CONCLUSION

The Tropical Grassland Society of Australia is at a crossroads. Membership has dropped by 43%, subscriptions to the journal by 32%. The one successful innovation is the sale of books on tropical pastures.

To reverse this decline major changes have been implemented in the subscription rate, newsletter and journal. More field days away from Brisbane are proposed to encourage primary producers to join the society. Much of the decline in membership is associated with the decline in profitability of the grazing industries since their heyday when the Society was established. Similarly, the early enthusiasm for the tropical pasture legumes, mostly released around the 1950s–1960s has not been fully justified as their deficiencies have become apparent and pests and diseases have taken their toll. Nevertheless these legumes will continue to play an important role on the farm and it is now, more than ever, important to increase communication between research workers and graziers—and also between graziers—so that the maximum benefit may be reaped from the available cultivars.

For this reason, the Society is looking to its Newsletter, occasional publications and field days as a means of encouraging communication between those working on, or deriving their livelihood from, improved pastures. The evolution of the journal has resulted in a publication which is now of little value to most farmers and it is therefore appropriate that the Society channel its major efforts in other directions. The Journal will continue to be of value to the research community and the Society will work towards ensuring its survival and development.

It is anticipated that these changes will bring new life into our Society through encouraging the interchange of ideas of interest and value to the grazing community who are, after all, the basis for the existence of the Society.

REFERENCES

EVANS, T. R. (1982)—The Tropical Grassland Society of Australia—A perspective. *Tropical Grasslands* **16:** 3–8.

SHAW, N. H. (1971)—The Tropical Grassland Society—Its activities, Membership and Future. *Tropical Grasslands* **5:** 55–59.

PERSISTENCE AND PRODUCTIVITY OF *CENTROSEMA VIRGINIANUM* AND *VIGNA PARKERI* CV. SHAW UNDER GRAZING ON THE COASTAL LOWLANDS OF SOUTH-EAST QUEENSLAND

R. M. JONES and R. J. CLEMENTS

CSIRO Division of Tropical Crops and Pastures, 306 Carmody Road, St. Lucia, 4067, Queensland

ABSTRACT

Two introductions and 7 bred lines of Centrosema virginianum *were grown with* Setaria sphacelata *var.* sericea *cv. Nandi and evaluated under common grazing at Beerwah in coastal south-east Queensland.* Macroptilium atropurpureum *cv. Siratro,* Desmodium intortum *cv. Greenleaf,* Centrosema *sp. aff.* pubescens *cv. Belalto and the recently released creeping vigna* (Vigna parkeri) *cv. Shaw were included in the experiment. From 1978 to 1982 the experiment was grazed for 4 days every 3 weeks, equivalent to a stocking rate of 1.5 beasts/ha on a full-year basis. From 1982 to 1986 this stocking rate was maintained on half the experiment and the other half was grazed at 2.3 beasts/ha (6 days every 3 weeks).*

Siratro produced the highest yield in the first year but by the end of the experiment all C. virginianum *lines outyielded Siratro at the lighter stocking rate. The best* C. virginianum *line at the end of the experiment, a composite cross based on 7 parents,* *usually comprised some 20% of the pasture at the end of autumn.* C. virginianum *did not persist at 2.3 beasts/ha* C. *sp. aff.* pubescens *cv. Belalto died out after 5 years and Greenleaf desmodium failed to establish.*

C. virginianum *lines showed good seedling regeneration and stoloniferous root development. Soil seed reserves of the better* C. virginianum *lines (c. 500 seeds/m²) were similar to the highest levels recorded under Siratro pastures.*

Yields of Shaw creeping vigna fluctuated markedly from year to year due to its poor growth and survival during dry periods. Shaw had higher nutritive value than C. virginianum *in terms of leaf:stem ratio, digestibility, and concentrations of nitrogen, phosphorus and potassium. Shaw spread throughout the experimental area.*

INTRODUCTION

Centrosema virginianum is a twining tropical legume which has a natural distribution from about 34°S in South America to 39°N in the U.S.A. Preliminary studies evaluating *C. virginianum* as a pasture legume in south-east Queensland have been described (Clements 1977, 1983; Clements and Thomson 1983). The initial studies were carried out at 5 sites, one being at Beerwah in the coastal lowlands of south-east Queensland. Growth at the Beerwah site was initially very poor and the site was abandoned after 1 year (Clements 1977). Subsequent observations however, showed that some *C. virginianum* had persisted under lenient farm grazing. Consequently a further experiment was established to evaluate a number of *C. virginianum* lines sown with a companion grass. Three commercially available legumes and *Vigna parkeri* CQ1374 (subsequently released as creeping vigna cv. Shaw), were also included in the experiment. The aim was to compare the persistence and productivity of these legumes under grazing.

METHODS

The experiment was carried out on a gleyed podzolic (Thompson 1958) or hapludalf soil (Dy 5.41—Northcote 1971) in south-east Queensland at Beerwah Research Station (26°50′S, 153°02′E, average annual rainfall 1600 mm). The site was cleared of native forest in 1966 and was part of an experiment measuring animal production from nitrogen fertilized pastures from 1967 to 1976 (Evans and Peake 1976). During this period the site was annually fertilized with nitrogen, phosphorus and potassium after receiving the recommended basal fertilization with trace elements (Bryan and Evans 1973). Soil pH was 4.6 to 4.7.

Pastures and pasture management

Two introduced and 7 bred lines of *Centrosema virginianum* (Table 2), together with *C.* sp. aff. *pubescens* cv. Belalto, *Macroptilium atropurpureum* cv. Siratro, *Desmodium intortum* cv. Greenleaf and creeping vigna (*Vigna parkeri*) cv. Shaw were sown into a cultivated seedbed in December 1977. Seed was inoculated with *Rhizobium* strains CB1923 (*Centrosema*), CB756 (Siratro and Shaw) or CB627 (Greenleaf desmodium). The legumes were sown at 2.5 kg/ha of scarified seed and the companion grass, *Setaria sphacelata* cv. Nandi, at 2 kg/ha into plots of 11 × 8 m. Plots were separated by a 90 cm wide laneway which was regularly mown to 2 cm height. There were initially 4 replicates in a randomised block design, each replicate being separately fenced. Thus, plots within a replicate were grazed in common.

Grazing commenced in September 1978 when each replicate was grazed by 1 steer for 2 days every 3 weeks. After November 1978 this was increased to 4 days grazing every 3 weeks, equivalent to 1.5 steers/ha on a yearlong basis. New animals were introduced into the experiment every August, their weights increasing from approximately 200 to 370 kg over the 12-month period. From August 1982, the stocking rate was increased to 2.3 beasts/ha on 2 replicates by increasing the grazing period from 4 to 6 days. The stocking rate on the remaining 2 replicates was continued at 1.5 steers/ha. Grazing ended in August 1986.

The site was fertilized annually with 250 kg/ha of superphosphate and 50 kg/ha of either potassium chloride or potassium sulphate. Trace elements (copper and zinc at 1 kg/ha and molybdenum at 100 g/ha) were reapplied in 1977 and molybdenum was again reapplied at the same rate in 1982.

Measurements

Legume seedling emergence was recorded in January 1978 using 4 quadrats, each of 0.5 m^2, per plot. Between 1978 and 1982 the presentation yield of pasture was measured in autumn (May) at the end of each growing season and prior to grazing by cutting a strip of 0.9 by 8 m through each plot to a height of c 7.5 cm. Subsamples were sorted into legume, green grass and litter. Following the introduction of the higher stocking rate in August 1982, yield and botanical composition were estimated to 2 cm above ground level, calibrating the estimates with cut and sorted standards. In each autumn of the last 3 years, 2 samples of Shaw and *Centrosema* (1 each of line 7 and CPI40057) were taken from material cut to 1 cm above ground level, sorted into leaf and stem, dried at 60–80°C, weighed, and ground for chemical analysis and measurement of uncorrected *in vitro* digestibility (Goto and Minson 1977).

In August 1982, 20 soil cores of 7 cm diameter were taken from each plot of 3 *C. virginianum* lines (line 1, line 7 and CPI40057), Siratro and Shaw. The cores were cut into 0–2.5 cm and 2.5–5.0 cm sections. Stolons on the soil surface were washed out and their weight and length measured. The number of rooted points, where 1 or a group of closely clustered roots originated from stolons, and the number of roots $>$ 1 mm diameter were also measured, as were the reserves of legume seeds in the soil (Jones and Bunch 1977). The same measurements were taken in July 1986 except that 30 cores were taken from each plot. Seedlings of the same 5 legumes were counted in April 1986 following good rains after a prolonged dry period, using 10 quadrats, each of 0.1 m^2, per plot.

The survival of legume seedlings emerging from grazed but otherwise undisturbed pasture was measured over the 1982–83 and 1983–84 summers. Four fixed quadrats of 1.0 $\times$ 0.5 m were pegged out in each plot of Shaw and *C. virginianum* line 7 and CPI40057. Newly emerged seedlings were marked with plastic coated wire and their location measured. Regular inspections were made to mark new seedlings and record the survival of tagged seedlings. Subsequent inspections in spring 1984, 1985 and 1986 followed the survival of tagged plants.

Rainfall

Rainfall was generally below average throughout the experimental period, particularly in summer where only 1 year in 9 had above average rainfall (Table 1).

TABLE 1

Rainfall for 1978–1986 at Beerwah (December recordings are from the previous year). Rainfalls in bold type are below the long term average.

Year	Summer (Dec.Jan.Feb.)	Autumn (Mar.Apr.May)	Winter (Jun.Jul.Aug.)	Spring (Sep.Oct.Nov.)	Yearly Total
			(mm)		
1978	**405**	489	**175**	**230**	**1297**
1979	**609**	**232**	**120**	**200**	**1161**
1980	**323**	467	**103**	**234**	**1127**
1981	**541**	452	**153**	288	**1434**
1982	822	453	**106**	**157**	**1538**
1983	**279**	644	522	560	2005
1984	**315**	**236**	350	311	**1212**
1985	**440**	664	283	**229**	1616
1986	**203**	**287**	**196**		
Long term average (1955–1981)	649	452	216	277	1594

TABLE 2

Percentage legume in the presentation yield during late autumn of plots sown to C. virginianum, *Siratro, Belalto centro and Shaw creeping vigna in 1978, with mean yield and percentage weed over all plots at low (1.5 beasts/ha) and high (2.3 beasts/ha) stocking rates.*
Lines 1 and 2 were F_6 families derived from the cross CPI40057 × 51366 (Clements and Thomson 1983) and lines 3 to 6 F_6s from 33808 × 40057. Line 7 was derived from a 7 parent composite cross (Clements 1976) with CPI40057 providing one-quarter of the genes.

	Low stocking rate									High stocking rate			
	1978	1979	1980	1981	1982	1983	1984	1985	1986	1983	1984	1985	1986
	(%)												
C. virginianum Line 1	4	18	20	18	22	7	19	20	6	5	13	5	1
C. virginianum Line 2	3	21	13	16	14	6	12	16	4	6	7	4	1
C. virginianum Line 3	2	4	15	21	24	9	9	15	7	4	2	2	1
C. virginianum Line 4	2	6	10	21	21	13	11	17	9	4	3	3	1
C. virginianum Line 5	1	1	5	19	22	6	8	10	5	6	3	3	1
C. virginianum Line 6	1	5	7	6	17	10	7	12	5	7	3	1	1
C. virginianum Line 7	2	6	12	19	32	21	24	22	18	10	6	3	1
C. virginianum CPI40057†	4	18	21	20	21	6	11	7	3	4	6	1	0
C. virginianum CPI55707	2	11	7	24	24	22	21	17	1	6	7	5	0
Siratro	27	21	17	7	3	1	0	0	0	1	0	0	0
Belalto centro	1	22	9	21	21	0	0	0	0	0	0	0	0
Shaw creeping vigna	1	15	1	2	12	1	2	4	0	2	7	10	0
LSD (P = 0.05)	3	7	11	9	13	5	9	11	3	4	7	7	ns
Total yield (kg/ha)	2930	4320	1063	3330	3660	9680	5050	8540	6790	6790	3600*	6610	3020
Monocot weed yield (kg/ha)	nm	nm	nm	nm	nm	304	230	300	295	320	290	790*	324

*differences between stocking rates significant at P = 0.05 respectively.
†CPI = Commonwealth Plant Introduction number.
nm—not measured.

From 1983 to 1986 summer rainfall (December to February), averaged 305 mm, less than 50% of the long term average. The summer and autumn of 1986 were particularly dry.

RESULTS

Establishment

Seedling numbers of the sown legumes, as measured 4 weeks after sowing, ranged from 3.0 (Greenleaf desmodium) to 7.3 seedlings/m² (*C. virginianum* line 1).

Legume and sward yield

Total presentation dry matter yields of the different legume/grass mixtures were usually not significantly different. Consequently we have compared legumes in terms of their percentage contribution to dry matter rather than in terms of legume yield, as this enabled easier comparison between accessions and years.

With the exception of Siratro (Table 2), little legume growth was recorded in the establishment year when plots were dominated by *Eleusine indica*. Greenleaf desmodium yields and plant density were negligible after the first year and are not included in Table 2. In the second and third years Siratro, Belalto centro and some *C. virginianum* accessions yielded well. However yields of Siratro then declined and were negligible after 4 years. Belalto centro persisted and grew well for 4 years but died during the dry 1982–83 summer. At the lighter stocking rate, the better *C. virginianum* lines comprised close to 20% of yield at the end of the growing seasons over a 7-year period with a decline in the final year. The composite cross (line 7) was the best line over the last 4 years. At the lighter stocking rate the percentage of Shaw fluctuated between years and was highest (12–15%) in 1979 and 1982, and lowest (< 1%) in 1980, 1983 and 1986.

The total yields of pasture measured at the light stocking rate increased 2-fold after 1982 (Table 2). However this was associated with the changed sampling procedure cutting much closer to ground level.

Under the higher stocking rate imposed in 1982 presentation pasture yields were half to two-thirds of the yields at the lighter stocking rate and the percentage of *C. virginianum* declined markedly. In contrast, the percentage of Shaw was 2 to 3 times higher at the higher stocking rate.

Over the last 4 years, monocot weeds comprised less than 5% of the presentation yield at the lighter stocking rate but some 10% at the higher stocking rate. The main weed species was *Eragrostis parviflora*, with *Axonopus affinis*, *Juncus* spp. and *Cyperus* spp. also present. By 1984 Shaw had spread into every plot in the experiment. The percentage of Shaw in the pasture in 1984, averaged over all plots, was 6% at the lighter stocking rate and 14% at the higher stocking rate. These legume percentages were slightly higher than in the plots actually sown to Shaw. As far as could be determined, there was little movement of *C. virginianum* lines out of the plots in which they were sown.

Soil seed reserves

The soil seed reserves of *C. virginianum* (lines 1, 7 and CPI40057), Siratro and Shaw, as measured in 1982 and 1986, are listed in Table 3. Shaw had the highest seed reserves and these were unaffected by the 2 stocking rates imposed after 1982. The seed reserves of Siratro were also unaffected by stocking rate as there was no seed set of Siratro after 1982. In contrast, seed reserves of *C. virginianum* in 1986 were consistently lower at the higher stocking rate. The reserves of line 7 were higher than those of line 1 and CPI40057 at the lower stocking rate. The average percentage of seed in the surface 2.5 cm of the top 5 cm, excluding seed of invading Shaw, was 73% in 1982 and 62% at the lighter stocking rate and 50% at the higher stocking rate in 1986. The seed reserves of Shaw in plots not sown to Shaw increased from 28 seeds/m² in 1982 to 220 seeds/m² in 1986 when, in contrast, there were only 4 *C. virginianum* seeds/m² in the Shaw plots.

TABLE 3

Soil seed reserves of 3 lines of C. virginianum, *Siratro and Shaw creeping vigna in the surface 5 cm of soil in the winter of 1982 and 1986.*

Line	Soil seeds		
	1.5 beasts/ha		2.3 beasts/ha
	1982	1986	1986
		(seeds/m^2)	
C. virginianum Line 1	508	342	219
C. virginianum Line 7	540	828	199
C. virginianum CPI40057	325	163	103
Siratro	155	80	88
Shaw creeping vigna	1331	980	824
LSD (P = 0.05)	466	373	289

Seedling recruitment and survival

Seedlings of *C. virginianum* and Shaw were frequently observed during the experiment although formal measurements were confined to the 1982–83 and 1983–84 seasons.

Over the 1982–83 season there was good emergence of seedlings, with Shaw having 82 seedlings/m^2, significantly more than *C. virginianum* line 7 (55) or CPI40057 (24). These seedling densities represent 9 to 13% of the soil seed reserves measured in the 1982 winter. In the following year there was much less seedling emergence, with Shaw having only 2 seedlings/m^2 compared with 9/m^2 in line 7 and 3/m^2 in CPI40057.

Seedling survival of both *C. virginianum* lines was similar. Averaging the percentage survival of seedlings emerging in 1982–83 and 1983–84, the survival of *C. virginianum* was much better than that of Shaw as follows:

	Percent survival after:			
	1st winter	2nd winter	3rd winter	4th winter
C. virginianum	35	2.5	0.2	0.05
Shaw	9	0.1	—	—

When seedlings were counted in April 1986, near the end of the experiment, the mean seedling density of the 3 *C. virginianum* lines (1, 7 and CPI40057) at the lighter stocking rate (17/m^2) was significantly higher than at the higher stocking rate (4/m^2). In contrast, the density of Shaw seedlings (6/m^2) was not affected by stocking rate. On average, only some 1.3% of the seed reserves of Shaw and 3.6% of the seed reserves of *C. virginianum* emerged as seedlings.

Stolon length and rooting from stolons

No stolons were recorded in 1986 at the higher stocking rate. At the lighter stocking rate the numbers of rooted points and of roots > 1 mm diameter in *C. virginianum* line 7 was similar in 1982 and 1986, even though the length of stolons was lower in 1986 (Table 4). The stolon lengths and numbers of rooted points and roots > 1 mm of lines 1 and CPI40057 were fewer in 1986 than in 1982. There were few Siratro stolons in 1982 and none in 1986. Few Shaw stolons were recorded in 1986 although there had been good stolon and root development in 1982. Shaw stolons were very light, averaging 0.3 g/m in both 1982 and 1986. *C. virginianum* stolons were heavier, *c.* 1.1 g/m in 1982 and 3.0 g/m in 1986.

Nutritive quality of C. virginianum *and* Shaw

In both leaf and stem, Shaw had significantly higher *in vitro* digestibility and concentrations of nitrogen, phosphorus and potassium than *C. virginianum* (Table 5).

TABLE 4

Stolon length, rooted points and number of adventitious roots > 1 mm diameter in 3 lines of C. virginianum, *Shaw creeping vigna and Siratro in the winter of 1982 and 1986.*

Species	Stolon length		Rooted points		Roots > 1 mm diameter	
	viii.82	vii.86	viii.82	vii.86	viii.82	vii.86
	(m/m²)		(No./m²)		(No./m²)	
C. virginianum Line 1	13.6(0.95)†	3.7	194(2.23)	88	36(1.50)	24
C. virginianum Line 7	25.4(1.40)	9.1	475(2.56)	366	40(1.50)	68
C. virginianum CPI40057	26.2(1.38)	2.3	460(2.60)	48	82(1.77)	12
Shaw creeping vigna	23.2(1.31)	0.5	433(2.48)	4	116(1.96)	0
Siratro	0.5(0.16)	0‡	9(0.63)	0	6(0.56)	0
LSD (P = 0.05)	(0.47)	ns	(0.80)	ns	(0.75)	ns

†brackets: log transformed data.
ns: not significantly different.
(‡ Siratro excluded from statistical analysis of 1986 results)

TABLE 5

Percentage of leaf and stem in the topgrowth of Centrosema virginianum *and Shaw creeping vigna, and* in vitro *digestibility and concentration of nitrogen, phosphorus, potassium and calcium in the leaf and stem of both species (means over 3 Years).*

	Leaf			Stem		
	C. virginianum		*Shaw*	*C. virginianum*		*Shaw*
Leaf or stemp (%)	50	**	65	50	**	35
N (%)	3.3	**	4.1	1.7	**	2.0
P (%)	0.20	**	0.27	0.15	***	0.25
K (%)	1.56		1.97	1.27	**	2.10
Ca (%)	1.43		0.96	0.99	*	0.55
DMD†	56	*	61	39	**	55

* ** ***—differences between species significant (P < 0.05, 0.01 and 0.001).
†Uncorrected *in vitro* digestibility of dry matter.

In contrast, the calcium concentration in Shaw was lower. Shaw had a higher leaf:stem ratio than *C. virginianum*.

Pests and Diseases

Periodic insect damage was noted on all legumes, in particular from leaf eating beetles (*Rhyparia* spp.) on Shaw, but none was serious. Occasional patchy yellowing of the topgrowth of both *C. virginianum* and Shaw was noted and root samples of both legumes were collected from these patches in 1985 and 1986 and from Shaw alone in 1982. This yellowing was associated with heavy infestation of root knot nematode (*Meloidogyne javanica*) in both legumes in 1985 and in Shaw in 1982, but the nematode infestation was much lower in 1986 (G. R. Stirling, pers. comm.).

DISCUSSION

Centrosema virginianum

This is the first time *C. virginianum* has been evaluated under grazing in a legume/grass pasture. Despite a slow establishment phase, which we have observed in other sowings, *C. virginianum* showed promise. It survived for 8 years at a stocking rate of 1.5 beasts/ha with the better lines contributing some 20% of presentation yield. In contrast, Greenleaf desmodium, Belalto centro and Siratro failed.

Greenleaf desmodium, which is climatically suited to the Beerwah environment (Bryan and Evans 1973) failed to persist after the first year. This could be attributed to competition from the vigorous growth of the weed *Eleusine indica* in the first year and also to the pH of 4.7 which is below optimum for Greenleaf desmodium (Imrie *et al.* 1983). Belalto persisted for 4 years but did not set seed at Beerwah, and death of the original plants appeared to be mainly due to soil moisture stress.

Siratro was more vigorous than Greenleaf desmodium in the presence of strong weed competition in the year of establishment, as has been recorded previously (Jones 1975). The failure of Siratro to persist after 4 years could have been partly due to a tendency for the Siratro plots to be more heavily grazed. However, Siratro persistence was also poor in an adjacent Siratro/setaria pasture under a lenient stocking rate with no opportunity for selective grazing between legumes (R. M. Jones unpublished data). Persistence of *C. virginianum* could not be attributed to lack of palatability. A check on diet composition during the 1981–82 summer using oesophageally fistulated cattle showed that *C. virginianum* was well eaten (T. R. Evans, pers. comm.).

The drop in *C. virginianum* yields at the last harvest is attributed primarily to the very dry 1986 summer and autumn when prolonged and severe moisture stress was observed. The poor yields of *C. virginianum* at the heavier stocking rate imposed from 1982 onwards show that, in this respect, *C. virginianum* is similar to other twining and scrambling tropical legumes such as Siratro (Jones and Jones 1978), Greenleaf desmodium (Imrie *et al.* 1983) and *Neonotonia wightii* (Cowan and Stobbs 1976).

Detailed measurements of soil seed reserves, seedling emergence, seedling survival and stolon rooting were restricted to the best *C. virginianum* line (7) and 2 other lines (1 and CPI 40057). However, observations of growth habit and flowering intensity of the remaining lines suggest that their mechanisms of persistence were similar to the measured lines.

The soil seed reserves of *C. virginianum* were at the upper end of the ranges of Siratro soil seed levels usually recorded in Siratro pastures (Tothill and Jones 1977) and seed reserves of line 7 increased between 1982 and 1986 at the lighter stocking rate. Seed reserves declined at the higher stocking rate where much less seed set was observed. No Siratro seed was set between 1982 and 1986, yet approximately half the seed present in 1982 survived over this period, confirming trends measured elsewhere in south east Queensland (Jones 1981).

Seedlings of *C. virginianum*, were frequently observed during the experiment. Although many of these seedlings died, sufficient numbers survived to provide an important means of long term persistence. For example, the *c.* 40 *C. virginianum* seedlings/m^2 over the 1982–1983 growing season contributed *c.* 13 plants/m^2 at the start of the next growing season and 1 plant/m^2 at the start of the following season. The 30% survival of seedlings until the next growing season is appreciably higher than the equivalent survival percentages of $<$ 1% for greenleaf and silverleaf desmodium (*Desmodium uncinatum*) at Beerwah (R. M. Jones, unpublished data).

The length of stolons (14–26 m/m^2) and number of rooted points of *C. virginianum* (200–480/m^2) in good legume plots in 1982 were only slightly below the 20–30 m/m^2 of stolons and 300–700 rooted points/m^2 of *D. intortum* in good *D. intortum* pastures (Jones 1980). As *D. intortum* appears to rely on rooting from stolons for long term persistence (Jones 1980) this suggests that rooting from stolons could be an important feature of *C. virginianum* persistence in this environment. No stolons were measured at the higher stocking rate in 1986. Even at the lighter stocking rate there were fewer stolons in 1986 than 1982 and this is mainly attributed to the dry 1986 summer.

Adventitious rooting of *C. virginianum* was more conspicuous in this experiment that it has generally been at other sites. This may be partly a reflection of the particular lines which were sown, excluding CPI55707 (R. J. Clements, unpublished data). The relatively moist sandy topsoil at Beerwah would also be more conducive to stolon rooting than the drier sites where most testing of *C. virginianum* has taken place (Clements 1977; Clements 1983).

The most promising *C. virginianum* line, a composite cross from 7 parents, was not outstanding in the first 2 years. The improvement with time may have been due to the genetic diversity in this line and the consequent opportunity for population improvement by natural selection. This could have occurred through vegetative and/or sexual reproduction. Although CPI40057 contributed one quarter of the genes in the initial composite cross it is obvious from measurements of soil seed reserves and seedling density, and from observations of flowering, that the composite cross seeded more heavily than CPI40057. This line has been observed previously to produce fewer seeds than the other parents of the composite cross (Clements 1977).

The results from this experiment show that *C. virginianum* may have the potential to become a useful pasture plant, though with poor tolerance of sustained heavy grazing pressures. The performance of the composite cross confirms previous work (Clements 1976) which suggests that this procedure may be a useful way to breed improved lines. However, further evaluation of the more promising lines of *C. virginianum* in a range of climatic environments and grazing conditions is required before it can be recommended as a pasture legume.

Shaw creeping vigna

The key features of Shaw in this experiment were its ability to spread and its erratic yield contribution to the pasture, reflecting its sensitivity to soil moisture stress. Thus Shaw yields were highest in the wetter years, such as 1982, and lowest in the very dry 1986 summer. This susceptibility to soil moisture stress may have been exacerbated by infestation by root knot nematode.

The spread of Shaw throughout the experiment could be a result of spread of seed in faeces as well as by rooted stolons which enabled Shaw to grow across the closely mown carpet grass (*Axonopus affinis*) laneways between plots. This ability of Shaw to spread in grazed pastures at Beerwah has been documented elsewhere by Jones (1982). Good swards of Shaw had similar densities of stolons and rooted points to *C. virginianum*, but the Shaw stolons were lighter with fewer roots $>$ 4 mm diameter (data not presented). Although Shaw can die out during extended dry periods, its long-term persistence is aided by its good reserves of soil seed even in areas where it has only recently invaded.

The herbage quality of Shaw, in terms of nitrogen, phosphorus and potassium percentages, *in vitro* digestibility and leaf:stem ratio, was better than *C. virginianum*. Clements (1977) has previously shown that the *in vitro* digestibility of *C. virginianum* leaves was similar to that of Siratro and that the digestibility of *C. virginianum* stems was approximately 6 units lower than Siratro. This suggests that the digestibility of Shaw stems could be up to 10 units higher than Siratro while Shaw leaves are 5 units higher than Siratro.

Shaw, which is native to the elevated tropics in East Africa, is a potentially useful legume for the wetter subtropics in sites where there are usually no extended dry periods. It has an ability to tolerate a range of grazing pressures. Its main disadvantage is its very poor drought tolerance which is most critical in the establishment year before Shaw can set seed.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made of the technical help given by Mr A. C. Brooks, G. A. Bunch, G. C. McDowall and C. J. Thomson and for the assistance provided by Mr. J. Biggs, Mr. S. Wright and other staff at the Beerwah Research Station.

REFERENCES

BRYAN, W. W. and EVANS, T. R. (1973)—Effect of soils, fertilizers and stocking rates on pastures and beef production on the Wallum of south-eastern Queensland 1. Botanical composition and chemical effects on plants and soils. *Australian Journal of Experimental Agriculture and Animal Husbandry* **13:** 516–529.

COWAN, R. T. and STOBBS, T. H. (1976)—Effects of nitrogen fertilizer applied in autumn and winter on milk production from a tropical grass-legume pasture grazed at four stocking rates. *Australian Journal of Experimental Agriculture and Animal Husbandry* **16:** 829–837.

CLEMENTS, R. J. (1976)—Plant breeding strategies for *Centrosema virginianum*. CSIRO Division of Tropical Crops and Pastures, Annual Report 1975–76. pp. 95–99.

CLEMENTS, R. J. (1977)—Agronomic variation in *Centrosema virginianum* in relation to its use as a subtropical pasture plant. *Australian Journal of Experimental Agriculture and Animal Husbandry* **17:** 435–444.

CLEMENTS, R. J. (1983)—Preliminary evaluation of accessions of *Centrosema virginianum* in subhumid south-east Queensland. CSIRO Division of Tropical Crops and Pastures, Genetic Resources Communication No. 4.

CLEMENTS, R. J. and THOMSON, C. J. (1983)—Breeding *Centrosema virginianum* in subtropical Queensland. CSIRO Divison of Tropical Crops and Pastures Technical Paper No. 26.

EVANS, T. R. and PEAKE, D. C. I. (1976)—Animal production from nitrogen fertilised pastures. CSIRO Division of Tropical Crops and Pastures. Annual Report 1975/76. p. 6.

GOTO, I. and MINSON, D. J. (1977)—Prediction of the dry matter digestibility of tropical grasses using a pepsin-cellulase assay. *Animal Feed Science and Technology* **2:** 247–253.

IMRIE, B. C., JONES, R. M. and KERRIDGE, P. C. (1983)—*Desmodium. In* "The role of *Centrosemas, Desmodium* and *Stylosanthes* in improving tropical pastures", eds R. L. Burt, P. P. Rotar, J. L. Walker and M. W. Silvey. (Westview Press: Boulder) pp. 97–140.

JONES, R. J. and JONES, R. M. (1978)—The ecology of Siratro-based pastures. *In* "Plant Relations in Pastures". ed. J. R. Wilson. (CSIRO: Melbourne) pp. 353–367.

JONES, R. M. (1975)—Effect of soil fertility, weed competition, defoliation and legume seeding rate on establishment of tropical pasture species in south-east Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **15:** 54–63.

JONES, R. M. (1980)—Persistence of Greenleaf desmodium in established pastures. *Tropical Grasslands* **14:** 123–124.

JONES, R. M. (1981)—Studies on the population dynamics of Siratro: the fate of Siratro seeds following oversowing into subtropical pastures. *Tropical Grasslands* **15:** 95–101.

JONES, R. M. (1982)—White clover (*Trifolium repens*) in subtropical south-east Queensland. III. Increasing clover and animal production by use of lime and flexible stocking rates. *Tropical Grasslands* **18:** 186–194.

JONES, R. M. and BUNCH, G. A. (1977)—Sampling and measuring the legume seed content of pasture soils and cattle faeces. CSIRO, Division of Tropical Crops and Pastures, Technical Memorandum No. 7.

NORTHCOTE, K H. (1971)—Factual key for the recognition of Australian soils. 3rd edition, (Rellim: Adelaide).

TOTHILL, J. C. and JONES, R. M. (1977)—Stability in sown and oversown Siratro pastures. *Tropical Grasslands* **11:** 55–65.

THOMPSON, C. H. (1958)—The soils of the CSIRO Beerwah experimental area, coastal lowlands, south east Queensland. CSIRO Divison of Soils, Divisional Report 15–57.

(Received October 27, 1986; Accepted for publication February 11, 1987)

SIMULATED LATITUDINAL EFFECTS ON FLOWERING AND SEED PRODUCTION OF *STYLOSANTHES GUIANENSIS* SELECTIONS

K. TRONGKONGSIN* and L. R. HUMPHREYS

Department of Agriculture, University of Queensland, St. Lucia, Qld 4067, Australia
*Present address: Faculty of Agricultural Technology, King Mongkut's Institute of Technology, Ladkrabang, Bangkok, 10520. Thailand.

ABSTRACT

Seedlings of Stylosanthes guianensis *var.* guianensis *cv. Cook and 5 tardio selections of* S. guianensis *ssp.* guianensis *var.* pauciflora *were grown at Brisbane (c. latitude 28°S) in a glasshouse with supplementary heating in natural daylength or in daylengths simulating latitude 4°, 16°, or 35°. The length of the phase to floral initiation and the node number were negatively related to latitude over the range 4° to 28° and similar at 28° and 35°. Inflorescence density and floret number per inflorescence were reduced at 4°, and highest seed production occurred at 28°.*

The apparent critical photoperiod for flowering varied from 11.5 to 12.3 h between selections. Tardio selections were poorly synchronised in their flowering relative to cv. Cook. CIAT 10136 and 1959 gave the highest seed yield, and selections differed in their capacity to produce seed at 4° and 16°, CIAT 1283 being superior in this respect.