eragrostis* spp. (love grasses), as soil nitrogen levels fluctuated. Weed populations such as *Sida* spp. also fluctuated markedly. There were no native perennial grasses capable of tolerating the high grazing pressures applied to these pastures. When superphosphate applications declined, *Melaleuca* species trees re-established and competed with the stylos, allowing a more balanced, although less productive, stylo–grass pasture.

The commercial seeding of extensive areas in Australia involved mixing stylo seed and 30 t of superphosphate on the ground, and then aerially spreading the mixture onto recently cleared woodlands at rates of 1–3 kg/ha seed and 100 kg/ha superphosphate. Seca established in open eucalypt woodlands when spread aerially at low rates of 0.25 kg/ha seed with 25 kg/ha superphosphate. These pastures took several years longer to develop, but the stylo could still become dominant, due to increased stocking rates and reduced burning.

In trials on commercial properties across Queensland, superphosphate-fertilised stylo pastures have consistently produced liveweight advantages of 30–40 kg/head over native pastures, with a higher stocking rate and a higher sale price per kg because of the better condition of the animals (Anon. 1994). In stylo pastures with higher rates of phosphorus fertiliser and wet season phosphorus supplementation, a liveweight advantage over native pastures of 70 kg/head can be achieved on low fertility soils, while in the absence of phosphorus fertiliser the liveweight advantage from stylos was only 9 kg/head.

With the increase in live cattle exports from northern Australia, improving the nutrition of cattle by better quality pastures, which include stylos, is necessary to meet market requirements for well-grown, younger animals. Returns to producers from these markets are greater than from the traditional marketing of older and less well-conditioned cattle for the chilled manufacturing beef trade (Winter et al 1996).

Miller et al (1997) estimated that the 600,000 ha of grazing land in northern Australia sown to stylo pastures was expanding annually by some 50,000 ha, using approximately 100 t of predominantly Seca, Verano and Amiga seed. Prices of cattle, seed and superphosphate and good summer rainfall have a great influence on the rate of commercial sowing.

Limitations of *Stylosanthes* Pastures for Animal Production

There has not always been a positive result in animal production from introducing stylos. Jones et al (2000) reported that there was no effect from legumes, including stylos, on liveweight gain during a ten-year period. This was largely attributed to poor rainfall, a low quantity of legume produced, and the fact that the site had enhanced soil nitrogen status from a previous productive legume pasture and applied nitrogen fertiliser.

The susceptibility of *Stylosanthes* to anthracnose (*C. gloeosporioides*) has been a major limitation of the genus and cultivar availability (Irwin et al 1984), as well as limiting the environmental adaptation and farmer adoption of stylos in animal production systems.

There are other biotic and abiotic constraints, ie poor seed production and an intolerance of heavy grazing, that limit stylo adoption in South America (Kelemu et al, this volume). When anthracnose-resistant stylo cultivars were developed, replacing Australian cultivars, these other biotic constraints limited their widespread adoption by farmers (Miles & Lascano 1997).

In South-East Asia and China factors limiting *Stylosanthes* adoption include: anthracnose damage, poor persistence of *S. guianensis* and low seed yields in the low latitude humid tropics (Guodao et al 1997). Cutting tolerance, an attribute not usually evaluated in Australia, is a necessary characteristic of a successful legume for the forage systems in this region.

There is increasing pressure on land resources in India and stylos have shown promise as a fodder in different management systems. They enrich soil nutrients and stabilise soil degradation. Anthracnose, head blight, virus diseases and insect pests threaten their potential role (Ramesh et al 1997). However, the availability of *S. seabrana* and promising new commercial utilisation schemes, including the use of stylo leaf meal in poultry rations, have generated a renewed interest in stylos in India (Ramesh et al, this volume) and other parts of Asia (Changjun et al, this volume; Guodao et al, this volume; Phaikaew et al, this volume).

Soil fertility

The wide variability reported in animal production from stylo pastures is due to soil fertility, companion grass species, mineral deficiencies, seasonal rainfall amount and distribution, stocking rates and animal class. The increase in animal production by incorporating stylo compared with a grass-only pasture is strongly influenced by soil fertility, especially the phosphorus status. Stylos are efficient at extracting phosphorus (Probert 1984). Superphosphate, which provides phosphorus and sulphur, has been the main fertiliser required for optimum legume establishment and growth and cattle performance on stylo pastures in the dry tropics of Australia. For example, Winter et al (1989) suggest that the mediocre growth of cattle could be due to the low levels of some nutrients, particularly phosphorus and sulphur, in native grass–stylo pastures. Superphosphate fertiliser tends to promote higher liveweight gains of cattle during the wet season and reduces the losses during the dry season. Jones (2004) suggests nitrogen limitation on some tropical soils, even with a productive stylo pasture, may still be limiting animal production during the dry season. Nitrogen, available energy (digestibility) and phosphorus are the main nutritional limitations to cattle production from pastures on infertile tropical soils of Australia (Coates et al 1997).

Supplements on *Stylosanthes* pastures

The value of additional supplements to cattle grazing stylo pastures is dependent on soil fertility status and especially the phosphorus level in Australian soils. Seca and Verano can grow at low phosphorus levels of 3–5 ppm (bicarbonate extractable); however, both plant growth and animal production will be restricted. Supplemental phosphorus fed directly can help alleviate this problem. There is no extra animal production benefit from feeding a phosphorus supplement to cattle grazing stylo pastures on soils with a P level above 8–10 ppm (Coates et al 1997).

Seasonal effects

The stylos in a pasture contribute to an extended weight gain period of several months after grasses have matured. These benefits improve the viability of cattle production by allowing access to higher priced markets for younger well-grown cattle. Reproductive performance is also enhanced, providing greater management and economic options to cattle producers.

Figure 4.4 Seasonal liveweight change in steers grazing *Stylosanthes hamata* cv. Verano and native grass pastures in northern Australia (after Gillard et al 1980).

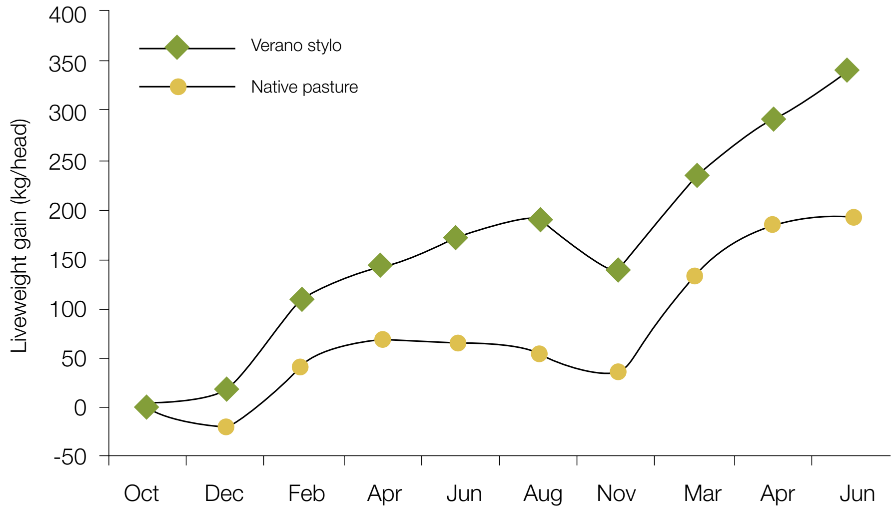
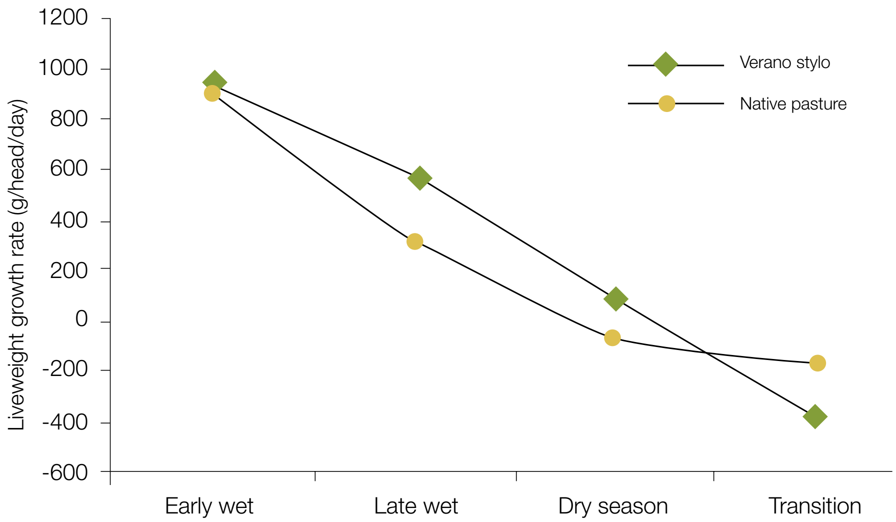


Figure 4.5 Steer growth rates (g/head/day) on *Stylosanthes hamata* cv. Verano and native grass in northern Queensland at four annual growth phases (after Gardener et al 1993). Note – the growth phases are of varying duration (weeks to months).



An example of steer liveweight improvement over seasons from adding a stylo to native pastures in northern Australia is shown in Figure 4.4. The extended weight gain period from the stylo into the winter dry season (May–August) has the most significant effect. Late in the dry season (October–November) there can be rapid weight loss for a short transition period if dry matter intake becomes limited after early summer storms produce new green grass leaf.

Gardener et al (1993) quantified four seasonal periods of liveweight change in northern Australia, which show that the main advantage of stylo in a pasture over native pasture alone is in the late wet and dry seasons, or mid-summer through winter (Figure 4.5). These periods are of very different durations (weeks to months) and vary annually with rainfall patterns. There is little advantage in the early wet season when green grass leaf is most plentiful and actively selected.

Diet selection

Seasonal diet selection studies show that the periods of greatest liveweight gain on stylo pasture relative to grass alone are when the diet has the highest proportion of stylo, such as in the late wet and dry seasons. The selection preference for green grass leaf over stylos in the early wet season has been reported consistently in Australia (eg Coates 1996; Gardener 1980; Hunter et al 1976). The strong perennial Seca is selected over a longer period than the short-lived perennial Verano (Coates 1996), providing an opportunity for a longer period of liveweight gain. The seasonal pattern of stylo selection is affected by rainfall amount and distribution, grass to stylo proportions and the associated grass species (Coates et al 1997).

Conclusions and Future

Sowing *Stylosanthes* species has provided animal production benefits from low quality tropical grass pastures, and the genus has the potential to provide even greater improvements in tropical and subtropical environments around the world. In recent years the increased cattle production from adding stylos has become well accepted, although not well documented experimentally. The increasing role of animal products in many people's diets and the higher food quality demands of consumers provide pressure to improve animal growth rates by improving their year-round nutrition. Stylo has the capacity to help in these evolving animal management strategies.

There are *Stylosanthes* species and ecotypes within current well adapted cultivars in South America that have not been included in detailed environmental adaptation or grazing production studies in Australia or in other tropical countries around the world. The genetic variation within these species, including *S. capitata* and *S. macrocephala*, require evaluation of their adaptation across the tropics and subtropics. This could lead to additional legume species for the grazing industry and may expand the role of legumes in land management.

Another area requiring research is the commercial development and management of stylo pastures, to provide optimal integration into sustainable and viable grazing and farming production systems. Species such as *S. seabrana*, that are adapted to heavier textured soils, have potential for incorporation into farming systems on these better cropping soils. Well-adapted stylos may help provide quality forage to increase animal growth rates and produce the carcase quality demanded by consumers, improve soil fertility and crop production, and provide management options for maintaining landscape sustainability demanded by the wider community.

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